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Table of Contents

Statistical Verification of Selected Bankruptcy Models – Case Study

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Abstract:

Broad range of simple and complex prediction methods can be found in professional literature that less or more successfully predict a company financial position in the future. Ability to predict the company financial position is based on the interpretation of reached ex-post retrospective financial analysis results. Financial managers should know theoretical fundaments of prediction methods but also recognize specific advantages and limitations resulting from prediction methods application.

Presented article is dedicated to testing of 10 prediction methods on 20 Slovak companies in agricultural sector. The sample companies consist of 10 successful and 10 not successful companies where economic added value (EVA) indicator was a criterion of company classification. Non-parametric set of mathematical – statistical tests was applied to testing of selected methods, which were applied in two cases, namely comparison of results within particular company groups and comparison of pairs of subjects within particular prediction methods. One of the results refers to possible substitution of the Ohlson model with Zmijewski model and, without effect on complex evaluation, linear correlation between selected models´ results that doesn´t allow their common application or inadequacy of the Kralicek Quick Test, and the Ohlson model application in their absolute expression.

Keywords: bankruptcy; financial analysis; prediction methods; statistical verification; Slovakia

JEL Classification: G30; G33

1. Introduction

Prediction methods became a subject of interest of both academic village and business sector representatives. This is logical, since the prediction methods are aimed at making aware financial managers of a crisis emergence in sufficient time advance, so as they could adopt eventual revitalization measures and the companies could avoid the crisis. It´s been a frequently discussed topic in these times since a company bankruptcy affects both business subject existence and almost all subjects that have something in common with the company. As stated by Valasková, Klieštik and Kováčová (2018), bankruptcy is currently considered a problem by almost all national economies and it can be expressed in various forms. We should also admit that prediction ability of methods decreases and thus, authors of prediction methods make efforts to develop such a method that will be able to provide required prediction ability value in the longest time horizon. It is extremely complicated in currently continuously changing and turbulent environment.

The presented article is focused on companies performing in agricultural sector which is known for its specific characteristics. The production processes in agriculture are supplemented by a factor of the impact of natural conditions, weather, the length of the production cycle and associated length of current assets turnover

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(Kravčáková Vozárová and Kotulič 2017, Kravčáková Vozárová, Kotulič and Šíra 2015). We agree with Bielikova *et al.* (2014) who state that the Slovak agricultural sector has been characterized with unstable corporate financial performance and economic environment during the latest years. Such situation is mainly attributable to major changes of market conditions, production, prices and climate conditions that affect business subjects' prosperity more than ever before, along with bureaucratic and tedious process of subsidy allocation.

The presented article is aimed at testing/ verifying the differences of prediction (narrative) ability of 10 prediction methods and system of non-parametric methods on the sample of 20 agricultural subjects. We focused on two tasks – comparison of results within the groups of prosperous and non-prosperous companies, and comparison of pairs of subjects within particular financial analysis models.

2. Literature review

Quickly developing environment and resulting changes and consequences have been very demanding for all subjects performing in the market economy, including business subjects. Current situation caused that many business subjects face existential problems that often result in cessation of their business activities. In this place, ex-ante financial analysis prediction methods become important as a supporting tool of financial management and decision making. Prediction methods are capable of identifying critical factors that could endanger the company existence in the future, *i.e*. correct response on the company figures could impact upon company financial position in the future. This fact represents their main advantage also compared to ex-post retrospective financial analysis (Karas and Režňáková 2017, Spuchláková 2016). The beginnings of scientific financial situation prediction are attributed to Beaver (1966), a founder of uni-dimensional discrimination analysis. The uni-dimensional discrimination analysis classifies a company as prosperous and non-prosperous (and evaluates its future outlook) based on a single indicator. According to Beaver (1966) five indicators show major statistical differences and development of their values is shown in the following Table 1:

Table 1. Average values of Beaver´s test proportional

Indicator	Healthy companies	5 years before bankruptcy	1 years before bankruptcy
Cash flow / Foreign capital	0,450	0,18	-0,07
Net profit / Total assets	0,075	0,06	-0,22
Foreign capital / Total assets	0,400	0,50	0,80
Net working capital / Total assets	0,400	0,30	0,05
Current assets / Short-term liabilities	3,300	2,50	2,10

Source: Beaver, W. 1966. Financial Ratios as Predictors of Failure.

According to Beaver, two of five above mentioned indicators best predict the future financial development, namely cash-flow/foreign capital, and net profit/ total assets (indicator ROA), because of lower percentage of incorrectly classified companies in case of these two indicators. In case of uni-dimensional discrimination analysis, we should pay more attention to selection of indicator with good distinguishing ability evaluated according to median test, graphical comparison of median values. Kočišová and Mišanková (2014) state simplicity that doesn´t require statistical knowledge as the major advantage of uni-dimensional discrimination analysis. On the other hand, methods of uni-dimensional discrimination analysis show many more disadvantages and as such, they haven´t been frequently applied in the business practice. They were criticized for their weak points, namely ambiguity of financial development prediction, and we should also bear in mind that some indicators can correctly predict financial development only together with other indicators (Spuchláková and Frajtová Michaliková 2016, Úradníček *et al.* 2016, Delina and Packová 2013, Gissel *et al.* 2007). Beaver stated that application of a few proportional indicators can show higher prediction ability than of a single indicator, and this started the new era of prediction models development (Gissel *et al.* 2007). Accordingly, methods of uni-dimensional discrimination analysis were developed, including more indicators in a company development prediction, and representing simple characteristics of corporate activity. Importance weight is allocated to the indicators, eliminating the deficiencies of uni-dimensional discrimination analysis methods (Delina and Packová 2013, Hiadlovský and Kráľ 2014), while the corporate prosperity is assessed in this method on basis of synthetic parameter calculation.

Altman (1968) has been considered a founder and most recognized representative of the uni-dimensional discrimination analysis. Methods of the uni-dimensional discrimination analysis represent the most frequently used way of corporate financial health prediction worldwide. Subsequently, a few economists and analysts (*e.g.* Taffler 1984, Springate 1978, Fulmer 1984, Neumaierová and Neumaier 1995, Grunwald 2001) developed the methods of financial position prediction that passed a few development stages and were verified in specific conditions of

national or local economies, respectively (*e.g*. Antunes, Ribeiro and Pereira 2017, Barreda *et al.* 2017, Singh and Mishra 2016, Pawelek, Pociecha and Baryla 2016). We used to meet so called modified prediction methods within V4 countries, resulting from major process of transformation that these countries passed through. The Hurtoš´s rating model, the Gurčík´s index, CH-index and Binkert´s discrimination analysis represent the models developed for the needs of Slovak companies. Along the other ones, prediction methods include also logit and probit models (*e.g*. Ohlson´s model, Zmijewski´s model, Jakubík and Teplý´s model, and Virag and Hajdu´s logit model).

3. Methodology

As we stated above, the article purpose is to test the differences of predictive (narrative) ability of 10 prediction methods on the sample of 20 agricultural subjects. Taking in account the sample nature, we decided to focus on ten methods which are used also by *e.g*. Jenčová *et al.* (2017) or Horváthová and Mokrišová (2018), as follows:

- Kralicek Quick test (hereinafter referred to as the „QT“);
- Altman´s Z-score (hereinafter referred to as the „ALT“);
- Beerman´s function (hereinafter referred to as the „BEE“);
- Index bonity (hereinafter referred to as the „IB“);
- Taffler´s model (hereinafter referred to as the „TAFF“);
- Index IN01 (hereinafter referred to as the „IN01“);
- CH Index (hereinafter referred to as the „CHI“);
- Gurčík´s index (hereinafter referred to as the „GUR“);
- Ohlson´s model (hereinafter referred to as the „OHL“);
- Zmijewski´s model (hereinafter referred to as the „ZMI“).

These methods were classified in three categories:

1. most frequently applied prediction methods in business practice (Quick test, Altman´s Z- score, Beerman´s function, Index of Financial Standing, and Taffler´s model). This group of methods also refers to generally recognized prediction methods;
2. prediction methods from V4 countries (Index IN01, CH Index, and Gurčík´s Index). Applying the prediction methods, one should take in account that these methods were developed in a different environment and are based on data from specific financial, legislative and information environment. This environment significantly differs from the environment where business countries from V4 countries perform. We used to meet modified prediction methods in these countries since their economy had passed major transformation process. This category includes also CH Index and Gurčík´s Index that were developed just for the needs of agricultural companies;
3. classification models (Ohlson´s model, Zmijewski´s model). Classification models include *e.g*. logit a probit models, decision trees and random forests. We decided to use the Ohlson´s model and Zmijewski´s model referring to the logit and probit models. We applied these models since they show much higher prediction ability compared to standard prediction models (multidimensional discrimination analysis).

Within the chosen models verification, it is very important to choose proper criterion of companies´ classification to the prosperous and non-prosperous ones. We can find various criterions in professional literature serving to classification of companies to the prosperous and non-prosperous ones. Problem of a suitable criterion is more than questionable and we should realize that a single universal criterion of a non-prosperous company that could be applied generally cannot be clearly identified.

We specified the term of non-prosperous company based on the Slovak and Czech authors since economic, legislative and business environment of country hugely impacts upon particular criterions choice. In case of some authors (*e.g*. Fedorova *et al.* 2013, Ashoori and Mohammadi 2011, Úradníček *et al.* 2016, Mendelová and Bieliková 2017, Klieštik *et al.* 2018), we can see that legislative specification of a company bankruptcy refers to criterion of a non-prosperous company.

Bieliková, Cút and Úradníček (2014) stated three following criterions to which a company can be considered a non-prosperous company:

- legislative definition of a company in prolongation in the Slovak Republic: a company is in prolongation if they are obliged to keep the books in compliance with special regulations, they have more than one creditor and their liabilities exceed the amount of assets; *i.e.* their equity is of minus value;
- non-prosperous company is such a company that reported loss during two consecutive years;
- non-prosperous company is such a company that doesn´t reach profit and its sales cost effectiveness (ROS) is negative, and total liquidity is lower than one (Šnircová 1997 also referred to such criterion).

Boďa and Úradníček (2016), Kráľ *et al.* (2016) work with three criterions – negative value of registered capital and final profit/ loss (EAT), as well as total liquidity lower than one. Valasková, Kieštik and Kovačová (2018) and also, Valaskova *et al.* (2018) consider non-prosperous companies as those whose proportion of registered capital to total liabilities is lower than 0.04, total liquidity is lower than one and the company reached loss.

Two conditions had to be met in the presented contribution to classification of a company in the group of prosperous or non-prosperous companies, namely EVA indicator value and value of business indicator. At first, we monitored EVA (economic added value) indicator of companies that represents summary characteristics of company performance (Neumaierová and Neumaier 2016, Šofranková *et al*. 2017, Čámská 2016, Neumaierová and Neumaier 2013, Mičudová 2013, Maňasová 2008). Business subjects reaching EVA indicator value higher than zero during period of years 2012-2015 were included in the group of prosperous companies. Companies reaching EVA indicator value lower than zero during period of years 2012-2015 were included in the group of non-prosperous companies., Along with indicator EVA, we monitored the Business Index value varying within A+++ (financially stable company) and FX (financially unstable company). Sample of prosperous companies analyzed by us reached Business Index within A+++ and B. Sample of non-prosperous companies analyzed by us reached Business Index within E and FX. The ten selected methods were verified on the sample of companies from year 2014, which was a year before their bankruptcy in case of non-prosperous companies in 2015. Based on set out criterions and available data, we compiled a sample of 20 agricultural companies. In the presented article, we refer to equal number of prosperous and non-prosperous companies; such approach was applied also in the work of Beaver (1966), Altman (1968) and others, *e.g.* Bieliková *et al.* (2014) and Amendola (2011).

We should take in account that we interpreted prediction methods verification as testing of correct classification of company; *i.e.* based on prediction method, prosperous companies were classified as prosperous ones and non- prosperous companies were classified as non- prosperous ones. Error type I. (error alfa), error type II. (error beta), and overall accuracy can be calculated within the prediction methods verification.

Table 2. Error type I and error type II

	Prediction-bankruptcy	Prediction-non-bankruptcy
Fact-bankruptcy	The correct result (TP)	Error type I (FN)
Fact-non-bankruptcy	Error type II (FP)	The correct result (TN)

Source: According to Klepáč, V., Hampel, D. 2017. Predicting financial distress of agriculture companies in EU.

Error type I – proportion of incorrectly classified companies in bankruptcy (false negative rate):

$$\text{FNR} = \frac{FN}{TP+FN}. \tag{1}$$

Error type II – proportion of incorrectly classified prosperous companies (false positive rate):

$$\text{FPR} = \frac{FP}{FP+TN}. \tag{2}$$

Overall accuracy - proportion of correctly classified companies:

$$\text{ACC} = \frac{TP+TN}{TP+TN+FP+FN}. \tag{3}$$

As already stated, classification of subjects in two groups – the prosperous and the non-prosperous ones – represented the precondition of the analyses below. Such classification is considered an axiom, *i.e*. it is not subject to further examination.

3.1. Applied mathematical-statistical methods

The following set of mathematical – statistical methods was applied to objectification of results obtained:

1. Shapiro-Wilkov test for identification of standard results distribution:

$$SW = \frac{(\sum u_i x_i)^2}{\sum u_i^2 \sum (x_i - \bar{x})^2} \tag{4}$$

where: u_i – constant, x_i - value of *i*-th statistical unit, $\bar{x}$ - average value of variable.

2. Kolmogorov-Smirnov test for comparison of distribution function of results:

$$D_{n_1,n_2} = \underset{-\infty < x < \infty}{sup} \left| F_{1,n_1}(x) - F_{2,n_2}(x) \right|, \tag{5}$$

where: $F_{1,n_1}(x)$ - empirical distribution function of first selection; $F_{2,n_2}(x)$ - empirical distribution function of second selection.

3. Kendall coefficient for identification of linear correlation between particular models´ results,

$$r_K = \frac{n_c - n_d}{n(n-1)/2} \quad (6)$$

where: n - number of observations of pair of variables; n_c - number of discordant pairs; n_d - number of concordant pairs.

4. Mann-Whitney test for identification of results´ median.

$$U' = n_y n_x \frac{n_y(n_y+1)}{2} - R_y, U = n_y n_x - U' \quad (7)$$

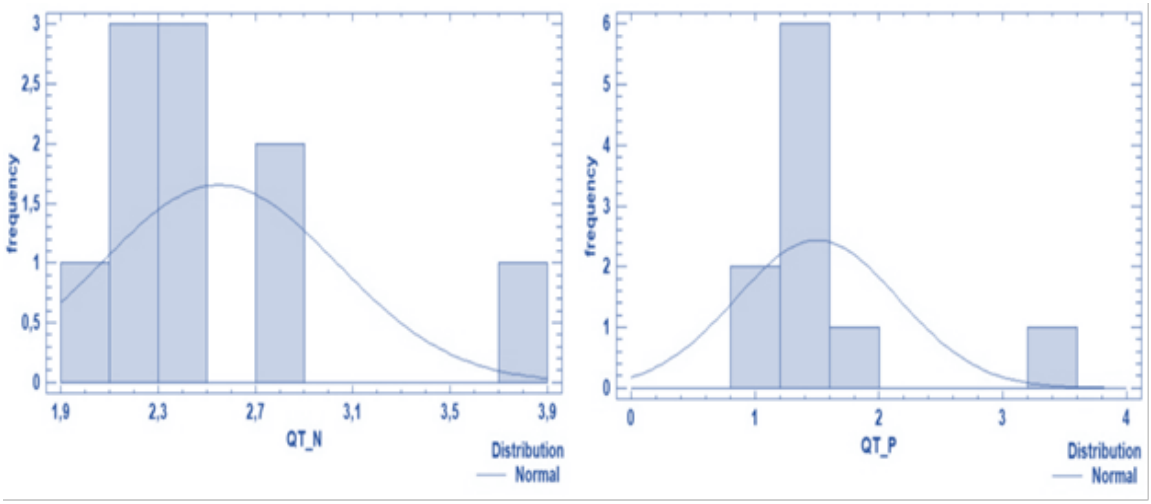
where: n_x - number of x-th sample observations; n_y - number of y-th sample observations; R_y - sum of y-th sample order; U, U´ - test criterion.

Particular analyses were processed in MS Excel, Statistica and Statgraphics software.

4. Results and discussion

Resulting from the above-stated findings, we can state that the differences between particular models are significant from methodological (as stated in the theoretical section of the article), and also narrative point of view. Accordingly, we decided to test these differences on the research sample of 20 subjects whose classification in two groups, *i.e.* group of prosperous subjects and group of non-prosperous subjects, can be found above. Total 10 models of financial analysis were tested (see the methodology), where Figure 1 depicts the absence of standard results distribution, as well as results of the Shapiro-Wilkov test (SW_N = 0.809, p = 0.019; SW_P=0.674, p < 0.001).

Figure 1. Verification of standard results distribution QT



Source: Own preparation.

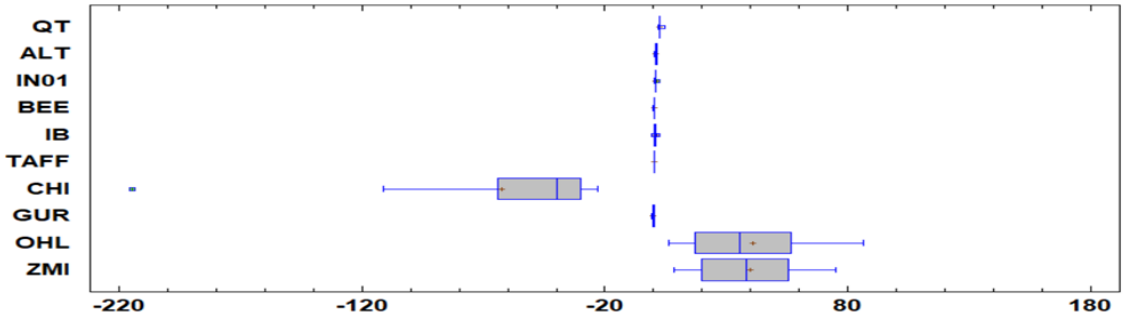
It resulted in the use of non-parametrical set of mathematical – statistical tests that were applied in the following cases:

- comparison of results within particular company groups,
- comparison of the pairs of subjects within particular financial analysis´ models.

4.1. Comparison of results within particular company groups (non-prosperous/prosperous)

Since the prediction methods were primarily intended for the needs of no-prosperous companies facing a crisis, we consider comparison of results in the group of non-prosperous companies as of primary importance. With regard to variability, we can classify the results of non-prosperous companies in two groups. The first group includes the models CHI, OHL and ZMI whose variability expressed through variation interval or standard deviation is high. Interestingly, both classification models are present in this group. The remaining part of the models is balanced, considering this classification; indicating minimum differences between complex results (Figure 2).

Figure 2. Box plot of non-prosperous companies´ results



Note: *two extreme values were removed (results of two companies) for better illustration
Source: Own preparation.

We can see major differences in the structure of results of particular financial analysis models in this company group (Table 3). Structure of results in the Beerman model was statistically equal to results of 4 models (ALT, IN01, TAFF, and GUR). The same equality can be found only in three cases (IN01-ALT, GUR-TAFF, and OHL-ZMI). Statistically significant differences were confirmed in further two cases/ pairs, *i.e*. application of various models means also various distribution functions of the results.

Table 3. Comparison of distribution functions of non-prosperous companies´ results

	QT	ALT	IN01	BEE	IB	TAFF	CHI	GUR	OHL	ZMI
QT										
ALT	1									
IN01	1	0								
BEE	1	0	0							
IB	1	1	1	1						
TAFF	1	1	1	0	1					
CHI	1	1	1	1	1	1				
GUR	1	1	1	0	1	0	1			
OHL	1	1	1	1	1	1	1	1		
ZMI	1	1	1	1	1	1	1	1	0	

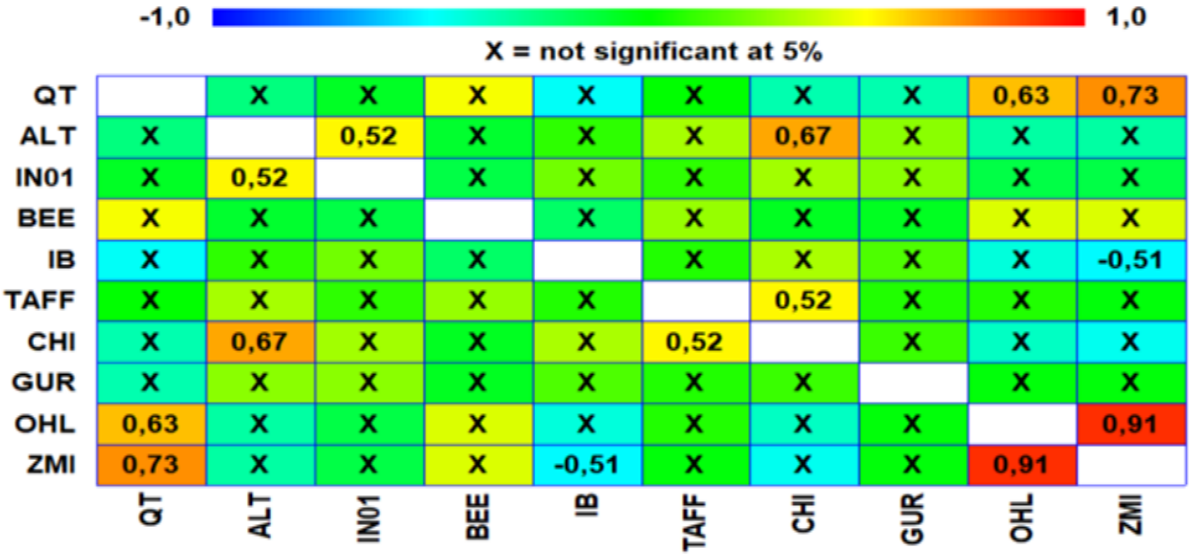
Note: 1 – different, 0 – equal
Source: Own preparation.

Results of particular models affect each other linearly with model ZMI reaching the worst result, significantly correlating to further 3 models´ results (QT, IB, and OHL). If we analyzed prediction ability in case of Zmijewski model only in the group of non-prosperous companies, the Zmijewski model would demonstrate 70% error type I. Accordingly, we can conclude that the Zmijewski model would cause huge problems to a company if it failed to identify potential financial problems in time and classified the company as the prosperous one, or not endangered by bankruptcy. In this light, model BEE is completely independent since no statistically significant correlation has been proved for it if combined with another model (Figure 3).

Comparing the variability of prosperous companies´ results, it is impossible to unambiguously identify the groups of models with high or low variability. Based on Figure 4, we consider variability of results equal or affected in isolated cases by accompany expressed itself as an outfield fortress or outfield value.

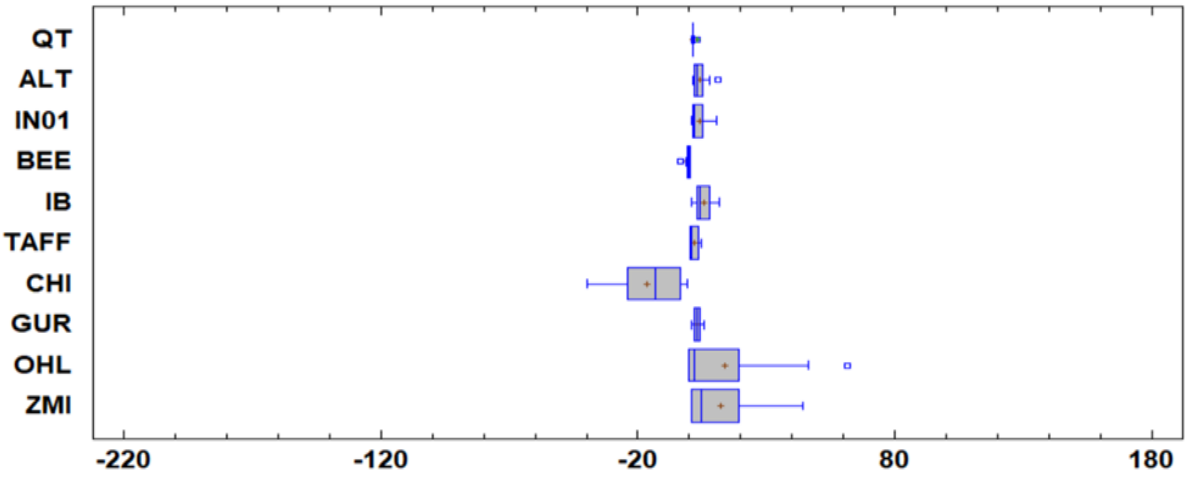
Significant overlay of distribution functions is illustrated in the Table 4 indicating different distribution function primarily of CHI model whose result structure showed statistically significant difference, compared to all the remaining models. On the contrary, CHI model result structure was the only difference in case of model OHL.

Figure 3. Correlation matrix of non-prosperous companies´ results



Source: Own preparation.

Figure 4. Box plot of prosperous companies´ results



Note: *two extreme values were removed (results of two companies) for better illustration
Source: Own preparation.

Table 4. Comparison distribution functions of prosperous companies´ results

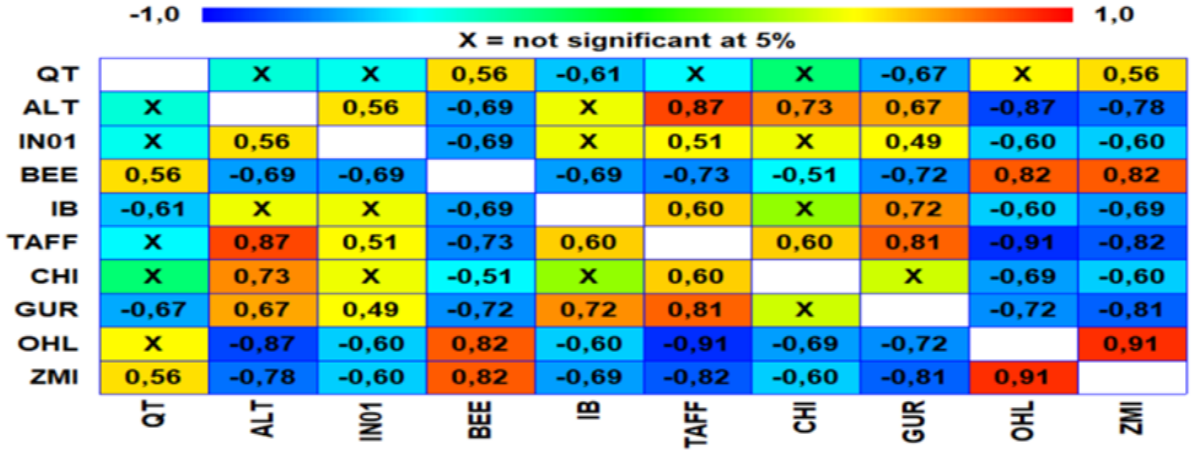
	QT	ALT	IN01	BEE	IB	TAFF	CHI	GUR	OHL	ZMI
QT										
ALT	1									
IN01	0	0								
BEE	1	1	1							
IB	1	0	0	1						
TAFF	0	1	0	1	0					
CHI	1	1	1	1	1	1				
GUR	1	0	0	1	0	0	1			
OHL	0	0	0	0	0	0	1	0		
ZMI	0	0	0	1	0	0	1	0	0	

Note: 1 – different, 0 - equal
Source: Own preparation.

Compared to the group of non-prosperous companies, this group is characterized with high number of confirmed negative correlations (see Figure 5). In such cases, we can state that evaluation improvement through

OHL model shall cause worse evaluation through models ALT, IN01, IB, TAFF, CHI, GUR, and BEE and concurrently it shall support the evaluation through model ZMI.

Figure 5. Prosperous companies´ results correlation matrix



Source: Own preparation.

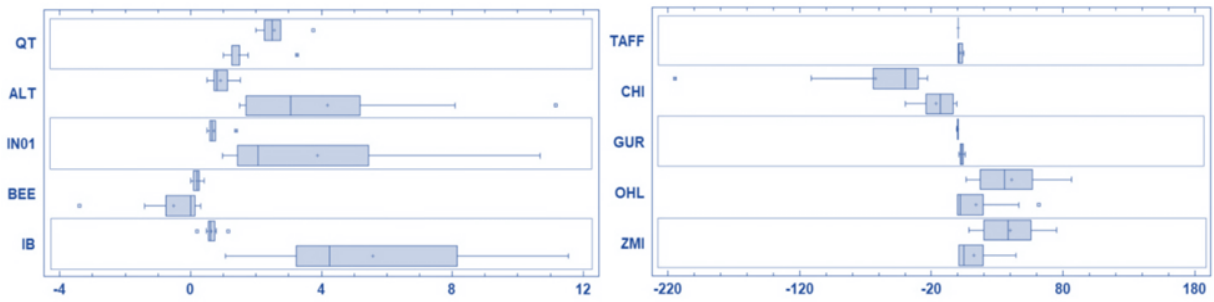
The above stated analyses point to significant differences in evaluation of prosperous and non-prosperous companies. The differences are apparent in the results structure/ distribution function, variability, as well as mutual linear correlations.

4.2. Comparison of subject pairs within particular financial analysis models

In the previous section, we dealt with groups of prosperous and non-prosperous companies and result of particular models within these groups.

Figure 6 depicts the differences in momentum characteristics expressed in the box plot aimed at pointing out the differences on individual level of the used models.

Figure 6. Box plot of prosperous companies´ results



Note: * two extreme values were removed (results of two companies) for better illustration
Source: Own preparation.

Graphical differences (Figure 6) were confirmed also during testing of median and distribution function of the results. Difference in medians was confirmed in each of the used tests. Distribution function didn´t change statistically significantly except in case of models BEE and OHL.

Table 5. Comparison of results of particular models within both company groups

	QT	ALT	IN01	BEE	IB	TAFF	CHI	GUR	OHL	ZMI
K-S	1	1	1	0	1	1	1	1	0	0
M-W	1	1	1	1	1	1	1	1	1	1
MEDIAN	NON*	PRO	PRO	PRO	PRO	PRO	PRO	PRO	NON*	PRO

Note: * non-prosperous companies are better evaluated
Source: Own preparation.

Eight of 10 models demonstrated better results of prosperous companies. We assessed this fact negatively since comparing cost associated with I. error type and II. error type, it is apparent that I. error type is associated

with higher cost (Gavúrová *et al.* 2017, Kuo 2013, and Gissel *et al.* 2007). Two model, in particular model QT and OHL in absolute expression evaluate higher the non-prosperous companies, which is a positive outcome.

Conclusion

Financial analysis represents a significant and frequently used tool of business subject financial health evaluation in the 21st century. Considering the time aspect, we can classify financial analysis to retrospective financial analysis ex-post and methods of financial analysis prediction ex-ante. Examined prediction method subject matter has been largely controverted and discussed also on the academic grounds, and more attention should be paid to formulation of conclusions and general recommendations. It is necessary to consider time limitations of prediction methods resulting from dynamically developing economic environment, and increasing risk and uncertainty rate.

Gavúrová *et al*. (2017) identified two main facts that significantly influence reduction of narrative capability of prediction methods. First of them refers to the sample of Slovak companies. Majority of methods (*e.g.* Altman´s Z-score, or the Ohlson´s model) was developed with the sample of American companies, thus reflecting financial standing of particular business subjects. Therefore, we included the Gurčík´s index and CH-Index (primarily intended for agricultural companies and developed on the sample of Slovak companies) in the group of 10 analyzed prediction methods. Another major factor refers to time period in which the methods were developed and subsequently verified. Some of the prediction methods were developed in the 2nd half of the 20th century that was significantly different in the terms of industrial sectors and overall business activity conditions. Along with the above mentioned facts, we could generally summarize major limitations resulting from the application of prediction methods in the following points:

- predicting the financial situation, majority of methods doesn´t take in account current macroeconomic indicators (inflation, interest rates, *etc*.);
- the methods are capable of predicting bankruptcy in global*, i.e.* they predict financial situation but are not able to specify either the area or the way of bankruptcy process;
- particular coefficients are not recalculated on regular basis, thus prediction success rate can be lower just because of outdated coefficients (weights) since current social – economic environment is considered dynamically changing;
- applying these prediction methods, a problem can occur with interpretation of some indicators because of different accounting methods applied in the country of origin and country of application;
- prediction methods presume the same scenario of bankruptcy onset in all companies' subject to analysis.

Accordingly, results obtained from generally recognized prediction methods cannot represent 100% indicator and critical baseline for the future for financial management (as confirmed also by the analyses performed by us), thus it is necessary to treat them very carefully. In current situation, we used to see efforts for development of new prediction methods that are developed and tailored to particular local or national conditions of business subjects. Concurrently, Klieštik, Vrbka and Rowland (2018), Gundová (2015), Hiadlovský and Kráľ (2014) stated that prediction methods should be updated to be in compliance with current economic and financial conditions.

Valasková *et al.* (2018) pointed out absenting prediction method for the needs of Slovak companies that would reflect specific conditions of the Slovak business environment. Developers of current prediction methods could refer to their findings focused on identification of statistically significant input ratio financial indicators. It resulted from our previous research work that if we focused on the sample of 10 non-prosperous agricultural companies, assets /foreign funds, EBIT/assets, company performance/assets, sales cost effectiveness (Lesáková, Gundová and Vinczeová, 2018) would be the best ratio indicators identifying upcoming financial problems. What is interesting, the same three indicators were identified also in the work of Bieliková *et al.* (2014), where the authors added one more indicator of indebtedness - debt/asset. For purposes of the presented article, we evaluated 20 subjects divided in two groups – group of prosperous and group of non-prosperous companies. Based on the analysis of companies´ results in 2014, we can make the following conclusions:

- major heterogeneous variability and overall structure of results in the group of non-prosperous companies. It could result from specific industrial sector (agriculture that is significantly affected by external factor being weather) that the companies perform in. For this reason, we would presume that the Gurčík´s index and CH-Index will attain the best results;
- OHL model results can be replaced with ZMI model or vice versa in both company groups;
- major linear correlation of results in particular models in the group of prosperous companies that disallows its current application;
- inadequacy of using models QT and OHL in their absolute expression.

Above stated results should be understood within their limitations caused by the range of selection structure. In the future, we intend to eliminate this deficiency through increased number of analyzed subjects and subsequent verification of new results vs the above ones.

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Leadership and its Changes as a Result of the Economic Crisis

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Abstract:

We consider the economic crisis as a significant factor of change, affecting also individual management functions - planning, organizing, leading people, human resources, control and decision-making. The aim of our contribution is to examine the impact of the crisis on one of these functions, namely leadership in company management. We are dealing with changes in team leadership, competencies, and in the styles of leadership of people caused by the crisis. The statistical hypothesis is tested on the significance level of 0.05 with 115 foreign and domestic companies participating in the research and running their business in the Slovak Republic. Our research has confirmed the impact of the crisis on the increased emphasis on ethical leadership.

Keywords: leadership; economic crisis; ethical leadership; management functions

JEL classification: D70; M16

1. Introduction

Current theory and practice are based on years of a proven and widely used system framework that divides the structure of management into several basic functions. In modern management theory, the division into the following functions is still used: planning, organization, decision making, human resources, management and control. This basic or detailed breakdown is very useful because it offers a solid structure into which new insights can easily be incorporated. The content of the features is constantly evolving and responding to changing environmental conditions. One of them is also the crisis, which is a milestone, the sudden disruption of the operation of an enterprise. Economic crisis, recession, stagnation, decline - these are the concepts that are still discussed in the mass media, while at the same time, they raise considerations among the recipients, or concerns over the future. (Zuzčák and Štofková 2010) The economic crisis has brought a large number of enterprises into crisis situations, which have resulted in their fundamental or existing changes in their current functioning. The changes made can also be seen in management functions.

The misconception of overcoming an economic crisis lies not only in reducing costs, increasing efficiency and productivity of the enterprise. As Burger (2009) asserts, it is necessary to focus on the future, to better estimate the situation, not to remain in a "waiting strategy to overcome a crisis", to predict more effectively, to make more effective and more pointed decisions, provide more motivating incentives to employees, more convincingly influence the attitudes of the subordinates, to change/adapt the method of managing the enterprise in the long run,

to apply new management methods that require multiple forms of knowledge acquisition, training activities, and so on.

In addition to the negative consequences, an economic crisis also presents new challenges, stimuli, the need for new solutions and changes in the functions themselves. The literature offers a number of analyses and assessments of the impact of the global economic crisis on various macroeconomic indicators. However, these studies address issues related to impacts on the management process only to a very limited extent. This issue is largely absent in our conditions. As a result, there is a research gap on which we have focused in our research. This article deals with leadership and its changes caused by the crisis. We deal with changes in team leadership, competencies, and in the styles of leadership of people caused by the crisis.

2. Literature review

Business managers are looking for the basics and lessons learned from the global economic crisis in the current, post-crisis period. And the just lingering crisis has highlighted the issue of leadership. According to Mako (2012), it is expected from leaders that in a time of crisis when employees are more controlled by fears and emotions, they will struggle with the current situation, courageously face the unfavorable situation, be able to communicate business challenges clearly and comprehensively, demonstrate confidence, thereby mobilizing internal resources. Many of us might think that the style of leadership is not so important in times of crisis, and the emphasis is of course, placed on greater directivity in governance, which is justifiable during a recession (Fenert and Cevik 2015). The exact style of leadership is indeed an important motivating factor in staff management. There is more than a need for a conscious leadership style in a crisis and post-crisis period that is able to follow trends, apply them, work with intuition to address new, untraditional, rare tasks, motivate employees through vision and so on.

At present, leadership in form of heroic leadership is abandoned and approaches facilitation (Bjørnå and Mikalsen 2015, To *et al.* 2015), where leaders create space and conditions for their employees to make their own choices and assume their own responsibility. In the context of the preferred style of leadership, the expression Participative Management is associated in the literature (Fener and Cevik 2015). Another trend in leadership in our conditions is the “leadership through vision” paradigm. (Hefti and Levie 2015, Friedman 2009) The economic crisis has allowed new leaders to emerge (Illies 2014, Fener and Cevik 2015), and real talented people have emerged from the ranks of employees. (Schuler *et al*. 2011). In connection with the current leadership, there are often inflected expressions - ethic, (Stouten *et al.* 2013, Zhu *et al*. 2015) character (Wright and Quick 2011), responsibility and maturity (De Hoogh and Den Hartog 2008).

The global economic crisis has resulted in the cessation of the business of several companies, uncovering the unethical behavior and decision-making of some leaders. They were talented, ambitious and charismatic leaders. However, the crisis highlighted the weaknesses of many uncritically “exalted” managers. Sloppiness, irresponsibility, greed, lavishness, fraud - these are the characteristics of managers who have committed themselves to the crisis (Ljudvigová 2014). The company was more focused on the assessment of leaders for this reason, not based on the company’s results, but the decisive view was on their moral profile, the satisfaction of their subordinate workers, or success in the formation of followers. (Bedrnová and Nový 2007)

The requirements for good behavior and management of managers are currently one of the main leadership priorities for several business leaders. This is confirmed by the results of the episodic research conducted in 2011-2012 by the University of Economics in Bratislava in cooperation with the Kingfisher Executive Search Personnel Agency, as part of the “Leadership in Companies in Slovakia" research project. The main purpose of the research was to find out how leaders are perceived by their subordinates. The results showed that for employees, leaders are characterized by directness, openness, honesty as well as morality and consistency. The demand for good behavior and leadership is one of the urgent needs in practice. (Ljudvigová 2014)

Ethical leadership is currently a phenomenon in leadership. This is due to the numerous instances of irresponsible, unethical, and unprincipled behavior in leadership positions in recent years. According to Ljudvigová (2014) the consequences of the crisis we feel are not the consequences of the economic crisis, but the crisis of relationships, morality and character (Hein *et al.* 2011). Several foreign authors address issues of ethical leadership (De Coninck 2015, Zhu *et al.* 2015, Gils *et al.* 2015, Piccolo *et al.* 2010, Johnson and Shelton 2014).

An important element in current leadership are three theories: serving (Zou *et al*. 2015), spiritual (Li – Yi 2013) and authentic leadership (Waite *et al.* 2014) The most prominent common feature of these theories is the increasing emphasis on ethical aspects in leadership (Ljudvigová 2013) and the reinforcement of the internal motivation of the followers. (Ljudvigová 2015) It is not possible to speak literally about trends since the problems of defined theories were known already in the 1980s, but today we are witnessing fruitful discussions on this topic.

The basis of serving leadership is that it is a natural feeling to serve someone, in other words, the leader must serve to know how to lead. (Dourado 2008) The concept of spiritual leadership emphasizes the reinforcement of the internal motivation of the followers (employees) by creating appropriate working conditions that emphasize the inner meaning of work to them (Yukl 2010) Leadership points to the need of doing meaningful things and finding a deeper sense in the manager's work. Authentic leadership describes an ideal leader who has a high degree of self-awareness in terms of their values, beliefs, feelings and abilities as well as a degree of self-acceptance similar to emotional maturity. The policy of authentic leadership attempts to integrate ideas of effective leadership with theories of ethical leadership. (Ljudvigová 2013)

Ljudvigová (2015) states that meaningful work; autonomy and interpersonal relationships at the workplace are important indicators of employee engagement and the subsequent development and success of enterprises. That is why managers should at this time highlight the sense of meaningful work to the employees, internally motivate them, or give them a sense of belonging to management. Due to the definition of new elements of current leadership in enterprises, new leadership requirements need to be identified. It creates an abstraction away from the "lonely leader with exceptional qualities and skills" and vertical leadership from the top down, and a common (team or rotating) leadership that uses the knowledge, ideas and abilities of all team members becomes the centerpiece of the attention (Fenert and Cevik 2015).

Table 1 provides an overview of the changes in the pre-crisis and crisis periods in leadership on the basis of obtained theoretical information.

Table 1. Comparison of changes in the pre-crisis and post-crisis period

Leadership in pre-crisis period	Leadership in post-crisis period
• Leadership based on one "solitary" leader • Directive/authoritative style of leadership • Unethical behavior and leadership decisions • Top-Down leadership • Leader - intelligence, initiative, good health, origin from the upper middle class	• The impact of the economic crisis has led to the issue of leadership (the crisis of relationships, morality and character); • Team (rotating) leadership; • Facilitating leadership style - Participative Management; • Emphasis on the moral profile of the leader, *i.e.* the ethical aspects of the leadership and the reinforcement of the internal motivation of the followers; • Bottom-Up leadership; • Leader - directness, openness, morality, ethical and professional qualities.

Source: Own compilation

3. Methodology

To obtain the desired results we have used the empirical method of observation using a questionnaire survey. The questionnaire was distributed by electronic communication at the beginning of October 2016, whereby data collection was completed in February 2017. 117 questionnaires have been included in the research sample, of which 2 did not meet the relevant completeness, due to which they were not included in the survey.

Targeted segment of our research was randomly chosen Slovak and foreign enterprises running their business in Slovak republic whereby respondents were members of higher management. The total number of distributed questionnaires was 370 and the return rate was 31%. Inductively-deductive methods, descriptive methods, one-dimensional, and two-dimensional descriptive statistics were used to analyze collected data. Statistical apparatus methods were used to test statistical hypotheses. Hypotheses were tested at the significance level of $\alpha = 0.05$. We have used following coefficients to verify the hypotheses: Chi-Square and Cramer's coefficient.

The analyzed enterprises were divided into three groups depending on the area in which they conduct their business activities in the market. The largest sample of our research samples was represented by manufacturing companies (41.70% or 48 enterprises), business (38.30% or 44 enterprises), and finally one-fifth of the enterprises belonged to the service sector (20% or 23 enterprises).

Table 2. Area of operation

Rating Criterion (area of operation)	Number of enterprises (in numbers)	Percentage (in %)
Production	48	41.70
Trade	44	38.30
Services	23	20.00
Total sum	115	100.00

Source: own processing

For the purpose of the closer characterization of the research sample, enterprises need to be characterized in terms of number of employees. On the basis of the evaluation criterion, large enterprises (33.90% or 39 enterprises) were the most dominant among all enterprises. On the contrary, micro-enterprises (16.50% or 19 enterprises) were the fewest. The structure of the research sample in terms of size is shown in Table 3.

Table 3. Enterprise size

Enterprise type	Rating Criterion (number of employees)	Number of enterprises (in numbers)	Percentage (in %)
Micro enterprise	up to 10	19	16.50
Small enterprise	10 – 49	26	22.60
Medium enterprise	50- 249	31	27.00
Big enterprise	over 250	39	33.90
Total sum		115	100.00

Source: own processing

The third evaluation criterion was the duration of the company's market presence. The research sample was dominated by long-established enterprises. Respondents (15 years and over) identified up to 67 enterprises (58.30%), representing more than half of all respondents. Other results within the evaluation criteria are shown in Table 4.

Table 4. Duration of operation

Rating Criterion (length of operation)	Number of enterprises (in numbers)	Percentage (in %)
15 years and over	67	58.30
10 – 14	27	23.50
7 – 9	13	11.30
3 – 6	4	3.50
less than 2 years	4	3.50
Total sum	115	100.00

Source: own processing

The economic crisis broke out in Slovakia at a time when our economy was at the height of the economic cycle. For this reason, we were interested in the impact of the crisis on the course of the economic development of the enterprises during the monitored period. The economic development in our understanding is the cumulative sum of turnover achieved in the given periods. The state of economic development during the monitored period is reported in Table 5.

Table 5. Economic development of enterprises

Rating Criterion (economic development)	Pre-crisis period		Crisis period		Post-crisis period	
	Number of enterprises (in numbers)	Share (in %)	Number of enterprises (in numbers)	Share (in %)	Number of enterprises (in numbers)	Share (in %)
Constant growth	40	34.78	9	7.82	20	17.40
Growth prevailed	64	55.65	42	36.52	61	53.04
Stagnation	8	6.96	45	39.14	24	20.87
Prevailing loss	3	2.61	18	15.65	9	7.82
Permanent loss	0	0.00	1	0.87	1	0.87
Total sum	115	100.00	115	100.00	115	100.00

Source: own processing

Of the analyzed enterprises, more than half of the majority in the pre-crisis period (until 2007) had economic growth assessed as predominantly growth (55.65% or 64 enterprises). Nearly two-fifths of enterprises admitted that they had sustained growth in the defined period (34.78% or 40 enterprises), 8 enterprises were stagnant, and only 3 enterprises characterized economic development as being loss-making instead.

In the case of the crisis period (2008-2011), it can be noticed that the enterprises started to exhibit elements of stagnation (45 enterprises), or they continued to document growth (42 enterprises); 18 enterprises suffered a major loss and 1 respondent reported a sustained loss in the problematic period.

During the post-crisis period (from 2012), we see an increase in the number of enterprises that have evaluated their development as compared to the previous period as a permanent growth or major growth. Affected

enterprises are slowing down from a crisis situation. When comparing boundary periods, *i.e*. pre-crisis and crisis, it is possible to observe a lower number of enterprises that are once again achieving sustainable growth and a more representative presence of stagnant enterprises.

The scientific articles in this field inform about the positive and negative impact of the crisis on entrepreneurial subjects. More than half of our respondents assessed the impact of the crisis as rather negative (52.20% or 60 enterprises). The second most frequent response was that the crisis had no impact on the performance of their business activity (39.10%, or 45 enterprises). Only 6 enterprises are convinced of the positive effects of the crisis, and 4 enterprises consider the effects of the crisis as very unfavourable.

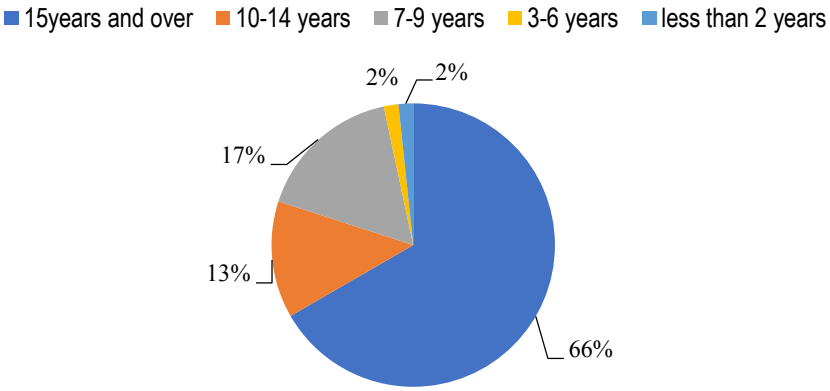
Table 6. The impact of the economic crisis on the enterprises

Rating Criterion (crisis impact)	Number of enterprises (in numbers)	Percentage (in %)
Very negative	4	3.50
Rather negative	60	52.20
Any	45	39.10
Rather positive	6	5.20
Very positive	0	0.00
Total sum	115	100.00

Source: own processing

More than half of our respondents are convinced of the negative effects of the economic crisis. Through a deeper analysis of respondents who identified the impact of the crisis as rather negative (60 respondents), we found that enterprises with a long-term existence in the existing market felt the unfavorable impact of the crisis (40 respondents). They account for more than 66% of the percentage. More about the negative impact of the economic crisis between enterprises is shown in Figure 1.

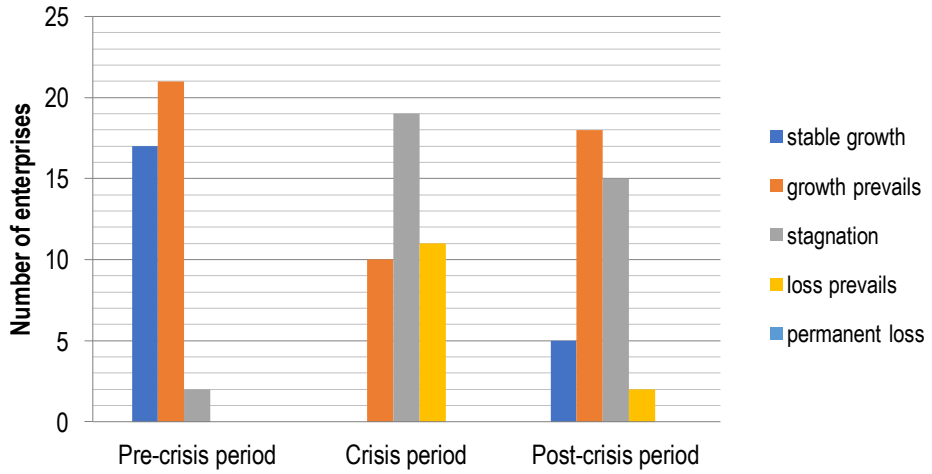
Figure 1. The negative impact of the crisis on the enterprises, taking into account the duration of existence on the market



Source: own processing

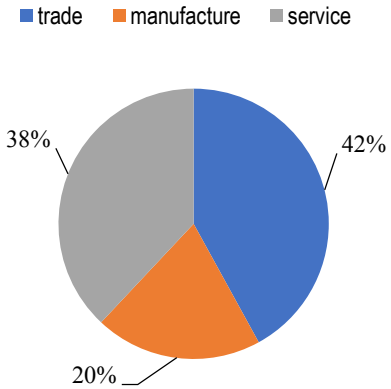
It is interesting that enterprises which have long been established, have not been able to make the most of the crisis despite their experience, but, on the contrary, were paralyzed temporarily, which proves a deteriorating economic development compared to the pre-crisis and crisis periods. In the crisis period, we observe a significant decline of enterprises that have grown compared with the pre-crisis period and the growth of stagnant enterprises or enterprises shown to be loss-making. The course of economic development in long-established enterprises is shown in Figure 2. Besides the negative impact of the crisis on the duration of the existence of the enterprises on the market, we were also interested in the impact of the crisis on the area of activity. Businesses (42%) and service enterprises (38%) dominated the gathered data. More about the negative impact of the economic crisis on the individual areas of action is shown in Figure 3.

Figure 2. The course of development in long-term established enterprises with a negative impact of the crisis



Source: own processing

Figure 3. The negative impact of the crisis on the enterprises, taking into account the operation area



Source: own processing

In the previous question, we found that the most sophisticated research sample characterized the impact of the economic crisis as rather negative. We were interested in the respondents' perception of the impact of the crisis in the individual management functions as well. In this assessment, enterprises have taken a more optimistic assessment. The impact of the crisis on management functions was characterized as partial or as none. Table 7 shows how enterprises estimate the impact of the economic crisis on management functions.

Table 7. The impact of the economic crisis on management functions

Rating Criterion (crisis impact)	Very		Medium		Partially		Not at all		Σ	
	Σ	%	Number	%	Σ	%	Σ	%	Σ	%
Planning	12	10.43	31	26.96	49	42.61	23	20.00	115	100
Organization	7	6.08	31	26.96	42	36.52	35	30.44	115	100
Decision making	4	3.48	35	30.43	43	37.39	33	28.70	115	100
Human Resources	11	9.56	25	21.74	38	33.05	41	35.65	115	100
Leadership	2	1.74	28	24.35	44	38.26	41	35.65	115	100
Check	5	4.35	31	26.96	36	31.30	43	37.39	115	100

Source: own processing

Leaders have said that team leadership is currently based on sharing the knowledge, ideas and capabilities of all team members. The results from our survey (see Table 8) point to the fact that there were more managers (56%) in the economic crisis who did not group their staff into teams. The rest of the respondents (44%) reinforced team building, team spirit and the principle of co-determination among employees. More and more managers are currently focusing on creating and optimizing teams. Our aim was to find out whether the increased interest in team building was the result of the economic crisis or not.

Table 8. The area of leadership during the crisis and today

	Stage of the evaluation				Σ
	1	2	3	4	
	Number of enterprises				
During the EC1 we put more emphasis on team building.	27	37	40	11	115
At present, we place emphasis on team building.	Yes		No		
	75		40		115
During the EC, the ethical aspects of leadership were highlighted.	17	31	50	17	115
At present, we focus on the ethical aspects of leadership.	Yes		No		
	68		47		115
The importance of employee engagement has grown over the EC.	10	21	60	24	115
At present, we place emphasis on employee engagement.	Yes		No		
	101		14		115

Note: 1 - completely disagree, 2 - partly disagree, 3 - partly agree, 4 - completely agree. *Source*: own processing

Our approach was as follows:

- Formulation of the zero hypothesis (H_0):

H_0: There is no contingency between the crisis and the post-crisis period in team building intensity;

- Formulation of an alternative hypothesis (H1)

H1: There is contingency between the crisis and the post-crisis period in team building intensity;

- Determination of significance level setting the level of significance at 5% (0.05);
- Calculation of test statistics a P – value, dividing point no. 4 into two parts:
  A. Verify at the significance level of 0.05 whether we can talk about the dependencies between periods and the level of team building. The calculation of the test statistics preceded the compilation of two auxiliary tables, see Table 9 and Table 10. The variables in the tables are as follows:
     - the line variable (a_1, a_2) are the monitored periods, in our case the crisis period and the present (r = 2);
     - the column variable (b_1, b_2, b_3 and b_4) are degrees of evaluation, where 1 - completely disagree, 2 - partly disagree, 3 - partly agree, 4 - completely agree (s = 4).

Table 9. Actual frequencies

O_{ij}	b_1	b_2	b_3	b_4	Σ
a_1	6	24	35	10	75
a_2	21	13	5	1	40
Σ	27	37	40	11	115

Source: own processing

Table 10. Theoretical frequencies

E_{ij}	b_1	b_2	b_3	b_4	Σ
a_1	17.61	24.13	26.09	7.17	75.00
a_2	9.39	12.87	13.91	3.83	40.00
Σ	27.00	37.00	40.00	11.00	115.00

Source: own processing

The squares of the deviations of the actual O_{ij} frequencies (Table 9) from E_{ij}'s theoretical frequencies (Table 10) were divided by the E_{ij} theoretical frequencies. The calculated values are shown in Table 11. By adding them in all the rows (i = 1, 2) and the columns (j = 1, 2, 3, 4), we obtained a square contingency (33.96).

Table 11. Chi-square

E_{ij}	b_1	b_2	b_3	b_4	Σ
a_1	7.65	0.00	3.05	1.11	11.81
a_2	14.35	0.00	5.71	2.09	22.15
Σ	22.00	0.00	8.76	3.20	33.96

Source: own processing

[1]EC - economic crisis.

We compared the calculated test characteristics with the 95th percentile x^2 divisions with (r - 1)x(s - 1) = (2 - 1)x(4 - 1) = 3 degrees of freedom, $x^2_{0.95}$ (3) = 7.815. Since the square contingency (33.96) exceeds the critical value, we can say that there is a significant dependence between the crisis and the post-crisis period and the level of team building. The intensity of team building is actually affected by the economic crisis.
There is a statistically significant dependence between the periods and the level of team formation at the significance level of 0.05. Point A was fulfilled.

B. Assess the degree of intensity of investigated dependence using appropriate measures. To assess the intensity of the contingency we used the Cramer coefficient, so-called Cramer's V, which has the following form:

$$V = \sqrt{\frac{x2}{n.h}} \quad (1)$$

We first calculated the average square contingency from:

$$\phi^2 = \frac{\chi^2}{n}$$

$$\phi^2 = \frac{33{,}96}{115} = 0{,}295 \quad (2)$$

The Cramer coefficient indicates the moderate dependence between the analyzed periods (crisis and post-crisis) and the rate of creation work teams. Hypothesis H_0 is rejected. Point B was fulfilled.

Table 12. Dependence of Cramer's coefficient

Coefficient used	Value
Cramer's coefficient	0.5434

Source: own processing

Several surveys, which we have already mentioned in the theoretical part of the thesis, have found that during the economic crisis, the ethical aspects of leadership – the responsibility and character of the leader – have been highlighted. Most of our respondents agree with the claim, and their number has been increasing in the current period.

According to theoretical sources, the crisis has manifested itself in the increased participation of lower organizational units in the enterprise. We have already confirmed our participation in management in decision making. In decision-making, we have found that business executives are now giving employees (even from lower levels of management) greater scope to be part of business decision-making processes. We have also confirmed this statement statistically, adding a statistically significant dependence between line and column variables. In the function of management – leading, we asked the respondents a similar question, *i.e.* whether the impact of the crisis has increased employee engagement. The results of the questionnaires clearly point to the fact that managers give their employees space to participate in management, and we are currently seeing an increase over the previous period. (see Table 8) In order not to retain the unconfirmed belief that the economic crisis has increased employee participation in management, we have decided to verify it statistically.

In Table 13 and 14, we compare the 2 sorting characters A and B, where:

- a_1, a_2 are the monitored periods, in our case the crisis period and the present;
- b_1, b_2, b_3 and b_4 are degrees of evaluation where 1 - completely disagree, 2 - partly disagree, 3 - partly agree, 4 - completely agree.

Table 13. Actual frequencies

O_{ij}	b_1	b_2	b_3	b_4	Σ
a_1	6	14	59	22	101
a_2	4	7	1	2	14
Σ	10	21	60	24	115

Source: own processing

When calculating the theoretical abilities (Table 14), the conditions for continuing the calculation of statistical dependence, or independence, were not fulfilled in three cases. For that reason, we could not go further, and we can only say that the growing interest in employee engagement is conditional on the onset and course of the economic crisis.

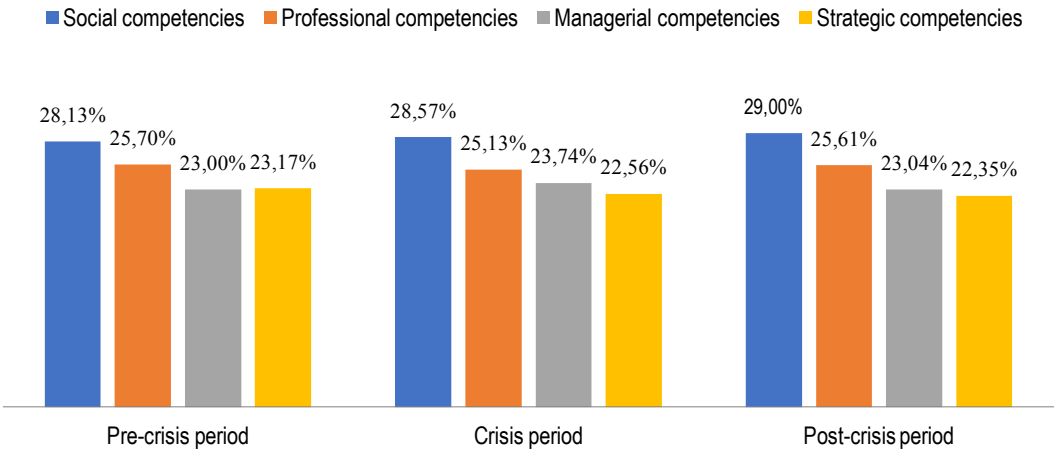
Table 14. Theoretical frequencies

Eij	b_1	b_2	b_3	b_4	Σ
a_1	8.78	18.44	52.70	21.08	101
a_2	1.22	2.56	7.30	2.92	14
Σ	10.00	21.00	60.00	24.00	115

Source: own processing

Managerial competencies are one of the key prerequisites for a successful business operation and especially in times of crisis. The economic crisis points to the importance of the communication skills of each manager, as part of his/her competencies to effectively lead and motivate employees who were more often subject to fears during the crisis period. Managerial competencies have also become the subject of our analysis.

Figure 4. Selected competencies in the monitored periods



Source: own processing

During all monitored periods, social competencies dominated the assessment, *i.e.* managers, regardless of the period in which they were located, were primarily supposed to know how to communicate, work on a team, and professionally solve conflicts and problems in the workplace. Managers awarded the competences on average 29% of 100%. Social competences, as the only one of the capabilities analyzed, achieves a steadily rising development during the monitored periods. Additional data (modus, minimum and maximum values) are reported by the respondents in Table 15.

Table 15: Modal, maximum and minimum values for social competencies

	Social competencies		
	Pre-crisis period	Crisis period	Post-crisis period
MODE	25	25	25
MAX	70	70	70
MIN	10	5	10

Source: own processing

Professional competencies, *i.e.* the ability to manage human resources, to control computer work, and to have language skills, according to our respondents, ranked second. On average, respondents identified 25% of 100% for all periods. Additional data (modus, minimum and maximum values) are reported by the respondents in Table 16.

Table 16. Modal, maximum and minimum values for professional competencies

	Professional competencies		
	Pre-crisis period	Crisis period	Post-crisis period
MODE	20	25	25
MAX	70	60	60
MIN	10	10	10

Source: own processing

Managers' competencies (*i.e.* leadership and team skills) and strategic competencies (*i.e.* the ability to strategically plan and think) have been allocated by our research sample at 23% of 100%. Strategic competencies have been ranked last in the ranking, except during the pre-crisis, when they scored higher as managerial competencies. Additional data (modus, minimum and maximum values) are reported by the respondents in Table 17 and 18.

Table 17. Modal, maximum and minimum values for managerial competencies

	Managerial competencies		
	Pre-crisis period	Crisis period	Post-crisis period
MODE	20	20	20
MAX	70	70	70
MIN	10	10	10

Source: own processing

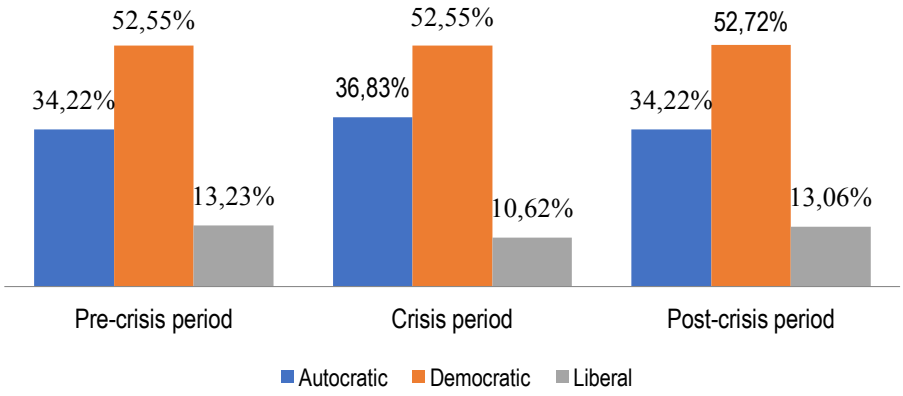
Table 18. Modal, maximum and minimum values for strategic competencies

	Strategic competencies		
	Pre-crisis period	Crisis period	Post-crisis period
MODE	25	25	25
MAX	70	70	70
MIN	0	0	0

Source: own processing

The aggregate results in Figure 5 are at a comparable level, and the impact of the economic crisis on individual competencies was only minimal in the observed differences. Managers' competence is the subject of several surveys globally.

Figure 5. The styles of leadership in the monitored periods



Source: own processing

Conclusion

The economic crisis has brought a large number of enterprises into crisis situations, which have resulted in their fundamental or existing changes in their current functioning. The changes made can also be seen in management functions. In our research we were aimed on examine the impact of the crisis on one of these functions, namely leadership in company management. Our research sample was created by 115 foreign and domestic companies running their business in Slovakia.

Our results confirmed, that there is contingency between the crisis and the post-crisis period in team building intensity. There is a statistically significant dependence between the periods and the level of team formation at the significance level of 0.05. In the crisis period, in which the managers found themselves, they required a different way of managing and leading their employees. A properly chosen leadership style becomes an instrument that encourages groups of motivated employees to attain personal goals and business goals at a time of crisis. Managers are expected to be more directors in the crisis. In our research sample, a democratic style with partial elements of autocratic style strongly dominated over all the periods under review. Higher authority can be noticed in the crisis period. After the passing crisis, managers once again decentralize their powers, which is evidence of a rising percentage in the case of the liberal style of leadership.

Acknowledgement

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Public-Private Partnership in the Field of Public Transport in the Czech Republic as Business Opportunities for Companies – Legal and Economic Aspects

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Abstract:

The paper is dealing with legal and economic aspects of Public Private Partnerships in the field of public transport. Public administration is obliged to provide public transport as a public service. This is the objective of this paper. The matter is governed by the Regulation (EC) 1370/2007 on the EU level on one hand and by the Act on Public Passengers Transport Services on national level on the other hand. The next objective is evaluation of economics of public transport in the selected region. The author examines effectiveness of public transport and using of competitive procedure in the European Union (member states). In some countries is supplier (company) selected in competitive way, is some countries are public subsidies on public transport given to individual companies.

Keywords: legal and economic aspects; public-private partnership; public administration; municipalities; companies; public transport accessibility; business aspects

JEL classification: H83; H77

1. Introduction

Provision of public transport accessibility can be considered as one of the basic public goods organized and/or provided by public administration. In the case of public goods and services the provision through unregulated market would not suffice for various reasons. These goods and services are therefore provided by various public authorities (*e.g.* through public procurement, through implementation of public-private partnership projects or by awarding service concessions) and are financed or co-financed from the system of public budgets (Dunn 2000, Jackson and Brown 2003, Jurčík 2014, Jurčík 2016, Stiglitz 2000).

Existing transport infrastructure, transport services supply in the region or the accessibility of the region, are listed among the most important factors that influence the development of individual regions. Inadequate transport infrastructure and the absence of related transport services hinder economic growth of any region (Graham 1998, Cidell 2006). The matter of public transport accessibility is mostly studied by the academics focused on transport geography, regional sciences, spatial development and related fields. Issues of regional disparities in rural transport services, importance of transport accessibility for development of certain areas or the question of impact of the lack of transport accessibility on the functioning of municipalities and the lives of their inhabitants are addressed quite frequently within this field of study (Geurs and van Wee 2004, Marada and Květoň 2010a, Marada and Květoň 2010b, de Stasio, Fiorello and Maffii 2011). The content of this paper complements the abovementioned approaches with another view which is focused on the very provision of certain public services by public administration, respectively on assessment of the effectiveness of public expenditure on the example of public transport accessibility.

The concept of public transport accessibility can be defined in various ways. Given the focus of this paper on the Czech public administration and financing of public transport accessibility the definition given by the Act No. 194/2010 Coll., on public passenger transport services and amending other Acts, as amended is used. Public transport accessibility in accordance with this Act refers to "securing transport every day of the week, especially to get access to schools and educational institutions, to the public authorities, to work, to health facilities providing basic health care and to meet the cultural, recreational, and social needs, including transport back, contributing to

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the sustainable development of the giver territory". The burden of transport provision by different modes of transport (mainly bus and railway) is given to the state, regions and municipalities. These entities provide necessary finance for transport services as purchasers of public passenger transport services with specific private carriers. The expenditure covers either the reclaimable loss of the carrier or subsidies for everyday operation (Jurčík 2014, 2016).

Expenditures on the provision of public transport accessibility are considered to be a part of public expenditures. Quite a large number of evaluation methods and mechanisms are used for their assessment, supervision and monitoring (Berglas and Pines 1981, Filippini and Prioni 2003, Murray 2001, Pina and Torres 2001, Roy and Yvrande-Billon 2007). One of the applicable methods is also the analysis of expenditure effectiveness sometimes also referred to as cost-effectiveness analysis (Ochrana 2006, Tetřevová 2008, Stiglitz 2000). The importance of a new paradigm with an attitudinal change of the competent individuals from short-term thinking – that is very typical for contemporary western world – to long-term planning taking into account also the environmental protection emphasized for example Dundelová (2013), Blatter *et al.* (2018), and Budzinski (2018).

2. Research background and methodology

The first objective of this paper is to analyze the relatively new legislation on awarding public transport contracts in the area of passenger transport. The matter is governed by the Regulation (EC) 1370/2007 on the EU level on one hand and by the Act on Public Passengers Transport Services on national level on the other hand. There are three types of awarding public services contracts: tender procedure under Directive 2004/18/EC and relevant national legislation; special competitive tender procedure; direct award.

The Czech legislator decided not to use the possibility to exclude the tender procedure for bus or tram transport concessions within the transition period of ten years under Art. 8(2) of the Regulation (EC) 1370/2007. This regulation contains regular tender procedure and the special competitive tender procedure under the Act on Public Passenger Transport Services a financing these services whose regulation is important (Oplotnik, Brezovnik, Vojinovic 2012). They also consider some new possibilities provided by the legislation in question, *i.e*. transfer of employees stipulated by the EU Regulation and obligation of the new operator to purchase the vehicles used by the previous operator. Based on this regulation was passed the Act No. 194/2010 Coll., on public passenger transport services and amending other Acts, as amended. New legislation of public passenger transport services in the European Union in 2007 has been determined by several important factors. The European Community, in whose jurisdiction the common transport policy (Article 3 point f) of the EC Treaty, now analogous provisions in Article 4 Sec. 2 point g) EC Treaty, TFEU) and regulatory powers (Art. 71 of the EU Treaty, now Article. 91 of the Treaty on the Functioning of the EU) has decided to unify generally quite fragmented legislation procurement services for the transport of passengers and providing compensation.

Some Member States or regions deregulated their transport market by largely opening to competition and procurement services. In some countries there is transport service under transparent open tenders (United Kingdom). In a system where is, although more or less, maintained a system of exclusive rights or compensation is paid from public sources and where free competition in the market of transport services is limited, these exclusive rights are granted on the basis of tenders. Other countries and regions have any competition in the public transport sector and virtually ruled out the possibility of local authorities in the organization and procurement of transport services which are virtually limitless. This was seen as an obstacle to improving efficiency and quality. In this situation, the European Community decided to "regulated competition" as a minimum standard, that Member States should be given the flexibility to establish the full deregulation of the sector. From above mentioned we can see important of European Union regulations (Radvan 2014, Oplotnik, Vojinovic and Acharya 2011).

Content of regulation is particularly conditioning essential attributes of public service contracts to be concluded between the competent authority in whose competence is the provision of transport services, and the carrier if the carrier is to be granted the exclusive right and / or compensation (Art. 3 and 4). Further regulation governs compensation [Art. 4 paragraph. 1 point. b), Art. 6 and Annex to Regulation]. An important part of the regulation is to determine how to select carriers for the conclusion of public service contracts (Art. 5). Finally, the regulation also regulates and ensures publicity and transparency in the award of public services and the provision of compensation (Art. 7) and the right of appeal and judicial protection in the context of the conclusion of public service contracts (Art. 5 par. 7). Also of importance is Art. 8, which as a result of certain compromise regulates long transition period (10 years) during which the Member States have gradually taken measures to bring them into line with Art. 5 of the Regulation. Thus, although the regulation as a whole entered into force in accordance with Art. 12 of December 3, 2009 its flagship Article. 5 until September 3, 2019 is applicable only through the actions of Member States to its gradual implementation.

Therefore, from the perspective of EU law is ensuring of transport of passengers in road transport currently rather curious situation where there is a fairly extensive treatment on the basis of directly applicable regulation in the field of public services and the provision of compensation (Regulation no. 1370/2007) and international bus transport [Council Regulation (EC) no. 12/98, which this year will be replaced by a new Council Regulation (EC) no. 1073/2009]. Domestic bus transport is thus one of the last areas where foreign carriers are not allowed to provide services in another EU Member State, if not use the freedom of establishment and shall not establish a state in a given organizational unit. In the rail transport liberalization cannot be spoken yet at any the level of EU.

3. Legal regulation of public transport in the European Community and in the Czech Republic

Czech Republic on Regulation no. 1370/2007 responded relatively quickly and comprehensively to adoption of Act no. 194/2010 Coll., On public passenger transport services and to amend other Acts (the "Act"), which became effective on July 1, 2010 already. The Act regulates complementary manner to the Regulation no. 1370/2007 defining the competencies of the state and local governments in providing transport service and the procedure for providing transport services including quality standards and verification. However, the law primarily governs the special invitation, discussed in more detail below, as the basic procedure for selecting the carrier to contract for public passenger transport services (§ 10-17) and direct input as an exceptional way contract (§ 18, 22).

The law also regulates the details concerning compensation and their calculations and verify the appropriateness of the above (§ 23). Are also significant procedural and jurisdictional provisions governing oversight of operations within the customer contracts of public service that performs the Czech Office for the Protection of Competition? The Government and the Ministry of Transport issued to implement ZVS several by-laws, the most important being Decree no. 296/2010 Coll., Procedures for the preparation of the financial model and determine the maximum amount of compensation and Government Regulation no. 63/2011 Coll., On the minimum values and indicators of quality and safety standards and how they were rendered in connection with the provision of public passenger transport services.

Table 1 contains a number of forms relating to notification of the provision of public services to external suppliers (companies) for Public Administration for rail and bus service and frequency of use thereof EU.

Table 1. Structure of procurement procedure in the Czech Republic

European Union Member States	2017	2018
Germany	230	250
Spain	155	169
Poland	93	101
United Kingdom	91	99
France	77	82
Italy	74	75
Finland	51	69
Sweden	44	55
The Czech Republic	20	25
Slovenia	18	23
Estonia	18	20
Austria	17	19
Slovakia	14	17
Denmark	13	16
Bulgaria	7	13
Latvia	5	11

Source: Tender Electronic Daily (ted.europa.eu), own preparation.

The Table 1 shows that Regulation 1370/2007, Act No. 194/2010 Coll., Public services, transport of Passengers, bus transport, railway, special Competitive tender procedure, transfer of Employees, purchase of vehicles is used in some states more, some less and some not at all.

The next objective of this paper is to evaluate public expenditure on public transport accessibility provided by bus lines. The method based on the example of selected municipalities of the Zlín Region of cost-effectiveness analysis was used. The second objective is to evaluate the system of public transport accessibility services in the Zlín Region in terms of its “fairness” to individual local authorities, *i.e.* whether the municipalities expend their finance and received corresponding output in form of a sufficient supply of bus transport services for their residents.

4. Evaluation of public expenditure in the field of public transport

Evaluation of public expenditure on the provision of public transport accessibility in this paper was conducted at the municipal level of the Czech Republic. The author selected 21 municipalities from the Zlín Region for analysis and comparison. The method of cost-effectiveness analysis (CEA) was used for this purpose. This analysis is useful in cases when the amount of costs for an activity in monetary units is known but the benefit in the form of output is quantified in physical units (compare with Ochrana 2006, Struk and Soukopová 2011, Tetřevová 2008). To simplify, we can say that under the criteria of efficiency the relationship between monetarily quantified inputs or costs (C) and in volume quantified outputs or effects (E) is observed. The indicator of cost-effectiveness (CEA) is defined as follows:

$$CEA = \frac{C}{E} \tag{1}$$

Inputs for the following analysis (C) are the costs of selected municipalities in the Zlín Region spent to provide basic public transport accessibility services by bus transport. The municipalities spend CZK 70 per inhabitant as form of contribution to the Zlín Region which then provides the definition of basic transport services and its purchase with individual contract carriers including subsequent financing (Koordinátor veřejné dopravy Zlínského kraje 2018). The data detailing the expenditure of selected municipalities was obtained from ÚFIS, the official information system of the Ministry of Finance of the Czech Republic which provides data on budgets and expenditures of all Czech municipalities (ÚFIS 2018).

The ÚFIS system provided information about the amount spent on financing public transport accessibility by bus transport in every municipality. According to the budget structure that is mandatory in the entire system of Czech public budgets the real expenditure of municipalities was identified for the year 2015 under the paragraph 2221 - Operation of public road transport and also under the section 5323 - Non-investment transfers to the regions. Other expenditures of the municipalities that may concern the public transport accessibility by bus were not taken into account (*e.g.* expenditure on the operation of city public transport).

The output (E) evaluated in the context of cost-effectiveness analysis was represent by supply of bus transport services in individual municipalities. It was expressed by the number of buses departing from particular municipality on weekdays (E1) and by the number of buses departing from particular municipality on over the weekend, *i.e*. the sum for Saturday and Sunday (E2). This number of departing bus connections does not take into account the direction or the final destination (compare with Marada and Květoň 2010b). Data on the bus transport was obtained from the public internet schedule IDOS (IDOS - the public internet schedule 2015).

As indicated above, the cost-effectiveness of total sum spent on the provision of public transport accessibility was assessed from two perspectives, as:

- effectiveness of expenditures in relation to the supply of the bus transport services on weekdays (indicator CEA1);
- effectiveness of expenditures in relation to the supply of the bus transport services over weekend (indicator CEA2).

The value of CEA1 and CEA2 indicator was calculated for every municipality. At the same time a value for entire set of the analyzed municipalities together was calculated (as a share of aggregate expenditure of all the analyzed municipalities on provision of basic public transportation accessibility and the sum of all departing buses from the analyzed municipalities on weekday - CEAS1, and over weekend - CEAS2).

Subsequently the efficiency rating (ER) was calculated in every evaluated municipality. It was represented by the ratio of CEA1 (or CEA2) indicator of individual municipality and CEAS1 (or CEAS2) indicator of the entire set of evaluated municipalities. Based on the principle of the calculation the ERS1 (or ERS2) indicator of the entire set is 1. Municipalities which scored ER1 (or ER2) indicator lesser than 1, may be considered as effective within the frame of the evaluated set of municipalities. Those municipalities which scored more than 1 are considered ineffective.

Table 1 represents the distribution of municipalities according to the values of ER1 (or ER2) indicator into five categories which were delimitated with minor adjustments according to Struk and Soukopová (2011). The final step of the analysis was to calculate the complex efficiency rating (CER) as the sum of the ER1 and ER2 indicators. The value of the complex CERS indicator of the entire evaluated set is 2. The municipalities that scored lesser value may be considered as effective and those which scored more than 2 may be considered as ineffective. The categorization of CER indicator is also shown in Table 2.

Table 2. The categorization of efficiency according to the efficiency rating

Category	Definition for ER1 and ER2	Definition for CER
1. Highly efficient	ER_1 (ER_2) of individual municipality < 70% ER_{S1} (ER_{S2}) of the entire set of municipalities	*CER* of individual municipality < 140% CER_S of the entire set of municipalities
2. Above average efficient	ER_1 (ER_2) of individual municipality is between 70% and 90% ER_{S1} (ER_{S2}) of the entire set of municipalities	*CER* of individual municipality is between 140% and 180% CER_S of the entire set of municipalities
3. Average efficient	ER_1 (ER_2) of individual municipality is between 90% and 110% ER_{S1} (ER_{S2}) of the entire set of municipalities	*CER* of individual municipality is between 180% and 220% CER_S of the entire set of municipalities
4. Below average efficient	ER_1 (ER_2) of individual municipality is between 110% and 130% ER_{S1} (ER_{S2}) of the entire set of municipalities	*CER* of individual municipality is between 220% and 260% CER_S of the entire set of municipalities
5. Highly inefficient	ER_1 (ER_2) of individual municipality > 130% ER_{S1} (ER_{S2}) of the entire set of municipalities	*CER* of individual municipality > 260% CER_S of the entire set of municipalities

Source: own preparation

5. Results

Table 3 presents the source data that was used for the analysis of cost-effectiveness. The total expenditure on the provision of public transport accessibility by bus in the Zlín Region in 2015 amounted to approximately CZK 302,4 million (sum of the Zlín Region and municipal resources) out of which the contribution of all municipalities to the Zlín Region was approximately CZK 41,3 million (Coordinator of the public transport of Zlín region - Koordinátor veřejné dopravy Zlínského kraje, 2014). Table 2 illustrates that 21 selected municipalities contributed with amount of about CZK 22,6 million which is more than half of the total contribution of all municipalities of the Zlín Region.

Table 3. Source data for the analysis

Municipality CER	Abbrev.	ER1	ER2	CER
Brumov-Bylnice	BrB	1,04	3,22	4,26
Bystřice pod Hostýnem	BpH	0,75	0,50	1,26
Holešov	Hol	0,78	0,70	1,48
Hulín	Hul	0,91	0,68	1,59
Chropyně	Chr	0,99	1,11	2,10
Kroměříž	Kro	1,54	1,44	2,97
Kunovice	Kun	0,30	0,69	1,00
Luhačovice	Luh	0,55	0,42	0,97
Napajedla	Nap	0,52	0,56	1,08
Otrokovice	Otr	1,06	1,24	2,30
Rožnov pod Radhoštěm	RpR	1,01	0,66	1,67
Slavičín	Sla	1,00	1,53	2,53
Staré Město	StM	0,26	0,30	0,55
Uherské Hradiště	UhH	0,77	0,91	1,68
Uherský Brod	UhB	1,12	1,09	2,22
Valašské Klobouky	VaK	0,65	1,26	1,91

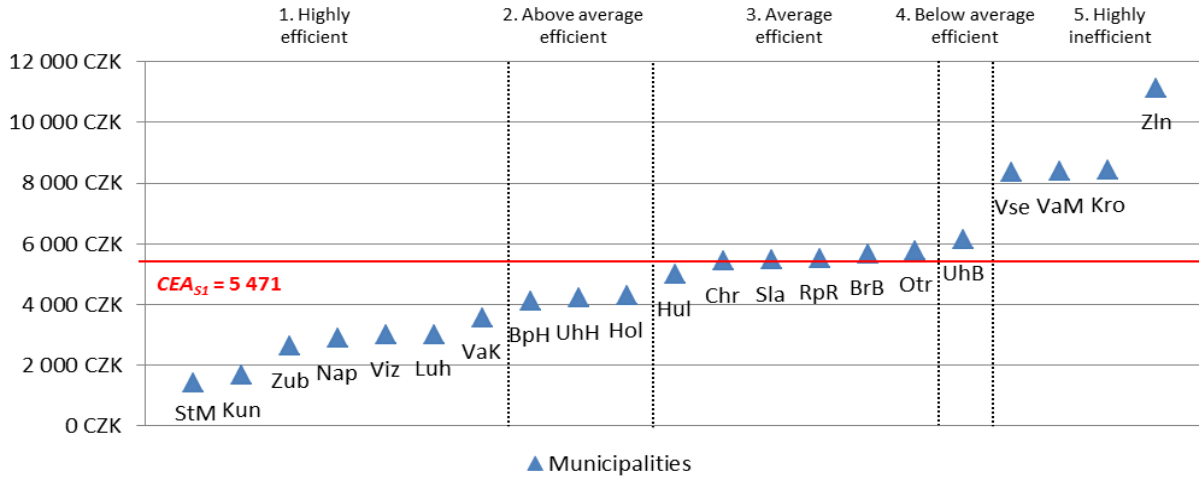
Source: Author based on Dunn (2000), Radvan (2014, 813-827)

Figure 1 and Figure 2 show the ranking of municipalities in ascending order according to the calculated values of cost-effectiveness indicators in relation to the supply of public bus transport on weekdays (CEA1) and in relation to the supply of public bus transport over weekends (CEA2). The figures also indicate the division of municipalities into defined categories of effectiveness and the value of the entire set of evaluated municipalities (CEAS1 = CZK 5 471 per departing bus connection on weekdays and CEAS2 = CZK 9 741 per bus connection over the weekend).

At this point it is possible through the comparison of Figure 1 and Figure 2 to confront the ranking of a municipality (or its inclusion in one of the five categories) based on the evaluated indicators of efficiency (weekdays vs. weekend). It can be concluded that the ranking of municipalities on weekdays and over weekend does not show significant differences. Municipalities that belong among the first two categories of more effective from the point of view of the weekdays in most cases belong into these categories also when using the perspective of the weekend bus transport supply (see *e.g.* Staré Město, Kunovice, Zubří or Napajedla). Similarly, such connection appears also

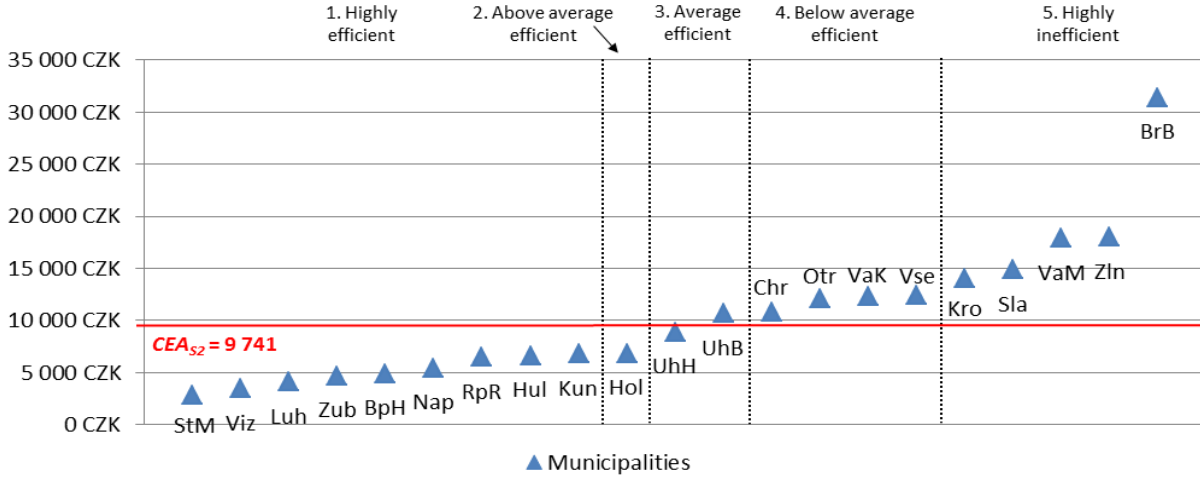
with less effective municipalities (see *e.g.* Zlín, Vsetín, Valašské Meziříčí or Kroměříž). However, there are exceptions such as the Brumov-Bylnice municipality whose ranking in the second figure is by far the worst due to the very limited supply of weekend bus transport. In the first figure the very same municipality, however, belongs to a category of average efficiency.

Figure 1. Efficiency of expenditure related to the supply of public bus transport on weekdays (CEA1)



Source: author

Figure 2. Efficiency of expenditure related to the supply of public bus transport over weekend (CEA2)



Source: author

Table 4 presents the resulting calculated values of the *effectiveness rating* indicator in individual municipalities rated for both views (weekdays and weekend). The last column of the table shows the value of *complex efficiency rating*. When comparing the values of individual municipalities, it can be determined whether under the evaluated criteria it belongs among the more effective, or rather the less effective subjects.

Table 4. Source data for the analysis

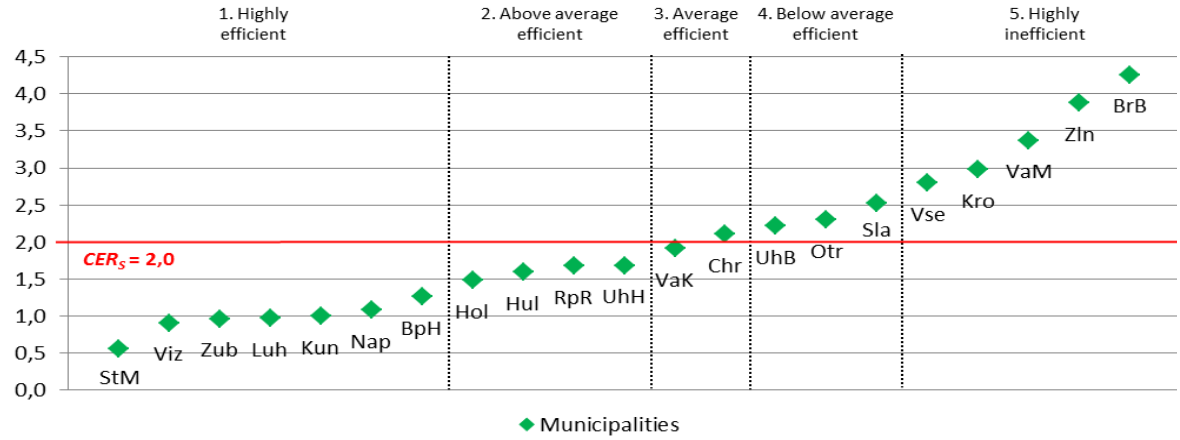
Municipality CER	Abbrev.	ER1	ER2	CER
Brumov-Bylnice	BrB	1,04	3,22	4,26
Bystřice pod Hostýnem	BpH	0,75	0,50	1,26
Holešov	Hol	0,78	0,70	1,48
Hulín	Hul	0,91	0,68	1,59
Chropyně	Chr	0,99	1,11	2,10
Kroměříž	Kro	1,54	1,44	2,97
Kunovice	Kun	0,30	0,69	1,00
Luhačovice	Luh	0,55	0,42	0,97
Napajedla	Nap	0,52	0,56	1,08
Otrokovice	Otr	1,06	1,24	2,30

Municipality CER	Abbrev.	ER1	ER2	CER
Rožnov pod Radhoštěm	RpR	1,01	0,66	1,67
Slavičín	Sla	1,00	1,53	2,53
Staré Město	StM	0,26	0,30	0,55
Uherské Hradiště	UhH	0,77	0,91	1,68
Uherský Brod	UhB	1,12	1,09	2,22
Valašské Klobouky	VaK	0,65	1,26	1,91
Valašské Meziříčí	VaM	1,53	1,84	3,37
Vizovice	Viz	0,55	0,36	0,90
Vsetín	Vse	1,53	1,27	2,80
Zlín	Zln	2,03	1,84	3,88
Zubří	Zub	0,48	0,48	0,96
The entire set of municipalities		1,00	1,00	2,00

Source: Author based on Dunn (2000) and Radvan (2014, 813-827)

Graphic representation of the final results of the efficiency evaluation in selected municipalities concerning the expenditure on public transport accessibility is shown in Figure 3 which shows all evaluated municipalities in ascending order by value of the complex efficiency rating (CER) indicator.

Figure 3. Final results according to the complex efficiency rating (CER)



Source: Author

Among the most effective municipalities in the case of expenditure on the public transport accessibility belong municipalities of Staré Město, Vizovice, Zubří, Luhačovice or Kunovice because the amounts they spend on public transport accessibility results in "above the average" number of bus transport connections (alternatively it can be said these municipalities achieve the lowest costs per one bus connections available for their residents). On the contrary, the municipalities of Brumov-Bylnice, Zlín, Valašské Meziříčí, Kroměříž or Vsetín belong among the least effective. For the amount these municipalities spend on public transport accessibility they obtain "below average" number of bus transport connections (or these municipalities have the highest costs per one bus connection available to the residents). The group of average effective municipalities, according to our analysis, includes the municipalities of Chropyně and Valašské Klobouky.

Conclusion

The first conclusion is that competition in the selection of the carrier to determine transport services taking place in some states more and some less competitive. The second objective of this paper dealt with evaluating the effectiveness of public expenditure on the public transport accessibility provided by bus transport when using the cost-effectiveness analysis on the example of selected municipalities of the Zlín Region. The second objective was to provide an assessment of the public transport accessibility system within the region in terms of its fairness to the individual municipalities that is to find out whether the expenditure of individual municipalities results in according to output in form of sufficient supply of bus transport services for their residents.

The possibility to use the cost-effectiveness analysis for evaluation of the municipal expenditures on the provision of public transport accessibility and the results of this analysis are presented in detail in previous chapters. The results of the analysis allow dividing the municipalities into five categories according to the effectiveness of the expenditures. As discussed in the previous chapter, the analysis revealed that municipalities which belong among

the effective in point of view of weekdays (achieve the lowest costs per bus connection available to the residents on weekdays), in most cases belong among the effective also from the point of view of the weekend transport connections (achieve the lowest costs per bus connection available to the residents over weekend). The final ranking of municipalities according to the complex efficiency rating allows for combination of the two points of views and establishes which municipalities are effective, average, or below average in general.

The results of the analysis, however, encouraged also to some additional questions. The first important question is the fairness of the system in which each municipality of the Zlín Region contributes to cover the expenses on provision of public transport accessibility according to the size of its population. The analysis indicates the system might be unjust as there is rather wide range of costs the evaluated municipalities expend per one bus connection available to their residents (*e.g.* in the case of weekday the costs per bus connection range between CZK 1 413 in the case of the Staré Město and CZK 11 122 in case of Zlín, the average of costs for the entire set of municipalities amounts to CZK 5 471). The current structure of municipal contribution for provision of public transport accessibility in the Zlín Region takes no account of the number of available bus connections and the question is whether the calculation of the municipal contributions should be altered considering these facts.

Another issue which also suggests another possible line of research is whether using the cost-effectiveness analysis can help with tracing common characteristics of the municipalities included in the efficiency categories. According to the results of the research it seems that the ranking of municipalities does not depend on the population size. Smaller municipalities are among the most effective (*e.g.* Staré Město or Vizovice) but also among the least effective (*e.g.* Brumov-Bylnice or Slavičín). Similarly, the larger municipalities are ranked as efficient (*e.g.* Uherské Hradiště or Rožnov pod Radhoštěm) and some of them among the least efficient (*e.g.* Zlín or Valašské Meziříčí). The author of this paper believe that the other factors affecting the effectiveness may involve the location of the municipality (some municipalities located on main transport routes show larger relative amount of available bus connections and consequently are more effective and vice versa a municipality located in the peripheral part of the region outside of the main transport routes show a smaller supply public bus transport connections and consequently lower effectiveness), lack of demand for public bus transport in certain municipalities or the historical setup of the system. In another research conducted by the author the outlined issues will be examined on sample of all the municipalities of the Zlín Region.

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*** IDOS - Veřejný internetový jízdní řád. Available at: http://jizdnirady.idnes.cz/autobusy/spojeni

*** Koordinátor veřejné dopravy Zlínského kraje. Available at: http://www.koved.cz

*** ÚFIS. Available at: http://wwwinfo.mfcr.cz/ufis

Production and Innovative Expenditures in Polish Industry

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Abstract:

Lying at the core of the research subject was the hypothesis that the formation of the value of the innovative production sold by the Polish industry is impacted more greatly by the streams of expenditures on physical capital, rather than the investment in human capital. Econometric analysis of the regression relationship between innovative marketed output and innovation expenditure involving physical and human capital shows that the relationship is determined by a homogeneous function in which innovation expenditure and innovation effects increase by the same percentage (1%). The cause thereof is asymmetry of the influence (elasticity) of physical capital (0.693) as compared to human capital (0.270) in Polish industry in the 2011-2013 period.

Keywords*:* regression relationship; innovations; industry; Poland

JEL classification: C13; L11; Q55

1. Introduction

The average economic growth syndrome is not conducive to creating increasing competitiveness, including budgeting expenditure on innovation in Polish industry. Enforced external impact is not conducive to taking decisions aimed at gaining a cost advantage in the long term, but in the short term only, which limits expenditure on innovative activity (Barrett, Musso and Padhi 2009). Research and development are very costly and do not always produce the expected results in manufacturing and services. In order to restructure uncertainty and risk, a new way of value creation was suggested, involving customer participation and acceptance. Normally, taste and needs are comprehensive and change quickly (Thomke and von Hippel 2002). The process of coming up with and implementing innovative solutions is characterized by multiple stages and complexity. In its definition the innovation process faces problems of multiple dimensions, constant changes and fluctuations (Dodgson *et al.* 2005). The drivers for applying innovation in an enterprise are internal needs which are initiated by external factors. They comprise the following: new needs, suppliers or partners' suggestions, R&D of research centres and state innovation policy (Costa and Jongen 2006). The results of the survey carried out by the Joint Research Centre (JRC) are not conclusive as to whether economic recovery or recession are factors that precipitate changes in applying new innovative technologies in enterprises. The results of the studies conducted by Cincera, Cozza, Tübke and Voigt (2010) are not conclusive as to cycle-related changes in innovative technologies. The Polish economy is characterized by a weak propensity for introducing innovation and cooperation in R&D. In previous years the Polish economy was regarded as a moderate innovator, whereas at present as a modest innovator (Innovation Union Scoreboard 2013).

The objective of the study is to identify the regression relationship between the value of innovative marketed output and innovation expenditure, which represents the flows of physical and human capital in Polish industry in the 2011-2013 period. In addition, its objective is to show the impact of physical and human capital on a relative increase in the value of innovative marketed output in Polish industry.

Lying at the core of the research subject was the hypothesis that the formation of the value of the innovative production sold by the Polish industry is impacted more greatly by the streams of expenditures on physical capital, rather than the investment in human capital.

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2. Literature review

For many years the expenditure on research and development constituted a measure of innovation intensity and, with it, also that of company growth (Cohen and Levinthal 1989, Gerards 2015). This category, although measurable, proved to be imprecise, since not all expenditure on R&D is implemented for a given innovation (Griliches 1986, Omelchenko 2015). Therefore, what transpired was a parallel source of risk in the application of innovation (Gorlevskaya *et al*. 2018). A further reason for the innovative changes turned out to be the desire of rivalry between companies (Zhon 2006, Capello, Caragliu and Fratesi 2015). A cause for undertaking innovation is also elucidated by the first-mover advantage theory (Zhon *et al.* 2005). All the more so since innovations are thereby associated with the innovative manufacturing process and a new product or one which has been significantly modernized (Hrytsay 2010).

In this fluctuating and complex conditioning, process improvement and innovative products projection, as shown by empirical research on R&D spending, confirm the positive effect on the size of the company (Scherer 1980, Vovchenko *et al.* 2016). One may indicate that an increase in the level of technology above the average can be proven within the high-end technical sector (Akhmetova 2017) and not in the low-technology sector (Keller and Yeaple, 2009, Jucevicius, Juceviciene, Gaidelus and Kalman 2016). Large companies have the financial resources and technology to invest substantial amounts in research and development and to reap the benefits of scale and sales for the broader R&D scope of activities with the possibility of restructuring the risk of these innovations (Nooteboom 1994, Annoni and Kozovska 2010). However, innovations in older enterprises are generally less influential than in younger companies (Sorenson and Stuart 2000, Zinovyeva *et al*. 2016). In contrast, the competences of enterprises improve with age, and they can realistically generate innovations while the value of new innovations cannot be overestimated (Fine 1998, Demedts 2015). In turn, Arrow (1962) argues that the monopolistic nature of industry causes it to be less innovative and more competitive. By means of a linear function, the relationship between competition and innovation with numerical simulation (Sacco and Schmutzer 2011) was examined. An interaction exists between innovation and competition. The increase in the level of innovation allows for a greater competition on the market. It ought to be noted, however, that the increase in innovation has a step and long-term nature, which determines the character of the development of an adequate level of competition (Raymond *et al.* 2010). It should also be remarked that the relationship between innovation and competitiveness is a parallel coincidence shifted in time.

The evolution of the innovation process models, linear models of innovation into curvilinear models led to the modern concept of the theory of open models (model = theory) of innovation (Gassmann *et al.* 2010, Belderbos 2012; Aivazian, Afanasiev and Kudrov 2017). The open innovation model is universal in nature, encompassing the high-tech industry, but also small and medium-sized enterprises.

The advantage of the model is that it includes not only expenditure on research and development, but also other streams of innovative investment associated with a variable rate of growth and the evolution of structural changes of these expenditures (Stejskal and Hajek 2015. In contrast, the regressive relationship between the innovation rate and the individual streams of investment in innovation is illustrated by the Cobb-Douglas model. It constitutes the substantive basis for a theory of innovation. It also helps recognize the interaction between the innovation rate and the streams shaping the innovative physical capital and human capital.

3. Methodological conditions of the studies carried out

The issue of measuring the correlation of exogenous variables is connected with an appropriate approach to the quantification of these variables. The correlation may, however, change as the definition of particular variables changes.

Provisionally the following variables have been adopted: Y – value of marketed output of new and significantly improved products; x_1 – expenditure (value) on research and development; x_2 – expenditure (value) on know-how from external sources and software; x_3 – expenditure (value) on buildings, structures and land; x_4 – expenditure (value) on machines, technical equipment and tools, as well as means of transport; ε – random component.

An exponential production function of the Cobb-Douglas type has been proposed:

$$Y = a x_1^b x_2^c x_3^d x_4^e \varepsilon \quad (1)$$

The relationship may also be expressed as:

$$Y = a x_1^b x_2^c x_5^f, \text{ where: } x_5 = x_3 + x_4 \quad (2)$$

or:

$Y = a x_3^d x_4^e x_6^g$, where: $x_6 = x_1 + x_2$ (3)

$Y = a x_4^e x_6^g$ (4)

All these equations are equivalent (Aczel and Sounderpandian 2002). However, correlations between exogenous variables differ in the above equations.

The subject of estimating logarithmic empirical data using the Least Squares Method is the value of innovative marketed output (of new and significantly improved products) and particular types of innovation expenditure in Polish industry in the 2011-2013 period. It is only in equations (1) and (4) in 2005-2007 that the function parameters are set at the significance level within the range: 0.00 – 0.05. However, they were the set relationships distant in time.

The aim of redefining exogenous variables is to preserve their interpretation sense, with higher correlation of exogenous variables with the endogenous variable and lower correlation between endogenous variables. This rule is the basis for obtaining good regression. The redefinition of exogenous variable x_5, as the total of variables x_3 and x_4 caused an increase in its correlation with other variables. which suggests that these variables should be separated, especially as the character of their functions is different, though in total they constitute physical capital. If there is collinearity, it is difficult to precisely estimate particular parameters, although it is possible to determine the functions of these parameters with considerable accuracy (Maddala 2009). The active character of capital (x_4) suggests (a redefinition of) the human capital exogenous variable x_6 as the total of x_1 and x_2. Thus, the following equation has been obtained:

$Y = a x_4^e x_6^g$, where: $x_6 = x_1 + x_2$ (5)

The function relationships obtained are shown in Table 2. Studies are carried out over three-year periods according to the methodological standards for innovations applied in all OECD countries.

Empirical data are expressed in 2005 prices, thus constant prices, which enables a comparison of data and the function parameters calculated. 2005 constant prices permitted an increase in the number of set N = 48, where the studies examined all regions (provinces) in Poland over a three-year period (2011-2013). 2005 is the point in time which marks the beginning of Poland's economic development in the EU structure.

The random nature of the random component was examined by a graphic analysis and the series number test, with significance at 0.05. The graphic analysis and the series number test confirmed the verification of the hypothesis on the right selection of the analytical model form (Table 2). To examine the normality of the random component, the Kolomogorov-Liliefors test was used. The calculated values compared to critical values with significance at 0.05 did not give grounds for rejecting the hypothesis that the distribution of random components was normal. Auto-correlation, in turn, was examined using the Durbin-Watson test, and on that basis no auto-correlation of the random component was found, significance being at 0.05. To verify the homoscedasticity hypothesis of random components, the Godfelda-Quandt test was used. With the adopted significance level at 0.05, the critical values of Snedecor's F distribution read were higher than the calculated ones, and therefore there were no grounds for rejecting the hypothesis on the homoscedasticity of random components. The most frequently recommended test to check homoscedasticity is the Goldfeld-Quandt test (Aczel and Sounderpandian 2002).

The mutual correlation of variables x_4 and x_6 (r) does not pose a problem as it does not exceed the overall level of multiple correlation (R) (2011-2013, 0.706, 0.806) (Klein 1962).

4. Characteristics of the set under examination

The examination was carried out based on the empirical set of all regions (provinces) in Poland in the 2011-2013 period (N – 48). Table 1 shows the statistical characteristics of the variable attributes.

The goal of industrial enterprises' innovation activity is to introduce on the market new and significantly improved products. The average level of the marketed output value of these products in Polish industry in the 2011-2013 period was PLN 7156 million. However, this average level represents a relatively wide set of extreme values of the attribute at a 1:46 ratio, which indicates the susceptibility of innovative marketed output to changes, whereas the internal variability of innovative marketed output is moderate.

New machines, technical equipment and tools, as well as means of transport are responsible for the passive transfer of technology to enterprises, though they are part of mobile fixed assets. They are also a major area of innovative activity in Poland's economic conditions. The average level of expenditure (value) on machines, technical equipment and tools, as well as means of transport is nearly 2.5 times higher than the average level of

expenditure (value) on know-how from external sources and software. However, internal variability of expenditure (value) on machines, technical equipment and tools, as well as means of transport is the lowest. The range of the limit values of the data set attribute of the above variable is 1: 40. It is slightly narrower than that of the set of the innovative marketed output value.

Table 1. Parameters of attributes of variables in Polish industry in the 2011-2013 period (in 2005 prices)

Specification	Unit of measurement	Symbol	Arithmetic mean	Range min.-max.	Variability coefficient %
Value of marketed output of new and significantly improved products	million PLN	Y	7,156.0	629.3 - 28,920.3	112.9
Expenditure (value) on machines, technical equipment and tools, and means of transport	million PLN	x_4	721.0	44.8 - 2,877.7	100.0
Expenditure (value) on R&D and on know-how from external sources and software	million PLN	x_6	301.2	18.0 - 1,722.6	126.8

Source: Industry Statistical Yearbook 2012, 2013 and 2014, Central Statistical Office (GUS), Warsaw, Poland. Our own calculations.

The innovation value depends primarily on the human capital flow value. In the variable (x_6) adopted the human capital flow is represented by expenditure (value) on R&D (research and development), as well as on know-how from external sources and software. Internal variability of human capital is higher than that of physical capital by almost 27 percentage points. R&D uncertainty and risk may be limited if the model of open-market innovation is used (Chesbrough 2010). The average level of the flow of human capital expenditure is, as mentioned above, nearly 2.5 times lower than that of physical capital. This indicates asymmetry of relationships between these two types of capital. It may be assumed that under specific technical conditions the increase in the value of innovations included in the marketed output is proportionate to the increase in the flow of human capital expenditure. This has a major role in the influence on the variability of innovative marketed output in Polish industry.

5. Selected conditions determining variability of innovative marketed output

The innovative activity of Polish industry is under the influence of the prevailing economic conditions. These conditions, included in the empirical data expressed in 2005 prices, are presented using curvilinear exponential regression of the Cobb-Douglas type, and the estimated parameters, together with the statistical evaluation, are shown in Table 2.

Data in Table 2 represent in a tabular form a regression relationship between the value of innovative marketed output of new and significantly improved products (Y) and expenditure on machines, technical equipment and tools, as well as means of transport (x_4) and expenditure (value) on R&D, know-how from external sources and software (x_6). The above aggregate variables (x_4 and x_6) explain 65% of the variability of the innovative marketed output value in industry. It is a good explanation. The remaining unexplained variability of the innovative marketed output value is provided by variables not taken into account in the study. The power of the relationship expressed in the correlation coefficient (R) between the innovative marketed output value and expenditure on machines, technical equipment and tools, as well as means of transport and expenditure on R&D, know-how from external sources and software equals 81% ($\sqrt{R^2}$ = R). Bajgar *et al.* (2012), distinguishes the following correlation types: 0.10-0.39 bracket - weak correlation, 0.40-0.69 medium correlation, 0.70-0.89 strong correlation and 0.90-1.00 very strong correlation. Standard errors of regression coefficients (parameters) are lower than 50% of their absolute values. However, the test t values are several times higher than the values of regression coefficients, whereas the significance of regression coefficients is within the range between 0.00 – 0.03. The above statistical evaluations of regression coefficients (parameters) provide information on the possibility of their use in the econometric analysis of variability of the innovative marketed output value of new and significantly improved products in Polish industry in the 2011-2013 period.

Table 2. Exponential regression of innovative marketed output of new and significantly improved products (Y) relative to expenditure on machines, technical equipment and tools, as well as means of transport (x_4) and expenditure on R&D and know-how from external sources and software (x_6) in Polish industry in the 2011-2013 period (2005 prices)

a*	Regression coefficient		Standard error			Test t			R^2
	x_4	x_6	a	x_4	x_6	a	x_4	x_6	
13.8391	O.693	0.270	0.66	0.15	0.12	3.95	4.61	2.29	0.65

Note: *Free de-logarithmic word. Significance level: 0.00-0.03.

Source: Industry Statistical Yearbook 2012, 2013 and 2014, Central Statistical Office (GUS), Warsaw, Poland. Our own numerical calculations.

Regression coefficients, function parameters at x_4 i x_6 determine the elasticity (elasticity coefficients) of the innovative marketed output value relative to expenditure on machines, technical equipment and tools, as well as means of transport, and also relative to expenditure on R&D, know-how from external sources and software in industry over 2011-2013. The Cobb-Douglas production function permits the perception of the role of factor resources (Zimkova and Barochovsky, 2007). Thus regression coefficients (function parameters) are in other words elasticity coefficients. They are Y elasticity relative to x_4 i x_6, and according to J. B. Clark's marginal productivity theory of distribution, they are the shares of innovation expenditure of these factors (x_4 and x_6) in the product (innovative marketed output) (Solow 1956). In exponential regression the indices at exogenous variables are interpreted as endogenous variable elasticity in relation to the relevant factors. The elasticity coefficient determines the percentage by which the dependent variable changes on average (increases or decreases), when factor x_j grows by 1%, assuming that other factors are constant. There is a regression relationship, not a causal one, which is difficult to prove.

Elasticity of the innovative marketed output value (Table 2) is higher relative to expenditure on machines, technical equipment and tools, as well as means of transport (0.693) than innovation expenditure on R&D, know-how from external sources and software (0.270). The former expenditure represents physical capital flows, whereas the latter represents human capital flows. Resulting from the relations between regression coefficients (elasticity coefficients), innovative marketed output relative to expenditure on machines, technical equipment and tools, as well as means of transport is nearly 2.6 higher than expenditure on R&D, know-how from external sources and software. Focus should be given to the growth in innovative marketed output versus the growth in physical capital. These relationships are independent of particular enterprises' decisions, and are determined by the milieu of a particular enterprise. Hence, the necessity of increasing expenditure on human capital remains a major variable in the innovation regression model. Since human capital is characterized by certain specific features, its own specific mechanism (a process taking place over decades), the innovative marketed output is only part of the total product. Thus the innovation regression (Cobb-Douglas) construction assumes that the elasticity of the created innovation value relative to human capital equals unity. It follows from the above-mentioned logical interpretation that at a specific technical level of Polish industry under examination, the influence of human capital expenditure is used to 25% relative to the requirement of the potential human capital growth. Thus, this indicates non-effective stimulation of human capital growth in Polish industry in the 2011-2013 period.

A conclusion may be drawn from the Cobb-Douglas innovation regression model that the elasticity of the innovation value relative to physical capital should be less than unity. In the studies conducted it is less than unity (Table 2), and accounts for more than two thirds of the elasticity of innovative marketed output relative to mobile physical capital (0.693). Expenditure on machines, technical equipment and tools, as well as means of transport, though responsible for a passive transfer of technology to enterprises, has the greatest influence on shaping the variability of the innovative marketed output of new and significantly improved products in Polish industry in the 2011-2013 period. Thus, it is the major area of industrial innovative activity and is a typical phenomenon in the Polish economic environment.

It follows from the total of elasticity coefficients (powers) (Table 2) equal to less than unity (0.963), though close to it, that innovative marketed output relative to the total impact of expenditure on machines, technical equipment and tools, as well as means of transport and on R&D, know-how from external sources and software increases almost proportionately, other expenditure being at a relatively stable level. A total increase in expenditure on machines, technical equipment and tools, as well as means of transport and on R&D, know-how from external sources and software by 10% brings about an almost 10% (9.63%) increase in the innovative marketed output value. Innovative marketed output has relatively constant marginal utility, and its markets are not subject to limitation connected with the saturation level. Therefore, thanks to affordable prices and growing demand (scale effect and reduction of average costs) the market in such products stimulates the whole economic system.

It follows from the proportion of influence (total of elasticities = 100%) (Table 2) that the influence of innovation expenditure on machines, technical equipment and tools, as well as means of transport on the increase in innovative marketed output amounted to 71.96%, whereas innovation expenditure on R&D, know-how from external sources and software amounted to 28.04%. Given the almost proportionate influence of innovation expenditure used in the analysis involving the total of physical and human capital on a relative increase in innovative marketed output, a relatively low human capital value causes the corresponding low sum of the innovation value in Polish industry in the 2011-2013 period. A very limited share of the human capital influence in relation to physical capital leads to limited influence of innovation on a relative increase in innovative marketed output. This explains the fact that asymmetry of human capital influence relative to physical capital does not enable a relative growth in innovative marketed output in Polish industry.

Conclusion

The conducted empirical studies have confirmed the hypothesis that the value of the innovative production sold by the Polish industry was influenced more substantially by the streams of expenditures on physical capital, rather than by the investment in human capital over the studied period. The dominant passive transfer of technologies to the Polish industry was due to the main innovation activity stimulated by grants from the European Union.

The studies conducted indicate that Polish industry is characterized by an unbalanced innovation potential primarily relying on human resources, with a very weak propensity for introducing innovation and cooperation in R&D. Human capital, in turn, is not fully used.

The regression relationship between the attributes of the innovative marketed output value and physical and human capital is a homogeneous function in which innovation expenditure and effects (innovative marketed output) grow by the same percentage (1%).

Given the specific technological level of Polish industry, with elasticity less than unity, only about 25% of human capital influence is used compared to the potential elasticity requirement equal to unity. The asymmetry of human capital influence (elasticity) in relation to physical capital limits the relative increase in the innovative marketed output of Polish industry in the 2011-2013 period.

The elasticity of the innovative marketed output is the highest relative to physical capital, responsible for a passive transfer of technology to industrial enterprises. Physical capital is a major area of the innovative activity of Polish industry and a typical phenomenon in the Polish economic environment.

Resulting from the proportion of the total elasticity, the variability of innovative marketed output in industry is mainly determined by physical capital – 72%, and less by human capital – 28%, other expenditure being at a relatively stable level.

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The Effect of Augmented Reality Shopping on E-Consumer Satisfaction

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Abstract:

The development of technology and the internet has brought great changes to the way consumers shop. The traditional way of visiting a store is considered no longer relevant, replaced with online shopping through social media, websites, and e-commerce. But the problem encountered is consumers cannot observe from various sides and details, touch and try the product. One of the solutions currently provided is through application of augmented reality. However, the application of this technology to online shopping media is still limited, therefore this research analyzes the effect of augmented reality shopping on e-satisfaction from 89 consumers in South Jakarta, Indonesia. Data were analyzed using SEM-PLS and smartPLS software package. The analysis results indicated that perceived augmentation and playfulness directly affect augmented quality (coeff = 0.396 and 0.286, respectively) while convenience and playfulness directly affect e-satisfaction (coeff = 0.478 and 0.221, respectively). Convenience gives a greater total effect on e-satisfaction than playfulness while perceived augmentation gives a greater total effect on augmented quality than playfulness. Finally, the presence augmented quality significantly increases the influence of convenience and playfulness on e-satisfaction.

Keywords: augmented reality; augmented quality; e-commerce; e-satisfaction; SEM-PLS

JEL classification: O32

1. Introduction

Within the past decade, e-commerce has become a necessity for citizens of the world, this is evident in the 53% of global internet users who made online purchases in 2016 (US Census Bureau 2017). The growth of technologies and the internet has allowed people to shift the way they do things, including the way we shop. The future of shopping will no longer require consumers to leave their houses and visit stores; consumers will be free from the hassle of crowded stores, low in-store stocks causing unavailability of products, and carrying big amounts of cash. Rapid e-commerce-related developments make it possible for retailers to provide 24/7 online-based stores where consumers can browse and purchase items whenever and wherever they are, and choose when the purchased products to arrive at their doorstep. Eventually, people will look to even more advanced platforms that grant them an easier and more convenient way to shop and handle their transactions.

As convenient as e-commerce is, some consumers may experience a bit of a drawback in purchasing items online, that is they cannot see, feel, and touch the desired items as they can at physical stores; they don't have the means to project how an item looks like in real life and if the item is up to their expectations. This is where augmented reality shopping can fill the loophole by enabling consumers to experience a more interesting,

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interactive, convenient, and satisfactory means of shopping, mimicking that of a traditional brick-and-mortar store experience even when they are at home.

The wonders of technology have brought us augmented reality, where individuals can use their gadgets to interact with both virtual and reality at the same time. In Indonesia, however, the use of augmented reality for commerce is not yet common, though there are several businesses that have started using these platforms such as *IKEA*, *Dulux*, and *Alfamind*. Therefore, the objective of this research is to discuss the effect of augmented reality shopping on e-satisfaction. This study contributes to the literature by providing empirical evidence of the relationship between augmented reality, augmented quality and e-satisfaction on online shopping sites and applications, especially in Indonesia.

2. Literature review

2.1. Augmented reality (AR)

Augmented Reality or AR is defined as an environment that includes both virtual reality and real-world factors, for instance, a user can use translucent goggles which lead them to see the real world as well as computer-generated images projected on top of that world **(**Azuma *et al.* 2001**)**. Caudell and Mizell (1992) first created this term, which is applied to describe a head-mounted digital display that guided workers in assembling large bundles of electrical wires for aircrafts. Augmented Reality allows consumers to see how products will look in their homes, how products will look on them when tried on, how to use and access further information about the products (Baird 2017). Agrawal (2017) stated that researchers are pulling graphics out of the computer screen and integrating them into the real world by pushing the barriers of photorealism in augmented reality.

Augmented Reality is not to be confused with Virtual Reality (VR), which removes the real elements and instead immerse the user in a totally virtual environment with virtual objects (Behzadan and Kamat 2005). Agrawal (2017) stated that there are certain key differences between the two which can be very well explained as follows:

- 75% virtual + 25% real = virtual reality;
- 75% real + 25% virtual = augmented reality.

In this digital era of heightened consumer expectations, AR is becoming an essential tool for e-commerce (Javornik, Rogers, Moutinho, and Freeman 2016).

Although the term of AR is considered new in online shopping, but previous studies that discussed this has been done a lot from analyzing the development of AR technology (Feiner, MacIntyre, Höllerer, and Webster 1997, Kukulakos and Vallino 1998, Pryor, Furness, and Viirree 1998, Höllerer, Feiner, Terauchi, Rashid, and Hallaway 1999, Azuma *et al.* 2001, Ohta, Sugaya, Igarashi, Ohtsuki, and Taguchi 2002) as well as problems encountered from every technological development generated (Fuhrmann, Hesina, Faure, and Gervautz 1999, Julier *et al.* 2000, Lepetit and Berger 2000, MacIntyre and Machado Coelho 2000). Research on the application of AR has been done in various fields including health (Fuchs *et al.* 1998), manufactures (Navab, Bascle, Appel, and Cubillo 1999), games (Jebara, Eyster, Weaver, Starner, and Pentland 1997, Ohshima, Satoh, Yamamoto, and Tamura 1998) entertainments (Cavallaro 1997) educations (Specht, Ternier, and Greller 2011, FitzGerald *et al.* 2013), tourisms (Kourouthanassis, Boletsis, Bardaki, and Chasanidou 2015), transportations (De Crescenzio *et al.* 2011), fashions (Tabuscha 2014), retails (Poushneh 2018) and online shoppings (Javornik, Rogers, Moutinho, and Freeman 2016). In the 1990s until the 2000s, AR studies focused on the technologies and applications used and the problems faced in their application in various fields. But since 2010, recent studies have focused on the user experiences, their expectations and the effects on various decisions and user satisfaction (Olsson, Lagerstam, Kärkkäinen, and Väänänen-Vainio-Mattila 2013, Chang *et al*. 2014, Huang and Liu 2014, Kourouthanassis, Boletsis, Bardaki, and Chasanidou 2015, Wang, Chiang, and Wang 2015, Javornik, Rogers, Moutinho, and Freeman 2016, Poushneh 2018).

The AR application on online shopping is a supporting factor in online marketing today. Wang, Chiang, and Wang (2015) proved that AR can increase the preference and efficiency when shopping online. In addition, the use of AR reduces the rate of return of products purchased online (Tabuscha 2014, Baier, Rese, and Schreiber 2015), and increase product values (Tabuscha 2014, Dacko 2017). Furthermore, AR significantly affects consumer satisfaction (Poushneh 2018) and behavioral intention such as word of mouth (WOM), repurchase intentions, and loyalty (Brakus, Schmitt, and Zarantonello 2009, Eyüboğlu 2011). Javornik, Rogers, Moutinho, and Freeman (2016) has defined three AR experience indicators: perceived augmentation (Javornik 2015), convenience (Forsythe, Liu, Shannon, and Gardner 2006) and playfulness (Moon and Kim 2001). Perceived augmentation is the user's perception of AR application (Song and Zinkhan 2008). Perceived augmentation has been indicated to have a positive effect on satisfaction and behavioral intentions (WOM and repurchase intentions) (Javornik 2015).

Convenience is a functional benefit that users receive from the AR use (Forsythe, Liu, Shannon, and Gardner 2006). Conversely, playfulness is a non functional benefit due to the use of AR (Forsythe, Liu, Shannon, and Gardner 2006; Moon and Kim 2001). Both of these benefits have positive effects on satisfaction and behavioral intentions on online shopping (Childers, Carr, Peck, and Carson 2001). Based on the above explanation, the hypotheses tested in this study are:

Hypothesis 1. Perceived augmentation has a positive effect on augmented quality;

Hypothesis 2. Convenience has a positive effect on augmented quality;

Hypothesis 3. Playfulness has a positive effect on augmented quality;

Hypothesis 4. Perceived augmentation has a positive effect on e-satisfaction;

Hypothesis 5. Convenience has a positive effect on e-satisfaction;

Hypothesis 6. Playfulness has a positive effect on e-satisfaction.

2.2. Augmented quality (AQ)

Augmented quality is the output obtained from user interaction with AR (Javornik, Rogers, Moutinho, and Freeman 2016, Poushneh 2018). The quality of information, mapping and awareness received by users when using AR has a positive effect on their behavior towards online shopping (Pantano and Servidio 2012). When all three aspects of augmented quality exceed user expectations, then AR will lead to e-satisfaction and loyalty. Based on the above explanation, the hypothesis tested in this study is:

Hypothesis 7. Augmented quality has a positive effect on e-satisfaction

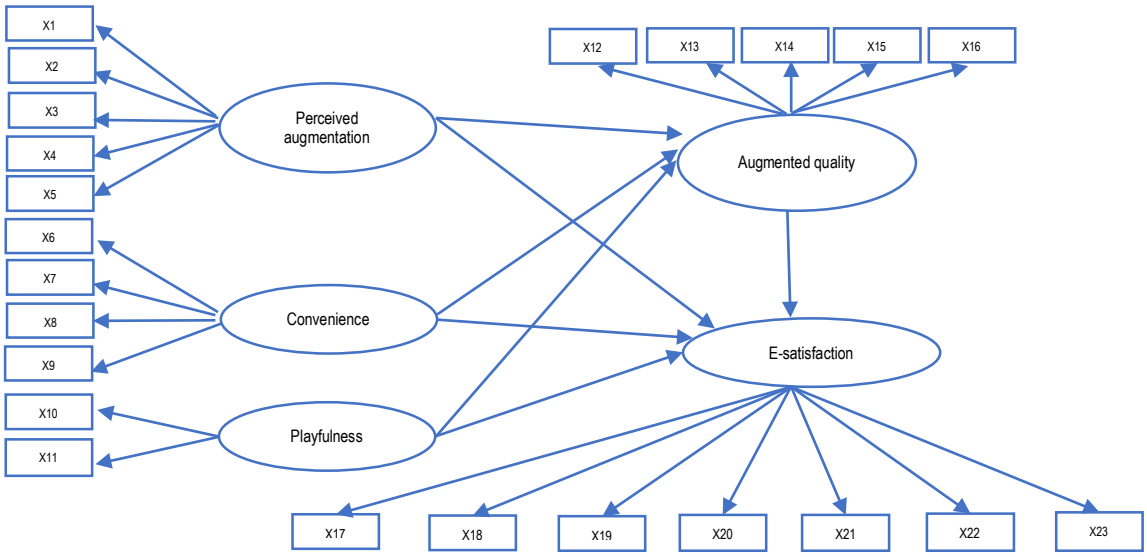
2.3. E-satisfaction

Oliver (2014) stated that satisfaction is a consumer psychological condition resulting from a series of experiences and interactions with products or services. Along with the current trends in online shopping, consumer satisfaction begins to shift from the satisfaction of the product or service traditionally to e-satisfaction. The online customer experience has become increasingly important due to the progress of technological developments and the increasing importance of the online aspects (Elliot and Fowell 2000). Customers benefit from online platforms by saving time and the offer of high flexibility, especially due to the round-the-clock accessibility (Agatz, Fleischmann, and Van Nunen 2008). Azam, Qiang, and Abdullah (2012) defined e-satisfaction as customer satisfaction resulting from previous purchasing experience with online shopping. E-satisfaction can be conceptualized as the consumer's judgment of their Internet retail stores (Szymanski and Hise 2000). Further research by Szymanski and Hise (2000) suggested that e-satisfaction is the result of the perceived convenience of consumers when shopping online, product characteristics, sites, and security of payment transactions. From attitudinal and behavioral perspective, e-satisfaction can be defined as a behavioral attitude (Cenfetelli, Benbasat, and Al-Natour 2005).

The online medium could improve the shopping process by enabling customers to sort and group information, by increasing the number of options available, and by enabling customers to access peer opinions and ratings (Meuter, Ostrom, Roundtree, and Bitner 2000). Potentially, there is more information available online which the customers will likely to devote more cognitive effort to their decision process because they can see the potential additional benefits through the additional effort (Johnson and Payne 1985). Additional information will improve the quality of the choices that customers make, which in turn, is likely to result in a service experience that delivers higher satisfaction when the choices are made online than offline (Shankar, Smith, and Rangaswamy 2003). Higher e-service quality, including AR technology will improve e-satisfaction (Bressolles, Durrieu, and Senecal 2014) and reduce the problem of uncertainty and distrust of consumers to the system. Consumer trust will bring satisfaction and loyalty (Leonnard 2018, Leonnard and Susanti 2019).

The constellation of causality between variables and hypotheses to be tested is constructed in Figure 1 below. The latent and manifest variables used in the analysis are denoted in Table A.1 (Appendix A.1).

Figure 1. The proposed model of augmented reality on e-satisfaction



3. Methodology

3.1. Samples

The respondents of this study are e-commerce buyers and sellers berjumlah 89 orang within the age range of 15 to 35 who live in South Jakarta, Indonesia. The survey was done through questionnaires via online Google Forms. Respondents consisted of 2.2% of high school students, 79.8% of university students, 12.4% of employees, 3.4% of entrepreneurs, 1.1% of housewives, and 1.1% others. Moreover, as many as 47.2% of respondents aged 15 to 20 years, 38.2% of respondents aged 34 years, 11.2% of respondents aged 27 to 31 years, and as many as 3.4% of respondents aged 32 to 35 years. Most respondents are university students with an age of 15 to 20 years, which supports the assumption that teenagers and young adults, mainly high school or university students, are more likely to try new technologies, specifically augmented-reality based shopping.

3.2. Measurements

Augmented experiences in this study were measured through three latent variables: perceived augmentation, convenience, and playfulness followed Javornik *et al.* (2016). Perceived augmentation consists of 5 attributes, convenience consists of 4 attributes, and playfulness consists of 2 attributes (Appendix A.1). Then the augmented quality followed Poushneh (2018) consisting of 5 attributes and e-satisfaction followed Bressolles, Durrieu, and Senecal (2014) which consists of 7 attributes. The measurements are obtained using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).

3.3. Data analysis

Data analysis is done through several stages. In the first stage exploratory factor analysis (EFA) is executed to adjust the attributes of each latent variable in accordance with the theory of data set conditions. The determination of attributes is determined by using Principal Component Analysis (PCA) and PROMAX rotation method. The choice of rotation method is based on the opinion of Fabrigar, Wegener, MacCallum, and Strahan (1999) and an application by Howat and Assaker (2013) which states that this method maximizes the variance and loadings of each attribute. Partial Least Square Structural Equation Model (PLS-SEM) was used to test the model using the SmartPLS 3.0 software.

The selection of this model is due to the number of samples that do not satisfy the assumptions to perform SEM covariance based analysis. Small sample size will result in poor parameter estimates, convergent assumptions are not met, and it causes Heywood cases. Therefore, PLS-SEM is a good alternative method for structural equation modeling. This model does not assume data normality and is based on variance (Yamin and Kurniawan 2011). The PLS-SEM stages include generating latent variable scores based on weight estimate, estimating path coefficients and estimating parameters (Lohmöller 1989). The evaluation of the goodness of the PLS-SEM model is executed through evaluation of the measurement model (convergent validity and discriminant validity) and structural model evaluation (Yamin and Kurniawan 2011).

4. Findings

4.1. Results of exploratory factor analysis (EFA)

The EFA results indicated the total variance is divided into 3 factors (initial eigenvalues > 1). This result is in accordance with the theory that there are three main variables used in this study; augmented reality experiences, augmented quality and e-satisfaction. Augmented reality experiences able to explain the variance of 54.354%, augmented quality of 7452% and e-satisfaction of 5.803%. The total variance explained by these three factors is 67.608% (Table 1).

Table 1. Exploratory factor analysis results using principal component analysis (PCA)

Component	Latent variables	Initial eigenvalues		
		Total	% of Variance	Cumulative %
1	Augmented reality experiences	12.501	54.354	54.354
2	Augmented quality	1.714	7.452	61.806
3	E-satisfaction	1.335	5.803	67.608

Furthermore, the determination of the attributes of each variable is based on the largest correlation with each factor. Augmented reality experiences consist of 11 attributes, while augmented quality consists of 5 attributes and e-satisfaction consists of 7 attributes (Table 2). Kaiser Meyer Oliver Measure of Sampling (KMO) value of EFA is 0.902 and Barlett Test of Spehricity sig. of 0.000.

Table 2. Rotated component matrix

Attributes	Augmented reality experiences	Augmented quality	E-satisfaction
X1	0.924		
X2	0.966		
X3	0.885		
X4	0.724		
X5	0.953		
X6	0.716		
X7	0.654		
X8	0.478		
X9	0.611		
X10	0.593		
X11	0.700		
X12		0.571	
X13		0.811	
X14		0.701	
X15		0.465	
X16		0.403	
X17			0.853
X18			0.574
X19			0.885
X20			0.816
X21			0.789
X22			0.547
X23			0.553

After performing EFA on the overall data set, further EFA analysis is performed on the attributes of augmented reality experiences which is divided into 3 factors consisting of perceived augmentation, playfulness, and convenience. This division is adapted to the theory used. Perceived augmentation able to explain the variance of 68.754%, playfulness of 6.733% and convenience of 4.407%. The total variance explained by these three factors is 79.895% (Table 3).

Furthermore, the determination of the attributes of each variable is based on the largest correlation with each factor. Perceived augmentation consists of 5 attributes, while convenience consists of 4 attributes and playfulness consists of 2 attributes (Table 4). The value of Kaiser Meyer Olkin Measure of Sampling (KMO) of EFA is 0.927 and Barlett Test of Spehricity sig. of 0.000.

Table 3. Exploratory factor analysis results using principal component analysis (PCA)

Component	Latent variables	Initial eigenvalues		
		Total	% of Variance	Cumulative %
1	Perceived augmentation	7.563	68.754	68.754
2	Convenience	0.485	4.407	79.895
3	Playfulness	0.741	6.733	75.487

Table 4. Rotated component matrix

Attributes	Perceived augmentation	Convenience	Playfulness
X4	0.769		
X5	0.829		
X6	0.547		
X9	1.054		
X10	0.468		
X11		0.612	
X22		1.025	
X23		0.696	
X24		0.501	
X8			0.650
X19			1.001

4.2. Partial Least Square Structural Equation Model (PLS-SEM) analysis

The evaluation of PLS-SEM model consists of evaluation of measurement model and evaluation of structural model. Evaluation of measurement model is executed by evaluating convergent validity through the indicator of validity, constraint reliability, and Average Variance Extracted (AVE). Evaluation of the validity indicator is executed by looking at the values of standardized loadings > 0.5 and t-statistics > 2.0. The results in table 5 indicated significant indicators of validity. The value of composite reliability and Cronbach's Alpha are all reliable with values > 0.7. Finally, the AVE value of all latent variables > 0.5 indicates latent variables have good convergent validity.

Table 5. Result of measurement model

Latent variables	Manifest variables	Std. Loadings	t-Statistics	Average Variance Extracted (AVE)	Composite reliability	Cronbach's Alpha	Rho A
Perceived augmentation	X1	0.895	30.483	0.773	0.945	0.926	0.926
	X2	0.881	22.741				
	X3	0.896	37.546				
	X4	0.902	26.360				
	X5	0.822	17.127				
Convenience	X6	0.924	48.752	0.772	0.931	0.901	0.906
	X7	0.844	17.717				
	X8	0.879	30.873				
	X9	0.865	24.188				
Playfulness	X10	0.915	42.383	0.849	0.918	0.822	0.826
	X11	0.927	53.470				
Augmented quality	X12	0.793	11.647	0.539	0.853	0.788	0.818
	X13	0.650	8.679				
	X14	0.620	6.429				
	X15	0.805	16.395				
	X16	0.784	17.156				
E-Satisfaction	X17	0.846	19.722	0.659	0.931	0.913	0.916
	X18	0.719	11.942				
	X19	0.840	21.344				
	X20	0.845	26.511				
	X21	0.820	17.697				
	X22	0.791	15.751				
	X23	0.815	18.340				

Evaluation of discriminant validity is executed by comparing the correlation of each attribute with latent variable in the cross loading table. The results indicated the highest correlation of each attribute with its latent variables compared with other variables. Therefore, discriminant validity has been reached (Table 6).

Table 6. Cross loadings

Labels	Augmented reality experiences			Augmented quality	E-satisfaction
	Perceived augmentation	Convenience	Playfulness		
X1	0.891	0.757	0.715	0.552	0.619
X2	0.888	0.698	0.662	0.654	0.546
X3	0.892	0.780	0.714	0.582	0.642
X4	0.905	0.662	0.661	0.601	0.549
X5	0.820	0.691	0.659	0.596	0.616
X6	0.755	0.926	0.736	0.616	0.728
X7	0.687	0.839	0.639	0.473	0.631
X8	0.676	0.880	0.729	0.548	0.664
X9	0.744	0.867	0.677	0.554	0.669
X10	0.744	0.747	0.917	0.571	0.638
X11	0.684	0.716	0.925	0.616	0.707
X12	0.532	0.526	0.546	0.793	0.524
X13	0.266	0.178	0.340	0.650	0.407
X14	0.344	0.250	0.302	0.620	0.392
X15	0.633	0.569	0.545	0.805	0.619
X16	0.603	0.613	0.576	0.784	0.625
X17	0.535	0.662	0.562	0.567	0.841
X18	0.431	0.482	0.446	0.655	0.741
X19	0.525	0.580	0.564	0.532	0.837
X20	0.587	0.656	0.578	0.513	0.836
X21	0.509	0.722	0.656	0.587	0.821
X22	0.572	0.554	0.642	0.606	0.796
X23	0.677	0.711	0.699	0.580	0.804

Further evaluation of the structural model is performed by looking at the path coefficients, direct, indirect, and total effects resulting from the relationship between each latent variable. Perceived augmentation and playfulness significantly affect augmented quality (coeff = 0.396 and 0.286, respectively). These results support hypotheses 1 and 3. Convenience and playfulness also significantly affect e-satisfaction (coeff = 0.478 and 0.221, respectively). These results support hypotheses 5 and 6. Finally, augmented quality significantly affects e-satisfaction (coeff = 0.345). This result supports hypothesis 7. Convenience gives the highest total effect on e-satisfaction (coeff = 0.505) then followed by playfulness (coeff = 0.320) while perceived augmentation does not significantly affect e-satisfaction. Perceived augmentation gives the highest total effect on augmented quality (coeff = 0.396) then followed by playfulness (coeff = 0.286) while convenience does not significantly affect augmented quality (Table 7).

Table 7. Direct, indirect, and total effects of PLS-SEM

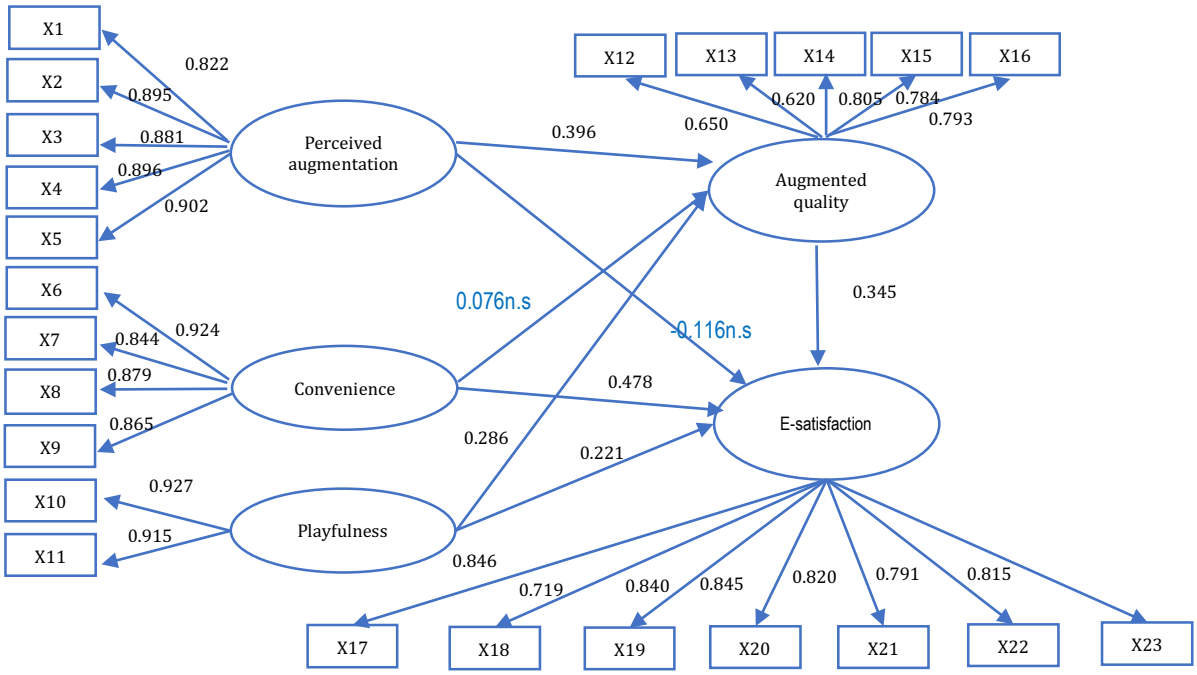
	Direct effect	Indirect effect	Total effect
Perceived augmentation -> Augmented quality	0.396	-	0.396
Perceived augmentation -> E- satisfaction	-0.116n.s	0.136	0.020n.s
Convenience -> Augmented quality	0.076n.s	-	0.076n.s
Convenience -> E- satisfaction	0.478	0.026n.s	0.505
Playfulness -> Augmented quality	0.286	-	0.286
Playfulness -> E- satisfaction	0.221	0.099n.s	0.320
Augmented quality -> E-satisfaction	0.345	-	0.345

Note: n.s = non-significant at alpha 0.05

The outer Variance Inflation Factor (VIF) score < 5 and the inner Variance Inflation Factor (VIF) < 4 in each variable indicated the absence of multicollinearity among variables. The value of R^2, *s* which can be explained by augmented quality is 50.3% and e-satisfaction is 69.9%.

The relationship between each of the latent variables is indicated in Figure 2 below.

Figure 2. Structural result model of PLS-SEM



Note: n.s = non-significant at alpha 0.05

5. Discussions

The results indicated that 5 of the 7 hypotheses proved. The dimensions of augmented reality experiences that significantly affect augmented quality are perceived augmentation and playfulness. Playfulness is a non functional benefit that consumers perceive by using AR when shopping online. These benefits are related to the emotional and social level of the consumers (Menon and Kahn 2002). While convenience is a functional benefit that consumers receive from the use of AR when shopping online (Forsythe, Liu, Shannon, and Gardner 2006). These benefits are related to convenience, product type, quality, and price (Bhatnagar and Ghose 2004).

The use of AR in the online shopping process significantly provides both these benefits. The presence of online shopping has provided many benefits and convenience for consumers compared to traditional shopping. However, on the other hand, online shopping also carries risks. One of the risks is products that are not in accordance with consumer expectations. This happens because consumers are not able to touch, see from various dimensions, and try directly the products before deciding to make a purchase. Consumers rely heavily on images displayed on e-commerce. This risk affects the consumer's desires to make a purchase. According to Bhatnagar and Ghose (2004), although the benefits offered by online shopping are numerous, consumers are more concerned about the risks they face than the benefits they may have.

The presence of AR has enabled consumers to experience trying, interacting and evaluating products as if they were in the actual store (Wojciechowski and Cellary 2013). The presence of AR produces output in the form of augmented quality higher than without AR. Augmented quality will ultimately affect their behavioral intentions for shopping. This result is in accordance with Poushneh (2018). Poushneh (2018) analyzed the effect of augmentation quality on customer satisfaction. The results obtained proved significant and positive, although it employed different dimensions; image recognition, correspondence quality, information quality, and access to user's personal information. In this study augmentation quality is measured through 5 attributes; AR in the online shopping app has many features, AR is very interesting and produces high output quality, AR is very easy to use, AR does not require any enhancements other than smartphones, tablets or laptops, AR capability to adjust with users is very high, AR can be used anytime and anywhere. These five attributes have covered both attributes proposed by Poushneh (2018); correspondence quality and information quality. Furthermore, convenience and playfulness significantly affect e-satisfaction. These results are consistent with Childers, Carr, Peck, and Carson (2001), Moon and Kim (2001) and Forsythe, Liu, Shannon, and Gardner (2006). This is indicated by the absence of augmented quality, the existence of convenience and playfulness when using AR has been able to bring to the user satisfaction. While perceived augmentation proved not significantly affect user satisfaction. Perceived augmentation is the user's perception of AR application (Song and Zinkhan 2008).

These variables include applications, features, and technologies that users perceive when using AR. The results of this study prove that the physical and technical aspects of AR do not affect the satisfaction of users directly. However, feelings, emotions and comfort felt when using AR are two very important variables for the user. In this study, playfulness measured through AR gives me a new experience, AR simplifies online shopping while convenience measured through AR in online shopping provides more attractive feature choices, AR in online shopping improves the quality of information delivery, online shopping using AR provides a variety of product options, online shopping using AR provides more options to view or try products in the real world. These attributes generally correspond to Moon and Kim (2001) and Forsythe, Liu, Shannon, and Gardner (2006).

The total effects of convenience (coeff. = 0.478) and playfulness (coeff. = 0.221) to e-satisfaction are higher than direct effect of each variable (coeff. = 0.505 and coeff. = 0.320, respectively). This result indicated the great effect of augmented quality as moderating variable to e-satisfaction. Augmented quality also significantly affects e-satisfaction (coeff. = 0.345). This result is in accordance with Szymanski and Hise (2000), Shankar, Smith, and Rangaswamy (2003), Bressolles, Durrieu, and Senecal (2014). An AR application which capable of delivering high AR output quality will lead to e-satisfaction. Thus, managers should not only focus on AR applications, features and technologies, but also on how they produce image quality, correspondence quality, and high quality information. In Indonesia, the application of augmented reality is still considered new. There has not many companies used this application yet. The results of this study indicated that significant AR applications will increase consumer satisfaction when shopping online. Although the effect of e-satisfaction on consumer behavioral intentions, such as re-purchase is not analyzed in this study, but from prior studies it has also proven to have a positive effect. Consumers who satisfy with AR have a greater chance to shop online. This is because the risks they face against product disguise are reduced. This application enables companies to reach a segment of consumers who did not believe in shopping online.

Conclusions and limitations

In this study, the relationship between augmented reality experiences with augmented quality and e-satisfaction is confirmed. Perceived augmentation and playfulness directly affect augmented quality (coeff. = 0.396 and 0.286, respectively) while convenience and playfulness directly affect e-satisfaction (coeff. = 0.478 and 0.221, respectively). Convenience gives a greater total effect on e-satisfaction than playfulness. Perceived augmentation gives a greater total effect on augmented quality than playfulness. The presence of augmented quality significantly increases the influence of convenience and playfulness on e-satisfaction. However, this study has some limitations. The first is the small number of samples and this study assume the use of AR applications on all sites and online shopping apps, but not specifically divide or use AR applications on specific brands or products. Further research that discusses the relationship between latent variables in a particular brand or product is strongly recommended.

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Appendix A

Table A.1. Variables and attributes used in the study

Latent variables	Labels	Attributes
Perceived augmentation	X4	AR helps me to visualize virtual objects become visible
	X5	AR provides information about virtual objects
	X6	AR is an excellent medium for delivering messages with texts, sounds, images, videos, animations
	X9	AR makes the app more interactive
	X10	Online shopping apps that use AR are more memorable and special
Convenience	X11	Shopping online using AR provides more choices of interesting features
	X22	I feel AR in online shopping improves the quality of information delivery
	X23	Online shopping using AR provides a variety of product options
	X24	Online shopping using AR gives you more options to view or try products in the real world
Playfulness	X8	Using an app with AR feature gives me a new experience
	X19	The use of AR in the app simplifies the online shopping process
Augmented quality	X7	AR on online shopping app has many features, is very interesting and produces high quality output
	X12	AR is very easy to use
	X14	AR does not require any enhancements other than smartphones, tablets, or laptops
	X15	The ability of AR to adjust with users is very high
	X16	AR can be used anytime and anywhere
E-Satisfaction	X17	Online shopping with AR makes it easy to access reviews and ratings from other customers
	X18	AR can be accessed easily
	X20	Shopping online using the AR feature is more efficient and effective
	X21	I feel AR in online shopping provides more information
	X25	Information accessed through AR provides satisfaction in online shopping
	X26	I would be more interested in choosing an online shopping app that uses AR
	X27	Online shopping with AR features is more satisfying as I can visualize products in the real world

The Impact of the Internet Economy on the Performance of Market Services in Slovakia

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Abstract:

Over the last two decades, the Slovak economy has undergone several restructuring processes, which have modified its character to maximize the benefits of services. These processes have also contributed to changes in the creation, development, and delivery of services. Modern services have arisen as a result of new information and communication technologies (ICT) and the Internet. The concept of the Internet economy refers to the utilization of ICT in individual countries. This article aims to detect the attained level of the Internet economy in Slovakia, and how it affects the performance of market services. Despite the slow pace of development in the Internet economy in Slovakia, the survey results have confirmed its positive impact on the performance of market services.

Keywords: internet; internet economy; information and communication technologies; market services; indexes

JEL classification: L86; O33; O11

1. Introduction

The services sector has become one of the most significant and dynamic constituents of the Slovak economy over the last two decades. In 2014, it employed 60.9% of workers and accounted for 61.1% of value added creation. The value-added share of services increased, and reached 61.5% in 2015 (World Bank 2015). Research has shown that ICT integration and the availability of a skilled workforce provide a firm foundation for the development and competitiveness of services. Information and communication technologies (ICT) represent a considerable part of the global economy. They are considered as being a dynamic subsector, which provides substantial opportunities for both the public and private sectors of the economy. They stimulate economic growth and GDP creation, create highly skilled jobs, and make a country more competitive (Informatizácia 2014). The concept of the Internet economy (ONS 2015) is concerned with factors influencing the utilization of ICT in the economies of individual countries. Over the last two decades, the Internet economy has greatly contributed to GDP creation in Slovakia, and thus, it has received considerable attention in professional and scientific practice.

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The significance of the Internet economy has been proven by several studies published by institutions that measure its level through indices, such as the ICT Development Index (IDI), the Digital Economy and Society Index (DESI), the Networked Readiness Index (NRI), and the e-Intensity Index. The results indicate that countries with the highest GDP per capita are placed at the forefront of the ranking indices. This article aims to estimate the impact of the Internet economy on the performance of the Slovak economy. Furthermore, it examines its influence on the most dynamic sector of the economy, i.e. the services sector.

2. Literature review

2.1. The Internet economy in the context of digital economy

There is no uniformly accepted definition of the broad concept of the Internet economy. Several authors even highlight the differences between the concepts of the Internet economy and digital economy. In addition to these two concepts, some authors and institutions use the terms such as the new economy, network or web economy interchangeably. The diversity in the various definitions of the digital economy is triggered by the innovations in ICT, and by the application of concepts such the post-industrial society, knowledge economy, new economy, online economy and e-economy (Cohen *et al.* 2000, Moraes and Laurindo 2013). Several researchers claim that digital economy is more developed and more complex than the Internet economy. They also highlight that digital economy is not synonymous with either the concept of knowledge economy or network economy.

On the contrary, Esfangareh and Hojeghan (2011), Iacono and Orlikowski (2000) consider the concepts of the Internet economy and digital economy as identical. Tapscott (1996) claims that digital economy is based on the interconnectedness of human intelligence through networks. Whereas, Carlsson (2004) defines digital economy as the extensive usage of the Internet at a higher level of connectivity. Haltiwangen and Jarmin (2000) argue that digital economy includes hardware, software, product sales, online services, e-currency exchange, and online education. Esfangareh, Hojeghan (2011) and Moulton (2000) describe digital economy as a complex of digital technologies (devices, software, semiconductors and telecoms) and e-commerce. Imlah (2013) and Rouse (2016) define it as a system based upon digital technologies, which may or may not utilize the Internet. Benito, de Juan, Gómez and Mochón (2015) propose the most comprehensive definition of digital economy, and emphasize its heterogeneity. They perceive it as a complex web of diverse companies with different positions in the value chain of a country's economy. They describe it in two ways: firstly, digital economy is not just merely created by an ICT subsector; it consists of four homogeneous components: telecommunications, mobile or Internet content and services, software and IT services, and application software; secondly, digital economy is perceived as a heterogeneous subsector generating the performance of the economy with diverse characteristics.

By contrast, the OECD (2013b) defines the Internet economy as a broad spectrum of economic, social and cultural activities carried out over the Internet and ICT. It is the broadest understanding of the Internet economy. According to Reed (2011), the Internet includes three conceptual clouds: a cloud for transferring information, a source cloud for data storage, and a social cloud for creating and establishing contacts over the Internet and networking. A large proportion of the various types of economic activities, including production, sales, distribution or consumption, are made over the Internet. All economic activities that are carried out or supported by the Internet contribute to the value creation of the Internet economy.

Firstly, these activities are performed through the operations and usage of the Internet. Secondly, they involve Internet-based activities such as e-commerce, online marketing, and searching. BCG (2012) quantifies the Internet economy based on its performance through e-GDP, which includes revenue generated by the provision and usage of the Internet, Internet advertising, and Internet sales. The OECD (2013a) claims that the main pillars of the Internet economy include access to the Internet through high-speed infrastructure, digital content, and ICT related to innovations and sustainable growth, and the development of intelligent applications.

Thus, the Internet economy is primarily based upon the Internet and ICT. It involves a wide range of activities over the Internet and ICT. It forms part of the digital economy, which is perceived to be more complex and heterogeneous, and successful in penetrating diverse sections of the economy. Moreover, it relies on digital technologies using all kinds of networks, which may and may not use the Internet and ICT. At present, digital economy is becoming increasingly intertwined with traditional economy. Moreover, the development of more advanced information and communication technologies leads to gradual convergence between the Internet and the digital economy.

2.2. The impact of information and communication technology on market services

Services have become an increasingly important sector in the economies of the world. They represent the fastest growing sector of the national economy. They also generate the largest share of economic growth in both developed

and developing countries (OECD 2006). The services sector dominates the global economy and supports the development of new types of services (Paton and McLaughlin 2008). It generates 70% of global GDP and significantly influences GDP creation by other sectors. Therefore, it creates enormous potential for economic growth and profitability (Lin and Hsieh 2011, Rust and Miu 2006, Chiou, Perng and Tseng 2012).

The OECD in 2003 and 2004 called attention to the fact that the services sector employed more workers than the manufacturing industry. It also highlighted the high degree of heterogeneity of the services sector in terms of ICT intensity. This was confirmed by British studies which proved that the sector of financial intermediation was much more dependent on network technologies than other services sectors (Gretton, Gali and Parham 2004). Maliranta and Rouvinen (2004) realized that the impact of ICT on labour productivity in Finland was higher in the services sector than in the manufacturing sector. Arvanitis (2004) in Switzerland reported a similar result, claiming that employment in ICT-using services was much higher than in the manufacturing industry. This can be explained by the absence of desktop computer desks and employee Internet access (Morrar, Gallouj and Abdeljawad 2014).

Service innovations support the continuous growth of the services sector; hence their primary goal is to create new value and new business models. Moreover, rapid advancements in ICT have enabled large-scale innovations in the services sector (Kuo, Chi and Yeh 2013, Kubičková 2009). Research on their strategic roles has led to a conclusion that technological innovations have greatly facilitated business processes in the services sector (health care, financial, engineering, and consulting services). Thus, ICT has gained an important position in the services sector (Chae and Olson 2011). It forms an indispensable part of services and promotes customer satisfaction (Agarwal and Singhi 2010). Today's societies are built upon digital services and ICT that play a central role in both the economy and daily life. They are naturally embedded in socio-economic relationships, in which people and technological facilities have become interconnected (Brandt 2007).

Thus, investments in ICT have a considerable impact on the development of the services sector. Several studies have already examined the impact of ICT on economic growth and employment. The impact of ICT on economic performance also needs to be analyzed. It has been acknowledged that widespread usage of ICT increases economic efficiency and revives productivity growth (OECD 2003, Alwahaishi and Snášel 2013).

3. Methodology

The impact of the Internet economy on market services was identified through the analysis of its development in the Slovak Republic. The following research question was answered to meet the research objectives.

Research question: *How did the Internet economy, measured by indices such as IDI, NRI and DESI, develop in the Slovak Republic?*

Multiple indices were used to monitor the achieved level of the Internet economy. They included the ICT Development Index (IDI), the Digital Economy and Society Index (DESI), the Networked Readiness Index (NRI), the Global Competitiveness Index (GCI), and the Boston Consulting Group e-Intensity Index. In addition to these, the Electronic Governance Development Index (EGDI), the Competitive IT Sector Index (ITICI) were also applied. Each index is based upon a different methodology; thus, their comparisons are not relevant. The indicators, presented in Table 1, support the comparison of the selected indices.

Table 1. Indicators of IDI, NRI, DESI and e-Intensity

Indicator	IDI	NRI	DESI	E-intensity index
ICT and Internet access	x	x	x	x
ICT and Internet usage	x	x	x	x
ICT skills	x	x	x	
ICT environment		x		
Impact of ICT		x		
Digital technologies integration			x	
Digital public services		x	x	x
ICT costs				x

Source: Own processing.

The above-mentioned indices utilized the indicators on ICT and Internet access and use. The indicator on ICT skills, expect for the e-intensity index, was also monitored in all the selected indices. The compared indices included indicators such as the economic and social impact of ICT (NRI), the integration of digital technologies (DESI), ICT costs (E-intensity Index) and the digital public services indicator (NRI, DESI, e-intensity). However, data for the e-intensity index were not available, thus, the development of the Internet economy in Slovakia was

not monitored by this index.

The OECD claims that the Internet economy is built upon three pillars: Internet access, digital content and ICT, and the development of intelligent applications. The ICT Development Index was used to identify the relationships among the Internet economy, market services and economic performance in the Slovak Republic. It is a complex index consisting of three sub-indices (access, ICT intensity, and ICT skills). The IDI is one of the most widely used ICT development indicators, thus, it offers a larger and more accessible database than other indices. The correlation and regression analysis was used to determine the relationship between economic performance measured by GDP per capita and ICT development measured by IDI in the Slovak Republic.

Hypotheses 0 and hypotheses 1 were proposed to identify the above-mentioned relationship. Hypotheses 0 and 2 were used to determine the relationship between the development of the Internet economy and value added in the selected sectors of market services in Slovakia.

Hypothesis 0: *ICT development measured by the IDI does not affect GDP per capita growth in Slovakia.*

Hypothesis 1: *ICT development measured by the IDI affects GDP per capita growth in the Slovak Republic.*

Hypothesis 0: *The development of the Internet economy measured by the ICT Development Index does not affect the value added (H0.1 to H0.7)* [2] *in the selected sectors of market services in Slovakia.*

Hypothesis 2: *The development of the Internet economy measured by the ICT Development Index affects the value added (H2.1 to H2.7)* [3] *in the selected sectors of market services in Slovakia.*

The hypotheses were verified by the XLStat statistical package and the Microsoft Excel Spreadsheet Software. In the regression analysis, the equation for the regression line is as follows:

$$Y=b_0+b_1x \quad (1)$$

The Durbin–Watson d statistic was used to test the existence of autocorrelation. It is calculated by the relation (n> 15):

$$d=\frac{\sum(e_t-e_{t-1})^2}{\sum e_t^2} \quad (2)$$

The method by Cohen (1988) was applied in the correlation analysis:

Table 2. Effect size

Effect size	R (correlation coefficient)
Very small	under 0,10
Small	0,11 – 0,30
Medium	0,31 – 0,50
Large	0,51 – 0,70
Very large	0,71 – 0,90
Huge	0,91 – 1,00

Source: Processing by Cohen (1988).

The examined market services sections based on SK NACE Revision 2 are listed in Table 3.

Table 3. Market services sections

Sections	Market services
G	Wholesale, retail business, repair of motor vehicles and motorcycles
H	Transport and storage
I	Accommodation and catering services
J	Information and Communication
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support services

Source: Own processing.

[2] Tags in hypothesis 0 by the selected sectors of market services: section G – H0.1, section H – H0.2, section I – H0.3, section J – H0.4, section L – H0.5, section M – H0.6, section N – H0.7.

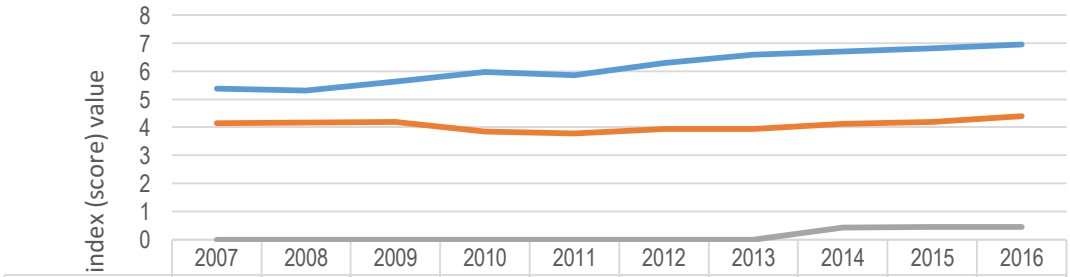
[3] Tags in hypothesis 2 by the selected sectors of market services: Hypothesis 2: section G – H2.1, section H – H2.2, section I – H2.3, section J – H2.4, section L – H2.5, section M – H2.6, section N – H2.7.

4. Results and discussion

Research question verification 1: *How did the Internet economy, measured by IDI, NRI, and DESI, develop in the Slovak Republic?*

The development of IDI, DESI and NRI is documented in Figure 1 and Figure 2. Data for the e-intensity index were not available, that is why, this index is not shown in the figures. The ICT Development Index score values range between 0 and 10; the higher the score values, the better the results in ICT development and use in Slovakia. The IDI score value accounted for 5.38 in 2007. It increased to 6.96 by 2016, *i.e.* by 1.58 points. The IDI score value, in comparison with the previous year, dropped by 0.1 points in 2011. However, there had been an increase in score values since 2012. In terms of IDI development, Slovakia witnessed considerable progress in ICT development, accessibility, usage, and skills. However, Slovakia moved down in the rankings of the examined countries, see Figure 2.

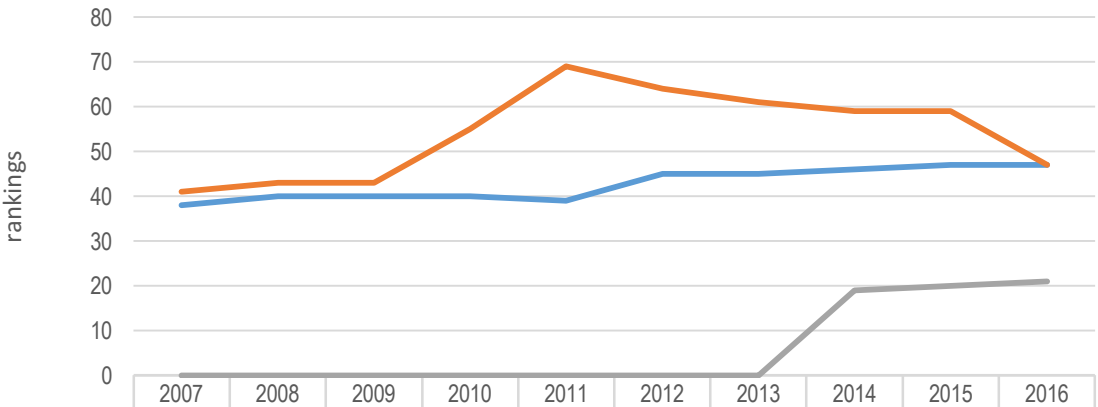
Figure 1. Indices based on score values in Slovakia for the years 2007-2016



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
IDI (0-10)	5,38	5,3	5,63	5,96	5,86	6,3	6,58	6,7	6,82	6,96
NRI (1-7)	4,15	4,17	4,19	3,86	3,79	3,94	3,95	4,12	4,2	4,4
DESI (0-1)	0	0	0	0	0	0	0	0,42	0,45	0,46

Source: Own processing. Data from ITU of the relevant year.

Figure 2. Indices based on the rankings for the years 2007–2016 in Slovakia



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
IDI	38	40	40	40	39	45	45	46	47	47
NRI	41	43	43	55	69	64	61	59	59	47
DESI	0	0	0	0	0	0	0	19	20	21

Source: Own processing. Data from ITU of the relevant year.

There were fluctuations in the timeline of NRI score values and rankings in Slovakia in the period between 2007 and 2016. The ranking of Slovakia deteriorated in 2011, which was corrected in the forthcoming years, but the country did not reach its 2007 ranking (Figure 2). The NRI score value increased from 4.15 points in 2007 to 4.19 points in 2009, then its score value decreased to 3.79 points in 2011. There had been a slight increase in the score value of the index since 2012. The value of NRI increased only by 0.25 points from 2007 to 2016.

The Digital Economy and Society Index (DESI) is one of the newest indices examining the development of digital economy of the EU member states. Its first measurements were made in 2014. The DESI score values range between 0 and 1. The DESI score values demonstrated an overall increase in Slovakia throughout the monitored

period. The first measurements were made in 2014, when the index reached 0.42 points (Figure 1). Slovakia ranked 19th among the European countries in 2014 (Figure 2). In 2016, Slovakia, with a total score of 0.46, ranked 21st among the EU-28, thus, its ranking worsened.

Slovakia's score values, despite a slight increase, were lower than the EU-28 average (0.52) in 2016, and thus growing at a slower pace than the EU-28. Slovakia ranked among the slow internet speed economies, such as the Czech Republic, Latvia, Slovenia, Hungary, and Poland, in the EU-28. However, in some of the monitored categories such as human capital, Slovakia reached the EU-28 average. Slovakia demonstrated the greatest shortcomings in digital public services.

Slovakia demonstrated an increase in the indices values based on the rankings (Figure 2) and the score values (Figure 1) of the selected indices for the years 2007–2016. This increase was perceived as a significant prerequisite for the development of the digital economy in the Slovak Republic. The most notable growth was recorded in the ICT Development Index (IDI). Thus, Slovakia dedicated enough attention to the implementation of digital technologies and the development of the Internet economy. However, Slovakia's rankings dropped in the individual indices during the monitored period. Even though, the indices values increased, Slovakia's rankings dropped. Therefore, the rate of progress in ICT development was assessed as insufficient in the Slovak Republic. Nevertheless, Slovakia has great potential for a more effective deployment of information and communication technologies.

Verification of hypotheses 0 and 1:

Hypothesis 0: ICT development measured by IDI does not affect GDP per capita growth in the Slovak Republic.

Hypothesis 1: ICT development measured by IDI affects GDP per capita growth in the Slovak Republic.

Table 4. GDP per capita and IDI development in Slovakia in the year 2007–2016

Indicator	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
IDI score	5,38	5,30	6,15	5,96	5,86	6,30	6,58	6,15	6,82	6,96
GDP per capita (EUR)	11,68	12,67	11,82	12,45	13,08	13,45	13,70	14,01	14,51	13,04

Source: Own processing. Data from ITU and Eurostat of the relevant year.

The IDI score values and GDP per capita increased year by year (Table 4.). The score value of the index increased from 5.38 in 2007 to 6.96 points in 2016 (an increase by 1.58 points). This indicated progress in ICT development in the Slovak Republic. While GDP per capita slightly decreased in 2009, the score values increased in 2010.

Table 5. Results of the regression and correlation model

Indicator	Variables	R (correlation coefficient)	R^2 adjusted (determination coefficient)	p-value	Durbin-Watson test
GDP per capita	Dependent variable	–	–	–	–
IDI	Independent variable	0,8875	0,2996	0,0588	1,80

Source: Own processing.

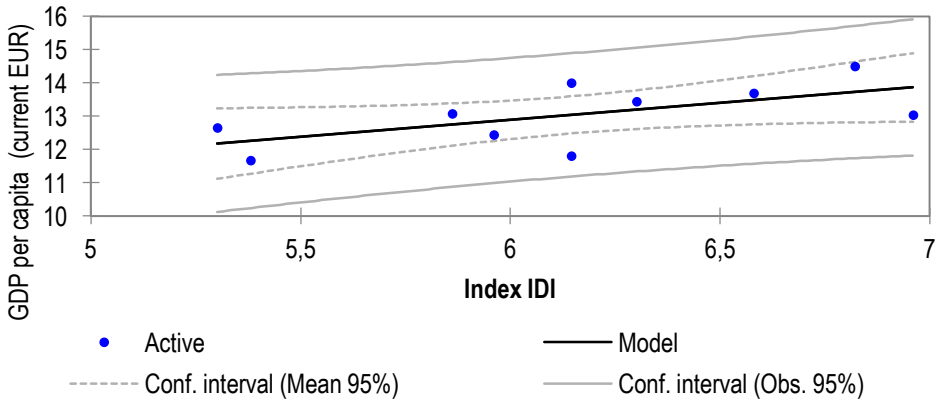
The IDI score values were defined as independent variables for each year, whereas GDP per capita was set as a dependent variable. The correlation analysis led to a correlation coefficient of 0.8875, which indicated a strong direct linear dependence between the IDI and GDP per capita.

Equation of the regression line:

$$\text{GDP per capita} = 6{,}79144 + 1{,}01703 * \text{IDI score} \quad (3)$$

The regression analysis was applied to determine the size and shape of dependence. The estimated model explained 29.96% of the data. The p-value of IDI was 0.0588, which indicated a statistically significant model at a significance level below 6%. Based on the p-value, the constant (0.0442) and the IDI variable parameter (0.0588) were estimated with 90% confidence. First-order autocorrelation was excluded by the Durbin-Watson test.

Figure 3. Relationship between the development of the Internet economy (IDI) and GDP per capita in 2007–2016, Slovakia



Source: Own processing.

Hypothesis 1 was verified, whereas, hypothesis 0 was rejected as a result of the regression and correlation analysis. A very large direct linear dependence was observed between ICT development and GDP per capita growth. The Internet economy measured by the IDI exerted a positive impact on the economy of Slovakia. Thus, the development of the Internet economy contributes to GDP per capita growth.

Verification of hypotheses 0 and 2:

Hypothesis 0: The development of the Internet economy measured by the ICT Development Index does not affect the value added (H0.1 to H0.7) [4] in the selected sectors of market services in Slovakia;

Hypothesis 2: The development of the Internet economy measured by the ICT Development Index affects the value added (H2.1 to H2.7) [5] in the selected sectors of market services in Slovakia.

The relationship between the development of the Internet economy and value added in the selected services sections is as follows:

- in section G, medium direct linear dependence. The model is statistically insignificant;
- in section H, large direct linear dependence. The model is statistically significant;
- in Section I, very large direct linear dependence. The model is statistically significant;
- in section J, large direct linear dependence. The model is statistically significant;
- in section L, very large direct linear dependence. The model is statistically significant;
- in section M, medium direct linear dependence. The model is statistically insignificant;
- in section N, large direct linear dependence. The model is statistically significant.

Table 6. Coefficients of the regressive and correlation analysis

Section NACE Rev. 2	Type	R Correlation coefficient	R^2 adjusted determination coefficient	p-value	Verified hypothesis
G	Wholesale, retail business, repair of motor vehicles and motorcycles	+0,3630	-0,0130	0,3769	H0.1
H	Transport and storage	+0,6723	0,3607	0,0678	H2.2
I	Accommodation and catering services	+0,7911	0,5636	0,0194	H2.3
J	Information and Communication	+0,6342	0,3026	0,0912	H2.4
L	Real estate activities	+0,8085	0,5960	0,0151	H2.5
M	Professional, scientific and technical activities	+0,3679	-0,0088	0,3700	H0.6
N	Administrative and support services	+0,7019	0,4081	0,0523	H2.7

Source: Own processing.

[4] Tags of hypothesis 0 by the selected sectors of market services: section G – H0.1, section H – H0.2, section I – H0.3, section J – H0.4, section L – H0.5, section M – H0.6, section N – H0.7.

[5] Tags of hypothesis 2 by the selected sectors of market services: Hypothesis 2: section G – H2.1, section H – H2.2, section I – H2.3, section J – H2.4, section L – H2.5, section M – H2.6, section N – H2.7.

The correlation coefficient indicates a direct linear dependence between the Internet economy and the value added in the selected sections of market services G, H, I, J, L, M, N. The determination coefficient shows low variability in sections G and M, and the models are statistically insignificant; however, the correlation coefficient and the regression line indicate direct linear dependence in both sections. Based on these findings, the hypothesis 2 is verified and the hypothesis 0 is rejected. Despite the heterogeneity of the services sector, and irrespective of the direction (intermediate or final consumption) of services, the achieved results have confirmed that the Internet economy has a positive impact on the performance of market services. Hence, the development of the Internet economy affects the growth of the value added in services.

Conclusion

Research on the impact of the Internet economy on market services in Slovakia has revealed several findings. Firstly, despite an increase in the score values of the monitored indices, Slovakia ranked among slowly developing Internet economies. Secondly, despite a moderate growth, Slovakia's score values were lower than the EU-28 average in 2016. It also grew at a slower pace than the EU 28 average in 2016.

Nevertheless, the development of the Internet economy measured by the IDI positively influences GDP per capita growth in Slovakia. Thus, the development of the Internet economy stipulates GDP per capita growth. The verification of the first hypothesis has confirmed that there is a strong direct linear dependence among the indicators.

Testing has confirmed a direct linear relationship between the development of the Internet economy and the value added in market services. At the same time, the analysis has shown that the development of the Internet economy positively influences value-added growth in market services. It is therefore important for service companies to use ICT in the design of their business processes to a greater extent than has been the case so far.

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The Role of the Power of Tax Authority in Voluntary Tax Compliance. The Case Study of Jakarta, Indonesia

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Abstract:

This study aims to analyze the voluntary tax compliance of individual taxpayers from deterrence variables. The power of tax authority as the deterrence variable consists of the scale of tax authorities' power, the probability of being detected and fines. To reduce the forms of tax authority's power on compliance, procedural fairness as its moderation is placed. This study was conducted in Jakarta and its surroundings considering the performance of tax revenue in this area higher than in other regions in Indonesia. The respondents were individual taxpayers who have private business or free employment. The primary data was obtained through survey method. To analyze the relationship between variables used the partial least squares structural equation modeling methods (PLS-SEM). The result showed that the power scale of tax authority affected the voluntary tax compliance while the probability of detected and fine were not. Procedural fairness weakened the influence of the power scale of tax authority on voluntary compliance. This study supports the theory of deterrence and slippery slope theory. The results of this study are useful for determination public policy.

Keywords: power scale of tax authorities; probability of detected; procedural fairness; slippery slope theory; deterrence theory

JEL classification: O31; O32

1. Introduction

In developing countries generally tax revenues are the largest source of domestic revenue, apart from foreign debt. The government will certainly avoid funding from foreign debt if it has independent capabilities. These countries will experience economic downturn if they are unable to manage their dependence on foreign debt. Installment payment and loan interest will gnaw on state budget so that it can hamper state expenditure and public spending (Yudiatmaja 2012). Foreign debt is proven to affect Gross Domestic Product (GDP) (Rahman, Musadieq and Sulasmiyati 2017, Yudiatmaja 2012). Therefore, the funding priority of taxes is generally central to these developing countries. Revenue from taxes is a stable and elastic financing source of governmental activities (Besley and Persson 2011). In fact, tax revenues are proven to accelerate the development and economic growth of a country at a particular critical point associated with a country's GDP (Gaspar, Jaramillo, and Wingender 2016).

One of the ways to meet tax revenue targets is increasing tax compliance. Tax compliance has proved to improve the performance of tax authorities (Kariyoto 2016). But the phenomenon shows the opposite, the level of

tax compliance is relatively low. In Indonesia, the population that is registered and has a taxpayer identification only reaches 9% of the target of 25% of the population that is considered eligible as a taxpayer (Bureau of Budget Analysis and the Implemtation of State Budget-Secretary General of the House of Representatives 2014). Therefore, the tax authorities actively suppress taxpayers in order to be obedient in paying taxes.

2. Literature review

Taxpayer is obedient because of fear to fined, afraid of being subjected to higher tax rates, and fear of being detected when doing tax avoidance (Surliani and Kardinal, 2014, Cahyonowati 2011, Jatmiko 2006, Rustianingsih, 2014, and Septarini 2015). Devos (2014) said this is as compliance because of impetus of economic factor. Forced compliance is obedient because of the deterrent effect of avoiding tax payments. This deterrence variable was first developed by Allingham and Sandmo (1972). According to Allingham and Sandmo (1972) in Deterrence's theory, compliance can be achieved if there is power that can force taxpayer to comply, such as imposing heavy fines on taxpayer's who are found to violate taxes, the high probability of being detected if the taxpayer intends to avoid taxes, and the high authority possessed tax authorities, as well as other powers owned by authorities. Therefore, someone in making decisions and reporting taxes is based on a logical consideration between the benefits and risks their face. Tax evasion may be avoided by taxpayer if the financial benefits are not worth the effort and cost (Allingham and Sandmo 1972). This kind of compliance usually occurs in developing country (Kogler, Batrancea, Nichita, Pantya, Belianine, and Kirchler 2013). Russia with the lowest international level of transparency between Austria, Hungary and Romania shows a higher level of forced compliance compared to the other three countries. These four countries are the object of Kogler's research, *et al.* (2013) that are different in economic and culture.

In developed countries, compliance with enforced forms of prevention that can have a deterrent effect on taxpayer shows inconsistent results (Hashimzade, Myles, and Nam 2012; Kim 2005; Alm, Bloomquist, and Mckee 2014). The citizens of developed countries already have an awareness that the government needs funds and as good citizens it is natural to be participating with taxpayers in accordance with applicable regulations. This suggests that non-economic factors also play a role in fostering tax compliance (Devos 2014).

This tax compliance can arise from one's intention to obey and the perception that compliance is easy to implement (Damayanti, Sutrisno, Subekti and Baridwan 2015). In fact, a person's level of religiosity can affect one's adherence (Torgler and Schneider 2005, Damayanti *et al.* 2015). Such compliance behavior is derived from the taxpayer's internal side. In a person there is an intention to pay taxes voluntarily (Wenzel 2004, Feld and Frey 2007). Citizens are obedient in paying taxes and without coercion from the tax authorities. Voluntary compliance is actually more desirable because it does not require a large cost and does not require a set of controls that must be done by the tax authorities in order to maintain the enforcement of tax provision (Muehlbacher, Kirchler, and Schwarzenberger 2011).

According to the Slippery slope theory, Tax compliance consists of enforce and voluntary tax compliance. Enforce tax compliance occurs because of the power of the tax authority while voluntary compliance due to trust. Voluntary compliance is certainly more desirable because it does not require large costs and does not require a series of controls for the enforcement of taxation provisions (Muehlbacher *et al.* 2011). This study intends to link the power of the tax authority with voluntary compliance because in developing countries such as Indonesia, the power of tax authorities is actually the main factor of tax compliance (Surliani and Kardinal 2014, Cahyonowati 2011, Jatmiko 2006, Rustianingsih 2014, and Septarini 2015). This study intends to provide evidence that factor of the power of tax authority which has been a factor that can force compulsory compliance, can also foster voluntary compliance.

In developed countries, compliance with enforced forms of prevention that can have a deterrent effect on taxpayer shows inconsistent results (Hashimzade and Myles 2012, Kim 2005, Alm, Bloomquist, and Mckee 2014) This research places procedural fairness as a moderating variable to reduce the forms of power of tax authority in obtaining compliance, especially voluntary compliance. Fairness is needed in tax collection because psychologically people assume that taxes are a burden. The tax paid does not necessarily give direct reciprocity to each payer, so it requires fair treatment for every citizen. Rawls (1971, 4-5) stressed the importance of balancing the distribution of rights and obligations in society. With procedural justice, every citizen has the opportunity to get benefits and at the same time bear the same burden.

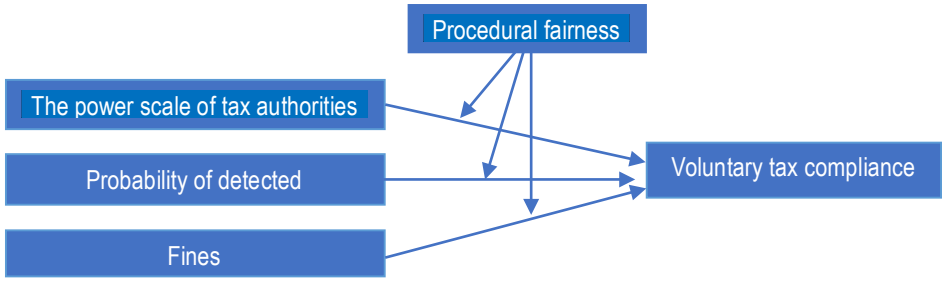
To ensure the distribution of rights and obligations in a balanced manner, a fair agreement is needed that can be achieved through an impartial procedure (Rawls 1971, 4-5). Procedural fairness refers to decisions made by authorities by involving community members (Tyler 1988). People feel that there is fairness when their voices are facilitated. Thus, procedural fairness can foster self-awareness to pay taxes voluntarily. Procedural fairness has a positive effect on taxpayer compliance (Ratmono 2014).

The rest of the paper is organized as follows, section 2 definition of relationship between research variables consisting of the power scale of tax authorities, probability of detected, fines, procedural fairness and voluntary tax compliance. Section 3 sample acquisition by survey method and SEM-PLS usage for analysis relation between variables. Section 4 results of analysis and research findings. The last section is conclusion.

2.1. Hypothesis development

The theoretical framework used in formulating hypotheses in this study is as follows:

Figure 1. Research model



This research intends to examine the power of tax authorities that can discourage unruly taxpayers associated with voluntary compliance. The power of tax authorities as a deterrence factor tested in this research consists of the power scale of tax authorities, probability of detected, and fines of Allingham and Sandmo detterence theory (1972). Tax authorities do not have to be powerful in applying forms of authority pressure to get tax compliance specially to get voluntary compliance. Tax authorities can implement fair procedures to reduce these forms of tax authority pressure. This study establishes procedural fairness that is expected to reduce the forms of the power of tax authorities in influencing voluntary compliance.

2.2. The power of tax authority and voluntary tax compliance

The power of tax authority variables to be tested in this research consist of the power scale of tax authorities, probability of detected and fines based on deterrence theory developed by Allingham and Sandmo (1972). The power scale of tax authorities shows the power of the tax authority because it has certain resources, that can force the taxpayer to comply. This can happen because the tax authority has the competence and ability in handling tax cases that occur. Tax authorities also consistently take precautions against tax evasion. This situation fosters taxpayer compliance that is forced. Conversely, the power of tax authorities when associated with voluntary compliance can have a negative effect (Muehlbacher *et al.* 2011). The power of tax authorities can be a signal that taxpayer is not trusted by tax authorities. In return taxpayer will look for opportunities to avoid paying taxes. This condition can create an unharmonious climate between taxpayers with tax authorities (Kirchler *et al.* 2008).

Likewise, with the pressure of the tax authorities through probability of detected. Taxpayer is obedient because of fear of possible inspection by tax authorities. Through research in Indonesia, probability of detected is generally implemented as a tax audit. In general, the results of this research indicate a positive relationship to forced compliance (Kariyoto 2016, Surliani and Kardinal 2014, Sari and Afriyanti 2012). Nevertheless, the results of this research have not been consistent. In Cahyonowati (2011) examination of tax proved has no effect on tax compliance. While in research Dijke and Verboon (2010) probability of detected affect the compliance of a person through personal tax norms.

The pressure of the tax authorities in the form of penalties on previous research has not provided consistent results. Several previous studies have shown that fines affect tax compliance (Surliani and Kardinal 2014, Septarini 2015, Jatmiko 2006). This compliance is a forced compliance. Taxpayer felt better to be obedient than being fined or subjected to high sanctions. However, there are also different research results, the fine does not affect a person to be obedient (Ratmono 2014). Other researchers associate fines with tax morale and tax compliance (Cahyonowati 2011). In Dijke and Verboon's research (2010) fines/tax penalties also affect a person's compliance through personal taxation norms. Thus, the following hypothesis can be derived:

H1: The power of tax authority that consists of the power scale of tax authorities, probability of detected and fines affect the voluntary tax compliance.

2.3. The effect of procedural fairness to the power of tax authority and voluntary tax compliance

Citizens of developing countries generally adhere to taxes due to pressure from the tax authorities (Kogler *et al.* 2013). In Indonesia, such research shows varieties results. Taxpayer complies to avoid pressure from tax authorities and other forms of deterrence applied by tax authorities (Hardiningsih and Yulianawati 2011, Cahyonowati 2011, Kariyoto 2016, Surliani and Kardinal 2014, Sari and Afriyanti 2012, Syakura and Baridwan 2014). However, the research of Rahmawaty, Ningsih and Fadhlia (2011) and also of Narita, Radianto and Upa (2012) showed different results. The strength of tax authorities that are implemented as policies in the field of taxation and the effectiveness of the tax system have no effect on tax compliance.

Likewise with the research conducted in developed countries, prevention variables do not consistently affect taxpayer compliance (Hashimzade *et al.* 2012, Kim 2005, Alm, Bloomquist, and Mckee 2014). Citizens are more interested in compliance that is voluntary (Kirchler *et al.* 2008, Hofmann, Hoelzl, and Kirchler 2008, Wahl, Kastlunger, and Kirchler 2010, Kirchler and Muehlbacher 2010, Muehlbacher *et al.* 2011, Prinz, Muehlbacher, and Kirchler 2014). Voluntary compliance is more desirable because it does not cost much and does not require a series of controls for the enforcement of tax provisions (Muehlbacher *et al.* 2011).

Based on the Slippery slope theory, the deterrence variable can have a negative effect on voluntary compliance. These factors can in fact provide a deterrent effect on taxpayer non-compliance. The pressure of the tax authorities is regarded as a sign of the tax authorities' distrust to taxpayer. As a result, taxpayer will try to avoid paying taxes (Muehlbacher *et al.* 2011). On the other hand, however, the power of tax authorities is still needed to foster voluntary compliance (Kogler *et al.* 2013). This encourages researchers to use procedural fairness variables as a variable that can reduce the negative effects of the relationship between the power of tax authorities and voluntary compliance.

Procedural fairness refers to a decision-making by authorities by involving citizens (Tyler 1988). Thus creating a synergistic climate between taxpayers and tax authorities (Kirchler *et al.* 2008). The synergistic climate between taxpayers and tax authorities is prevalent in developed countries (Kogler *et al.* 2013). The citizens of the community believe in the good intentions of the tax authorities in carrying out their duties to raise funds to finance the development of the state and as good citizens are properly participated by paying tax according to the provisions. This synergistic climate can occur when people are well organized. The setting up of institutions in society has used a fairness basis (Rawls 1971, 4-5). Rawls (1971, 4-5) emphasized the importance of balancing the distribution of equal rights and obligations in society. Every citizen has the opportunity to have the same benefit and bear the same burden. To ensure an equal distribution of rights and obligations it requires a fair deal that can be achieved through impartial procedures (Rawls 1971, 4-5). Therefore, the following hypothesis can be proposed:

H2: Procedural fairness weakens the effect of the power of tax authority that consists of the power scale of tax authorities, probability of detected and fines to the voluntary tax compliance.

3. Methodology

The sample in this research is collected from a part of individual taxpayer population living in Jakarta and its surrounding areas. Jakarta as the capital of the State of Indonesia has an attraction for most of its citizens to do business in this area. The largest economic activity in Indonesia is conducted in Jakarta. As the capital city of Indonesia, Jakarta contributes 16.4% of the country's economic activity in 2014 (Agustina, and Sari 2016). This region is selected as a survey area. Tax revenue in this region shows better performance compared to tax revenues in other regions. Jakarta's tax revenues reach 74% of total national tax revenue (Anonymous 2014). This indicates that most of the national economic transactions are conducted and administrated in the Jakarta area. The success of tax revenues in this region encourages researchers to further analyze the variables related to tax compliance in the Jakarta area and beyond.

Respondents in this research are individual taxpayers who conduct business or freelance work. An individual taxpayer has an obligation to submit its annual tax return. This annual tax return as a form of accountability in compliance with tax regulations (UU KUP Year 2007 paragraph 1/*The General Tax Provisions and Procedures Law number 28 Year 2007*, 2007). Respondents were asked to complete a prepared questionnaire, which illustrates the research variables with seven preferred scales for each of the proposed statements.

Sample establishment used convenience method due to the limitations in accessing individual taxpayer's data at the Directorate general of taxes office. Individual taxpayer's information is confidential. Nevertheless, the researcher strict in choosing the respondent according to the criteria that have been set. While the number of individual taxpayer data in Jakarta area are still possible to be obtained, hence in this research, determining the

amount of sample is using Slovin method with the error rate of 10%. N is equal to 155.352 and represents the number of individual taxpayer that must fill annual tax return at Regional Office in Jakarta, December 31, 2016.

$e = 10\% = 0.1$ $e^2 = 0.12 = 0.01$

$n = (155.352)/1 + (155.352 \text{ X } 0.01) = 99.90$ rounded up to 100 people/respondents (1)

Thus based on the Slovin formula the number of samples to be taken is 100 people/respondents. Data analysis was done with Smart PLS 3 statistic program. Based on This program is properly used to analyze the relationship between variables on theories testing that still require empirical verification in the field. According to the researchers, the deterrence theory and SSF theory still require empirical evidences in the field because the results of research are still dynamic. Data analysis with PLS program prioritizes more in explaining the relationship between variables rather than a set of assumptions that must be met such as when using CB-SEM program for data analysis (Sholihin and Ratmono 2013).

Research models with the help of PLS programs are presented through outer model and inner model relationships. The Outer model illustrates the reflective relationship between variables and their indicators. Role of thumbs outer loading indicator score measurement is > 0.7 (Hair, Hult, Ringle, and Sarstedt 2014). Inner model relationships are to analyze the relationship between latent variables. Output results of inner model test can be known through the coefficient path value of the relationship between latent variables with significance value and R^2. Before analyzing the inner model relationship, the data quality is tested through validity and reliability test. Validity test is performed through convergent test and discriminant validity, while reliability test is done by Cronbach Alpha measurement and Composite Reliability, see Ghozali and Latan (2015, 74-78) and Hair, Hult, Ringle, and Sarstedt (2014).

4. Result

Table 1. Respondent's descriptive

Variable	Quantity	Percentage
Gender		
Female	56	56%
Male	44	44%
Age		
< 20 year	3	3%
20 – 40 year	35	35%
41 – 60 year	62	62%
Last Formal Education		
< Senior High School	8	8%
Senior high school	27	27%
Under Graduated	50	50%
Graduated	15	15%
Business Fields		
Services	47	47%
Trading	19	19%
Manufacturing	4	4%
Other	30	30%
Average Revenue per-month ('000)		
<4.500 (± <USD 330)		
4.500 – < 10.000 (± USD 330 - <USD 735)	35	35%
10.000 – < 50.000 (± USD 735 - <USD 3.677)	32	32%
≥50.000 (± USD 3.677 - <USD 8.386)	28	28%
≥ 250.000 (± ≥USD 8.386)	5	5%
TOTAL	100	100%

Table 1 shows that the average respondent was female by 56%, while the rest was male by 44%. Respondents were generally mature because most of them aged 41-60 years old, by 62%. The next largest respondents aged 20-40 years old, 35%. The Formal education of respondents was also quite high, most have under graduated, by 50%, even there were some who graduated, by 15%. The next largest respondents were those with formal senior high school education, by 27%. The largest business field of respondents is service by 47%, then trading, 19%. While the production business is quite low, only 3%. The respondents' business fields that are not accommodated in service, trade and production groups are included in other groups, amounting to 30%.

Generally, respondents are low-income <4.500.000 IDR (± <USD 330) per month, by 35%. The next largest respondents are respondents earning 4,500,000 -10,000,000 IDR (± USD 330 - <USD 735) per month, by 32% and 28% are the respondents earning 10,000,000 - 50,000,000 IDR (± USD 735 - <USD 3.677) per month.

4.1. Descriptive statistics

This research uses survey method for data collection. Descriptive item analysis aims to determine the responses of respondents on each indicator. This questionnaire presents seven scale of choices. Scale (1) was to strongly disagree until scale (7) to strongly agree. This broader range aims to make it easier for respondents to make decision. The descriptive of respondent responses can be known through from the mean and standard deviation

Table 2. Variable indicator's descriptive

Variable	N	Mean	Std. Deviation
The power scale of tax authorities (PS)	100	4,533	1,723
Probability of detected (PD)	100	4,484	1,654
Fines (FI)	100	4,603	1,667
Procedural fairness (PF)	100	4,587	1,587
Voluntary tax compliance (VC)	100	5,374	1,672

This study has five variables, *i.e*. the power scale of tax authorities (PS), probability of detected (PD), fines ((FI), procedural fairness (PF) and voluntary tax compliance (VC). The power scale of tax authorities indicates the authority that can compel taxpayer compliance because it has certain resources, competence and capacity in handling taxation. This variable has three indicators that are operationalized in three statements (Muehlbacher *et al*. 2011). The average value of respondents' answers is 4.533 with standard deviation 1,723. Probability of detected is the ability of the authorities to detect tax violations and tax evasion by tax payer. This variable is operationalized in seven statements (Wenzel 2002, Verboon & Dijke 2011, and Kogler *et al.* 2013). The average value of respondents' answers is 4.484 with standard deviation 1,654. Fines is tax penalties/sanctions imposed on taxpayer in violation of applicable taxation provisions. This variable is operationalized in four statements (Wenzel 2004, Verboon and Dijke 2007, 2011, Ratmono 2014). The average value of respondents' answers is 4.603 with standard deviation 1,667. Procedural fairness places equal rights and obligations for every citizen to ensure the proper disbursement of rights and obligations in accordance with a fair deal. This fair deal can be achieved through in procedural Fairness. This variable is operationalized in six statements (Tyler 1997, Verboon and Dijke 2010, 2011, Ratmono 2014). The average value of respondents' answers is 4.587 with standard deviation 1,587. The result shows that average value of all item for each variable indicates above 3,5. This indicates that respondent agreed that all of item were needed for tax compliance. Voluntary tax compliance is operationalized in seven statements (Kogler *et al.* 2013, Muehlbacher *et al*. 2011). The average value of respondents' answers to taxpayer compliance is 5,374 with standard deviation 1,672. This indicates that respondents generally understand the importance of voluntary tax compliance.

4.2. Measurement model

Based on smart PLS 3, data analysis can be done through Outer model and Inner model testing. Outer model analyze the validity and reliability and Inner model analyze the relationship between variable in the model.

Table 3. Outer loadings

Item	FI	VC	PD	PS	PF
FI2	0,806				
FI3	0,862				
FI4	0,889				
VC1		0,832			
VC2		0,754			
VC3		0,831			
VC4		0,873			
VC5		0,889			
VC6		0,883			
PD1			0,618		
PD2			0,756		
PD3			0,791		
PD4			0,865		

Item	FI	VC	PD	PS	PF
PD5			0,879		
PD6			0,642		
PD7			0,782		
PS1				0,714	
PS2				0,876	
PS3				0,854	
PF1					0,834
PF3					0,861
PF4					0,885

The quality of the data can be analyzing through a measurement model with assess the relationship between indicator and its variables. In this study the outer model describes the reflective indicator. Table 3 shows the outer loading test results from the last running data. Items which low loading factor values (<0.7) are eliminated. Fines items 1, procedural fairness items 2, 5 and 6, and voluntary tax compliance items 6 have been removed due to low loading factor. After removing all of the low loading factor items, all indicators have met the role of thumbs outer loading value by > 0.7 (Hair, Hult *et al.* 2014,104).

Table 4. Convergent validity and reliability

Constructs	Initial			Iteration		
	AVE	CR	Cronbach's Alpha	AVE	CR	Cronbach's Alpha
Procedural fairness (PF)	0,468	0,833	0,758	0,623	0,866	0,793
Power scale of tax authority (PS)	0,669	0,857	0,755	0,669	0,858	0,755
Probability of detected (PD)	0,589	0,908	0,884	0,589	0,908	0,884
Fines (FI)	0,621	0,864	0,826	0,728	0,889	0,816
Voluntary tax compliance (VC)	0,637	0,922	0,899	0,714	0,937	0,919

Validity testing can be done through convergent validity and discriminant validity. Table 4 shows the results of the convergent validity test on the first and last running data. The result of PLS algorithm test shows that all variables have fulfilled the role of thumbs from validity test, AVE > 0,5 (Hair, Hult *et al.* 2014, 107). Similarly, reliability testing has also fulfilled the role of the thumb, which is Alpha Cronbach>0.7 and Composite Reliability>0.7.

Table 5. Fornell Larcker criterion discriminant validity

Variable	FI	PF	VC	PD	PS
FI	0,853				
PF	0,387	0,860			
VC	0,353	0,520	0,845		
PD	0,554	0,440	0,390	0,768	
PS	0,479	0,638	0,624	0,617	0,818

Validity testing with discriminant validity can be done through with Cross loadings and Fornell Larcker criterion test. All of item reveals the value of Cross loadings factor > 0.7, which means it has passed the loading factor test and it also shows a higher value than loading factor of other variables in this model. The result of crossing loadings test indicates that all item of the variable is proven to explain the variables and the items are proved not to be correlated with the other variable items in the model. Likewise, with Fornell Larcker criterion testing has proved that the loading factor value of each variable exceeds than all of the correlations from other variables in this model as in the Table 5.

4.3. Structural model

The relationship between latent variables can be shown in the inner model testing. The result of this test can be known from R^2 value and path coefficient value with its significance. In Table 6 the result of inner model test indicates that the voluntary tax compliance is only influenced by the power scale of tax authorities. While detected probability, fines and procedural fairness did not. The effect of procedural fairness moderation weakens the relationship between power scale of tax authorities and voluntary tax compliance with a coefficient value of -0.323 (significance). This effect reveals as pure moderation. While the effect of procedural fairness moderation on probability of detected and voluntary tax compliance relationships is classified as Homological moderation.

Table 6. Inner Model and Hypothesis Decision

Hypothesis	Path Coefficient	t. Statistics	Decision
The power scale of tax authorities →Voluntary tax compliance	0,467	3,946*	Accepted
Probability of detected →Voluntary tax compliance	-0,034	0,263*	Rejected
Fines → Voluntary tax compliance	0,019	0,211*	Rejected
M1 → Voluntary Tax compliance	-0,323	2,906*	Accepted
M2 → Voluntary Tax compliance	0,025	0,157*	Rejected
M3 → Voluntary Tax compliance	0,114	1,044*	Rejected

Note: M1: The power scale of tax authorities*Procedural Fairness; M2: Probability of detected*Procedural Fairness; M3: Fines*Procedural Fairness; (*p<0.05)

The value of R2 was 49.7% (significant). This shows that the relationship between latent variables consisting of the power scale of tax authorities, probability of detected, fines and moderate variables of procedural fairness, in explaining the voluntary tax compliance has the value of 49.7%. The remaining 51.3% indicates that the voluntary tax compliance is explained by other variables that are not analyzed in this research.

Table 6 shows that not all hypotheses are supported. H_1 hypotheses test the power scale of tax authorities, probability of detected and fines to voluntary compliance. Only the power scale of tax authorities has an effect on voluntary compliance. The correlation coefficient shows a score of 0.467 with t. statistic 3,946 (significance). While the detected probability and fines have no effect on voluntary compliance. Likewise, with H_2 hypothesis. Not all moderate effects of procedural fairness weaken the relationship between independent variable to voluntary tax compliance. Only for the power scale of tax authorities, procedural fairness was weakening its relationship to tax voluntary compliance. Coefficient value is -0.323 with t. statistic 2,906 (significance).

5. Discussion

The results of this research indicate that voluntary compliance is influenced by the power scale of tax authorities. This result is in line with the research conducted by Kogler *et al.* (2013) and Muehlbacher *et al.* (2011). In the power scale of the tax authorities indicates that tax authorities perform an effective and efficient resistance to crimes in the taxation field. Tax authorities have expertise in disclosing tax evasion by taxpayer. Such matters make the taxpayer believe in the performance of the tax authorities. Thus, even though the power scale of the tax authorities is actually a form of pressure on the taxpayer, it too can generate voluntary compliance.

Procedural fairness weakens the relationship of the power scale of tax authority to voluntary compliance. The results of this study were in line with research conducted by Kirchler, Kogler, and Muehlbacher (2014). Voluntary compliance basically does not require a fair tax implementation for citizens with a high level of trust in authority. Voluntary compliance concerns the internal side of the taxpayer. Taxpayers do intend to pay taxes regardless of whether the tax is fair or not. Based on Slippery Slope theory, voluntary compliance comes from the intention of a person to pay taxes. Tax payer will still pay taxes despite the fact that there is an opportunity to avoid taxes. The results of this study prove that procedural fairness can reduce the power of tax authority. Residents will be willing to pay taxes voluntarily as long as the tax authorities apply procedural fairness in their activities (Feld and Frey 2007). Procedural fairness guarantees the distribution of equal rights and obligations in accordance with a fair agreement. Procedural fairness places equal rights and obligations for every citizen.

While, probability of detected and fines do not affect the voluntary tax compliance. This study is in line with the research conducted by Ratmono 2014. Probability of detected and fines are actually deterrence variables so they will affect to enforced compliance not the voluntary tax compliance. This study supports the theory of deterrence and slippery slope theory. The results of this study are useful for determination public policy.

While, probability of detected and fines do not affect the voluntary tax compliance. This study is in line with the research conducted by Ratmono 2014. Probability of detected and fines are actually deterrence variables so they will affect to enforced compliance not the voluntary tax compliance (Kariyoto 2016, Surliani and Kardinal 2014, Sari and Afriyanti 2012, Septarini 2015, Jatmiko 2006, and Cahyonowati 2011). The results of this research support the deterrence theory of Allingham and Sandmo (1972), while voluntary compliance will not be affected by the pressure of the tax authorities. Even rational citizens in acting, are paying attention to ethics/morals, not solely because of cost-benefit of deterrence factors analysis (Wenzel 2004). Voluntary tax compliance based on Slippery Slope theory, arises because of trust (Kirchler *et al.* 2008). The study also concluded that moderate procedural fairness also did not affect the relationship between probabilities of detected to voluntary tax compliance. It is similar to fines and voluntary tax compliance. In Dijke and Verboon's research (2010), probability of detected and fines influence voluntary tax compliance through personal taxation norms.

Conclusion

The research concludes that the power scale of tax authorities remains necessary to foster voluntary tax compliance. While probability of detected and fines have no effect on voluntary tax compliance. According to deterrence theory, the form of pressure from tax authorities will lead to enforced compliance. While voluntary compliance requires public trust. The power scale of the tax authorities reflects the power of tax authorities that can force taxpayer to be honest, to effectively and efficiently combat tax crimes and to have expertise in disclosing tax evasion. This study proves that the power scale of tax authorities can also lead to a voluntary compliance.

The results of this research are useful as an input in the determination of policies in the field of taxation. Citizens are apparently paying attention to this power scale of tax authorities in fostering voluntary tax compliance. For the citizens, this is a guarantee that authority is sincere in carrying out their duties. In this study, procedural fairness weakens the effect of the power scale of tax authority on voluntary tax compliance. Citizens prefer to have tax authorities that have the scale of the power to good tax collection and indifferent with procedural fairness.

This research was conducted on taxpayers who live in Jakarta and surrounding areas. Even though, the citizens of Jakarta consist of various cultures, this research ignores one's culture or habit. Future research can observe this, which is what makes a person honest in their taxes. The sample in this study is generally targeted at low-income citizens. In future research, it is necessary to consider more balanced strata of society. The question can be “is there any difference in compliance among them?”, since this study did not address this issue.

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Macroeconomic Indicators and Stock Market Prices: Evidence from Vietnam

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Abstract:

This paper investigates the short and long - run dynamics among macroeconomic indicators and the Vietnamese stock prices by applying Johansen co-integration, Vector Error Correction Model, Granger Causality Test. The dependent variable is the Stock Prices Index - VN-Index and the seven independent variables are: Consumer Price Index, Exchange Rate, Vietnam Interbank Rate, Industrial Production, Money Supply, Oil Price, Gold Price in the period of ten years from January 2006 to June 2016. The study has found that in the long term, there are one positive relationships between VN-Index and real industrial production; five negative relationships between VN-Index and the others macro indicator. In the short term, VN-Index is positively affected by itself one-month lag and negatively by its two-month lag and real Vietnam interbank rate two month lags. Otherwise, VN-Index one-month lag negatively effects on real money supply. The other factors have the short run relationship with the VN-Index but not strongly significant. Besides that, by examining the Granger Causality test, it shows that there is only one-way causality from VN-Index to Consumer Price Index.

Keywords: macroeconomic indicators; stock market prices; Vietnam

JEL classification: E44; F62; O11

1. Introduction

Equity markets are the gathering place of the securities' buyers and sellers and keep the key role in the mobilization capital of businesses. Its growth represents for the development of industry and commercial operations of the country. Recently, there are plenty of researches that investigate the relationship between the macroeconomic variables and the stock market prices. However, depending on the scenes of different countries in various economic situations give us the several results.

The purpose of this study not only defines the relationship among seven macro factors and VN-Index but identifies whether causal relationships exist or not. We approach this study by the literature of Efficient Market with the Market Classification and use the quantitative methods with monthly time-series data in the period of 2006 to 2016. All the data are not only transferred to its real value but also adjusted the seasonal factors.

In the study, the equilibrium among Vietnamese stock prices indicator (VN-Index) and seven key macroeconomic variables including money supply (MS), interest rates (IR), consumer price index (CPI), exchange rate (EXR), industrial production (IP), gold price (GP), oil price (OP) is significantly explained by the processing of a series of time-series models. The Unit Root Test, Co-integration test indicating the VAR model, and the Vector Error Correlation Model are conducted to finding the short and long-run relationship, and the Granger Causality is applied to indicate the probability of causality between those variables including.

2. Literature review

Firstly, the negative relationship between CPI and stock price are examined in many researches before such as (Khuyen 2010), (Joserp 2013), (Kieu and Diep 2013), (Mei, Huan and Tien 2015), and (Akbar, Butt and Chaudhry 2018). Although they apply different methodologies, the results all show the same signal.

Secondly, (Khaled and Ngoc 2009) investigate a positive correlation among long-term rate and interbank rate and stock indicator. Additionally, they also show a negative in short-term rate, the same results with as Joserp (2013), Mei, Huan and Tien (2015), Ndlovu *et al.* (2018), and Czapkiewicz, Jamer and Landmesser (2018).

Whereas, Sezgin, Rafet and Seyfettin (2008) and Khuyen (2010) use lending rate and deposit rate, in which found the insignificant of these relationships.

Thirdly, Wongbangpo (2002) have found out the relationship of the five macroeconomic factors and the stock returns for several ASEAN countries. In the long-run, all five stock price indexes are positively related to money supply. Kieu and Diep (2013) and Akbar, Butt and Chaudhry (2018) show the same result.

In term of the relation of industrial production and stock indicator, Khaled and Ngoc (2009) investigate the effects of not only Vietnam but also US macroeconomic factors on Vietnamese stock. This is the first empirical research found out the associations between stock prices and the domestic, the international market in Viet Nam using monthly time series data from January 2001 to April 2008. They found that there is a positive effect of industrial production on Vietnamese stock prices. Phuong *et al. (*2015), and Czapkiewicz, Jamer and Landmesser (2018) give the same results as well, however, Khuyen (2010) find an insignificant relationship of this.

Vinh (2014) studies on the impacts of the S&P 500 Index, the Vietnam's macroeconomic variables on the VN-Index in the period from 2005 to 2012. The analysis shows that the VN-Index was co-integrated with the US Dollar - VN Dong exchange rates, gold prices and oil prices during and after the crisis. In the long-run, the low level of co-integration between VN-Index and gold prices indicate diversification benefits for those investing in both Vietnam's stock and gold markets. In contrary, Kieu and Diep (2013) and Al-Ameer *et al. (*2018) indicates that gold price positively impacts on the stock prices.

Bjornland and Leitemo (2005) has given a reasoning that rising of oil price in Norway would cause stronger growth in economy in general and growth in stock market prices in particular. Ankit *et al*. (2018) has researched that oil price is affected negatively to stock price. Otherwise, Basher and Sadorsky (2006) studies on 21 countries have proved that the stock returns of most of those countries and oil prices being positive and significantly statistic at the 10% level.

Recently, Long and Hien (2018) finds the short and long run relations between real money M2 and VNI-Index. Furthermore, Hien and Long (2019) studies the stability of Vietnam money demand function and show that lack of the VNI-Index in the money demand function would possibly contain a misspecification issue.

Finally, Robert (2008) investigates the relationship between stock prices and variety macro factors for Brazil, Russia, India, and China (BRIC) using the Box-Jenkins ARIMA model. It has showed that the markets those countries performance the weak-form market efficiency. The author also discloses the positively relationship between stock prices and exchange rate. Giving an opposite result with Robert, (Mei, Huan and Tien 2015) have examined how these factors could affect to Stock market after Vietnam joined the World Trade Organization (WTO). Using the ADF Unit Root test reveals that these variables used in this study are stationary. Analyzing of Co-integration test presents evidence about the long-run relationship between Vietnam stock index (VNI) and other variables. This study uses VECM to forecast the near future of VNI and VAR test to find the relationship between VNI and the factors. The results suggest that VN-Index was negative with exchange rate. Sezgin, Rafet and Seyfettin (2008), Joserp (2013), and Ndlovu, *et al*. (2018) had found the same result in other countries. However, Kieu and Diep (2013) disclose an insignificant impact from exchange rate to stock prices while Gwahula (2018) investigate the negative relationship.

3. Methodology

The monthly data are collected from trusty data sources in the period of ten-year from January 2006 to June 2016 (126 observations). We transfer data from nominal to real data and apply seasonal adjustment before taking logarithm form to reduce the discrepancy between the variables.

The volatility of Vietnam Stock Exchange: VN-Index is an index demonstrating the price of all shares traded on the Hochiminh City Stock Exchange, which officially has put into operation in July 2000. It is compared the current market value with basis market value on 28th, July 2000 and has grown approximately seven times through over fifteen-year. In the financial crisis period of 2007-2009, the VN-Index got a peak at 1,171 point on 12nd, March 2007. Data source: Hochiminh City Stock Exchange. Inflation (CPI): (Francis 2010) remarks that inflation rate was the further target in the monetary policy of government on the macroeconomic. Date source: International Financial Statistics.

Interest Rate (IR): Interest rate is one of the monetary tools in expansionary and contractionary fiscal policy of government. The interbank rate is the lending rate of short-term loans between commercial banks in the monetary capital market. The Federal Bank requires commercial banks report their reserve account daily. The commercial banks have responsibility to make sure that these accounts could be fulfilled the minimum amount of required reserve. It is no special things happened unless the interbank rate gets too high, when most the banks do not have much excess money. Consequently, the banks as borrowers are going to increase the interest rate to attract the

idle cash in order to raise the capital and increase the lending rate as well. Thus, the residences have alternative to get safer return (Data source: Datastream).

Money Supply (M2): Similar with the interest rate - money supply is one of the monetary tools in expansionary and contractionary policy of government. When the government pump money into the market, it will generate more investment opportunities in stocks, real estate etc. The stock prices would increase because the own companies have more equity to expand their manufacturing activities bringing back better income as well as revenue. However, pumping money need to be strictly manage caused its opposite effects in the inflation outcome. Data source: International Financial Statistics.

Oil World Price (OP). Data source: Global Economic Monitor.

Gold World Price (GP): Investment in gold seems to be like an efficient way to wealth protection especially when the economy be worse. It becomes the safety asset caused its enduring value. We are going to use gold world price in this study because the gold world price could be easily collected without error information. Data source: World Gold Council.

Real Effective Exchange Rate (REER): Geske and Roll (1983) imply that the more goods export, the higher cash flows into the domestic companies led to the growth up of stock prices. Otherwise, Dornbusch, Fischer and Samuelson (1980) suppose that if those domestic companies were heavy importers, when the domestic currency weaker, their stock prices declined causes the higher expenses and the lower revenues. On the other hand, Branson (1983) assumes that foreign exchange was an asset, investors would flexibly sell the forex to buy stocks and vice versa. This processing will affect the supply-demand of both forex and stocks. Many researches analyze foreign currency appreciation will boost the exporting and depress the importing activities. Overall, this relationship is either a positive or a negative or none relationship (Data source: Zsolt Darvas).

Industrial Production (IP): the volume of goods produced by industrial enterprises that illustrates the changes in overall economic activity calculates Industrial Production - the proxy for real economy activities. According to (McMillan 2009) – an increase in the manufacturing activities raises the future cash flow that brings bank a high future dividend so that the investors have been willing buying shares at higher prices (Euromoney Institutional Investor Company)

Table 1. Summary descriptive statistic of variables

Variable	Mean	Min	Max	Std. Dev.	Skewness	Kurtosis
VNI	544.104	261.5364	1110.986	177.2815	1.6298	5.4982
CPI	110.5014	62.4810	149.5799	29.5700	-0.2193	1.5584
REER	101.0842	100.8832	101.3643	0.1447	0.0209	2.0327
RVNIBOR	6.2145	-31.0335	72.1642	32.9437	0.5624	1.9782
LRIPS	-6.02e-10	-0.5688	0.7299	0.3721	0.6176	1.8374
LRM2S	-1.53e-09	-0.7078	0.6395	0.3655	-0.0855	2.1768
LOPS	-1.69e-10	-0.9279	0.5159	0.3265	-1.0261	3.3485
LGPS	1.11e-09	-0.4588	0.4336	0.2359	0.0217	2.0693
n = 126 (Time: Jan 2006 to June 2016)						

Source: The result of the author's research

The negative correlation between the VN-Index and CPI, REER, Ln (Real M2), Ln (Oil Price) and Ln (Gold Price) except Real VNIBOR and Ln (Real IP) are showed in the Table 2 below:

Table 2. Correlation matrix between variables

Variable	VNI	CPI	REER	RVNIBOR	LRIP	LRM2	LOP	LGP
VNI	1.00							
CPI	-0.287	1.00						
REER	-0.191	0.899	1.00					
RVNIBOR	0.328	-0.985	-0.863	1.00				
LRIP	0.062	0.835	0.910	-0.767	1.00			
LRM2	-0.124	0.944	0.913	-0.944	0.867	1.00		
LGP	-0.013	-0.269	-0.582	0.242	-0.487	0.442	1.00	
LOP	-0.406	0.615	-0.259	-0.679	-0.178	-0.510	0.283	1.00

Source: The result of the author's research

Unit Root Tests: The variables should be checked-up its non-stationary, if it is non-stationary, it could give us a spurious regression. Because of its population in studying, we use Augmented Dickey-Fuller (ADF) test in the study. Based on the results from ADF test, all the data are stationary at 1st level. This shows a signal that among variables could have an impact in the long term; thereby the author carries out the Johansen Cointegration test.

Optimal Lag Terms: We employ the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) to determine the optimal lag lengths. This is so important in investors' investment strategies, although they have news related to macro economy, they do not know how long will it effect on their stock portfolio. Following (Mei, Huan, and Tien 2015), we have the unrestricted k order Gausian VAR model can be represented as equation (1):

$$Y_t = \mu + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \ldots + \Phi_k Y_{t-p} + e_t \quad (1)$$

where: Y_t: a vector of variables; μ: vector of intercepts Φ_1, $\Phi_2 \ldots \Phi_k$: p × p matrices of parameters with all eigenvalues of Φ having module less than one so that the VAR is stationary; e_t: a vector of uncorrelated structural shocks.

Table 3. Unit Root Tests results (ADF)

Variable	NOCONSTANT		DRIFT		TREND	
	Level	1st Difference	Level	1st Difference	Level	1st Difference
CPI	-0.58	-6.686***	-2.82***	-	-2.931	-6.62***
REER	2.904	-3.037***	-0.891	-4.388***	-1.253	-4.482***
RVNIBOR	1.696	-8.081***	-0.344	-8.458***	-2.491	-8.461***
LRIPS	-2.549**	-	-2.696***	-7.782	-0.054	-6.857***
LRM2S	0.397	-10.817***	0.449	-11.196***	-1.918	-11.428***
LOPS	-0.892	-6.638***	-0.917	-	-2.815	-7.76***
LGPS	-1.744*	-5.762***	-1.726**	-	-2.182	-5.764***
VNI	-1.997**	-	-2.008**	-	-1.485	-8.404***

Source: The result of the author's research.
Note: *, ** and *** denote significant at 10%, 5% and 1% level respectively.

The two lag periods are selected as optimal lag term for our study by the result of the Table 4 below:

Table 4. Lag order selection criteria

lag	LR	FPE	AIC	HQIC	SBIC
0	-	0.0108	18.17	18.245	18.354
1	2683.8	8.6e-12	-2.779	-2.107*	-1.124*
2	166.94	6.3e-12*	-3.098*	-1.829	0.0274
3	85.50*	9.3-12	-2.75	-0.883	1.8467
4	-	0.0108	18.17	18.245	18.354

Source: The result of the author's research.
Note: * represents for the lags order selection.

Co-integration Test: Variables are co-integrated have two-criteria: first is it is non-stationary or stationary in the same difference; second is the error term is stationary. If there are no cointegration meaning no long-term relationship between two variables.

Table 5. Trace test result for cointegration rank

Hypothesizes no. of CE(s)	Eigenvalue	Trace Statistic		
		Statistic	5% Critical Value	1% Critical Value
None	.	173.85	156.00	168.36
At most 1	0.32170	126.1***	124.24	133.57
At most 2	0.25113	90.54**	94.15	103.18

Source: The result of the author's research.
Note: *, ** and *** denote significant at 10%, 5% and 1% level respectively.

One cointegration significant at 1% level in the Table 5. Indicates that there were one long-term stable relationships among stock price and seven selected macroeconomic variables by using up to three lags length, hence, we use Vector Error Correction Model to define this long-run equilibrium in the model.

Vector Error Correlation Model: The Table 6. shows that VNI has negatively long-run equilibrium with Real Effective Exchange Rate, Real Interbank Rate, Real M2, Oil Price and Gold Price, whereas, it is positively with Real Industrial Production. Although the coefficient of Consumer Price Index is not significant, its negative coefficient value shows us that CPI and VNI have a negative relationship.

Table 6. The cointegration coefficients from the Johansen cointegration test

VNI	CPI	REER	RVNIBOR	LRIPS	LRM2S	LOPS	LGPS
1.***	25.6	9302.5***	55.2***	-2017.3***	1442.4**	1601.9***	1281.3**

Source: The result of the author's research.
Note: *, ** and *** denote significant at 10%, 5% and 1% level respectively.

The co-integration equation can be written:

VNI= - 9302.5REER - 55.2RVNIBOR + 2017.3LRIPS - 1442.4LRM2 - 1601.9LOPS - 1281.3LGPS + 944187.4 (2)

Table 7. A VECM estimates of 1st different of variables

Variable	DVNI	DCPI	DREER	DRVNIBO	DLRIP	DLRM2	DLOP	DLGP
ECT(-1)	-	0.0003	0.000014*	-0.0017***	0.00003	-0.000012	-0.0009***	-0.0004**
DVNI(-1)	0.46**	-0.0014	0.00788	-0.00072	-0.0001	0.00012*	-0.00015	0.00002
DVNI(-2)	-	-0.0025*	-0.00002	-0.00063	-9.89e-06	-0.00001	0.00005	0.00004
DCPI(-1)	-6.334	0.4354***	-0.0009	-0.466**	-0.0042	-0.0064	0.0174	0.0107
DCPI(-2)	9.972	0.1375	0.00122	0.1719	-0.0108	-0.0097	-0.0017	-0.0088
DREER(-1)	-	-8.1724	0.1858	30.537***	-0.5377	0.1696	-0.704	-0.0864
DREER(-2)	121.8	-7.92*	-0.3464***	16.817*	0.2798**	0.51865**	0.6507	0.2555
DRVNIBOR(-1)	2.594	-0.0279	-0.00073	0.065	-0.0007	-0.00273	0.0077	0.0004
DRVNIBOR(-2)	-	0.0374	0.000313	0.1838*	-0.0044	-0.0021	-0.0037	-0.0037
DLRIP(-1)	-	0.1174	0.0214	-1.452	-0.603***	-0.00074	-0.0038	-0.0609
DLRIP(-2)	33.37	0.2027	0.0174	-0.753	-0.1762*	-0.0133	-0.0634	-0.0609
DLRM2(-1)	27.41	3.6544	-0.0842	-9.116**	0.3707	-0.1204	0.0381	0.0973
DLRM2(-2)	94.48	-2.8298	-0.0564	1.0928	-0.0177	-0.1405	0.1906	0.0316
DLOP(-1)	5.851	1.429*	-0.0128	3.28**	0.1117	0.0047	0.269**	0.041
DLOP(-2)	66.79	0.491	-0.0153	1.9465	-0.0604	0.0085	0.149	-0.044
DLGP(-1)	102.5	1.0597	0.0488	1.9489	-0.0843	-0.0303	-0.017	-0.018
DLGP(-2)	-	-0.547	-0.0012	-2.773	0.2255	0.0372	0.055	-0.104
CONS	0.028	0.402***	0.0059**	-0.6287***	0.0204	0.017***	-0.0275**	-0.005

Source: The result of the author's research.
Note: *, ** and *** denote significant at 10%, 5% and 1% level respectively.

The Table 7 shows the negative error correction term significantly supporting for cointegration in the model, meaning that there was an existence of the long run steady-state equilibrium between VNI and the factors. Furthermore, the ECM indicates a feedback of approximately 4.19% (ECT (-1) = 0.00419) of the previous period's disequilibrium from long run. In the short run, VNI is positive significant affected by itself one-month lag at 1% significant level and negatively by its two-month lag at 10% level; VNI is negative impacted by Real Vietnam Interbank Rate two month lags at 5% level and VNI one-month lag negatively effect on Real M2 at 1% level. The other factors have the short run relationship with the VNI but not significant.

Granger Causality Test: The VAR model is conducted to analyze the short-term relations, which identify causality relationships among these variables and explain more about their relations by the Granger Causality Test. The Table 8 shows us some possible causality relationship can be exist in the model. From VAR model, VN-Index one-month lag can cause Consumer Price Index.

Table 8. VAR model results

Variable	DVNI	DCPI	DREER	DRVNIBO	DLRIP	DLRM2	DLGP	DLOP
DVNI(-1)	0.4163***	-0.0027**	0.00001	-0.0009	-0.0001	0.00007	3.47e-06	-0.0001
DCPI(-1)	-4.3663	0.6077***	0.0015	-0.5582***	-0.0055	-0.0114***	-0.0004	0.0105
DREER(-	-440.939	-6.0933	0.2849	16.715**	-0.3284	0.1204	-0.4227	-1.4589***
DRVNIBO	3.1437	0.0238	-0.00006	0.0774	-0.0014	-0.0013	-0.0009	0.0058
DLRIP(-1)	22.415	0.2287	0.0057	0.4919	-0.5465***	0.0013	-0.0104	0.118
DLRM2(-	-40.478	3.5576	-0.077	-	-0.3543	-0.0914	0.0997	0.2719
DLGP(-1)	75.789	1.128	0.052	1.3551	-0.0829	-0.0368	-0.0246	-0.0097
DLOP(-1)	-12.684	1.978**	0.0048	2.2593	0.0905	-0.019	0.0023	0.2573
CONS	8.236	0.28328	0.0014	-0.2828	0.0129	0.0181	0.0041	-0.0051

Source: The result of the author's research.
Note: *, ** and *** denote significant at 10%, 5% and 1% level respectively.

Table 9. Granger Causality test results

#	Causality		P-Value	Results	Conclusion
	From	To			
1	VNI	CPI	0.0198	Do not reject	VNI lead CPI
	CPI	VNI	0.4877	Reject	
2	VNI	REER	0.7389	Reject	No causality
	REER	VNI	0.1616	Reject	
3	VNI	RVNIBOR	0.6844	Reject	No causality
	RVNIBOR	VNI	0.3907	Reject	
4	VNI	LRIP	0.3035	Reject	No causality
	LRIP	VNI	0.6755	Reject	
5	VNI	LRM2	0.1489	Reject	No causality
	LRM2	VNI	0.8084	Reject	
6	VNI	LOP	0.4270	Reject	No causality
	LOP	VNI	0.5099	Reject	
7	VNI	LGPS	0.9673	Reject	No causality
	LGPS	VNI	0.8360	Reject	

Source: The result of the author's research.

The Table 9 presents the past change in VNI could only lead change in the Consumer Price Index – the indirection causality from VNI to CPI.

Residuals diagnostics: Post-Autocorrelation Check by Lagrange Multiplier (LM) Test and Post-Heteroscedasticity Check by Jarque-Bera (JB) Test of Normality. When the model has autocorrelation and/or heteroscedasticity, we should use different model called Cointegration regression based on Long-run Covariance (LRCOV) to get better estimation with the Heteroscedasticity and Autocorrelation-consistent (HAC) standard errors in the previous model.

Lagrange Multiplier Test: The presence of serial correlation is examined by Breusch-Godfrey Serial Correlation LM Test.

Table 10. The Lagrange Multiplier Test results

Lag	Prob > chi 2	
	Vector Error Correction Model	Vector Auto Regression
1	0.57671	0.39911
2	0.61449	0.75103

Source: The result of the author's research.

The P-value of all lags order in the model are greater than 0.05 meaning that we could not reject H_0 or our VECM and VAR model had no autocorrelation. Jarque-Bera Test:

Table 11. Jarque-Bera Test results

Prob > chi 2	
Vector Error Correction Model	Vector Auto Regression
0.00198	0.07926

Source: The result of the author's research.

The P-value of all lags order in the model is greater than 0.05 meaning that we could not reject H_0 or our VAR' residuals are normally distributed whereas our VECM's residuals are not normally distributed.

4. Implication

A stock market is not only an interesting but also a risky channel of investment. The significant statistically relationship between VN-Index and selected macro factors would be useful for the diversification process and the risk management of investors. Based on the results have gotten above, investors could forecast how stock market changes if macroeconomic indicators such as industrial production, real effective exchange rate, real Vietnam interbank rate, real M2 and gold price changing to enhance their portfolio performance. Stock investors have gradually become more professional, who can combine the VN-Index historical information and other factors to make a prediction about the stock prices.

Conclusion

The whole processing has demonstrated several meaningful findings. In the long term, there are one positive relationship between VN-Index and real industrial production; five negative relationships between VN-Index and real effective exchange rate, real Vietnam interbank rate, real M2, oil world price and gold world price. In the short term, VN-Index is positively affected by itself one-month lag and negatively by its two-month lag and real Vietnam interbank rate two month lags. Otherwise, VN-Index one-month lag negatively effects on real M2. The other factors have the short run relationship with the VN-Index but not strongly significant.

By examining the Granger Causality test, it shows that there is only one-way causality from VN-Index to Consumer Price Index. The results of short-run relationship and the Granger causality in this study are fewer results than other researches. This might be because the processing of transferring data by the author, expecting to use the accurate and reliable data as more as possible. Many previous studies used nominal and not adjusted seasonal data. Generally, the relationships in the long-term results found by the author are all along with other previous researches. These results have important implications for the investors, which contribute to enriching their theoretical basis of relationship among stock market and macro economy.

Besides macroeconomic conditions, many other factors affect stock price and its movement such as microeconomic factors. From the ideas of Efficient Market Theory, the author has an interest in the performance of the company in determining the price of a stock. Indeed, higher corporate profits lead to higher stock prices due to high demand or the positive or negative news of businesses lead to higher or lower stock prices. On the other hand, this research topic seems to be not widespread in Vietnam, so in further research, we can discuss the role of micro economic factors on the stock price and how an investor can create a strategy to diversify portfolios by analyzing on microeconomics.

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Understanding Relationships between Charter Rates and Ship Building Prices in Liquefied Natural Gas Shipping Markets

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Abstract:

There would be rise in LNG shipping business with USA and Australia looking to boosts exports with promising new tonnages from the year 2018. The shipping Charter rates have seen great rise in 2011 but recently have dropping low due increase in supply of ships and limited growth in cargo. The order book of LNG is looking promising there is a need to understand the volatility of LNG charter rates and New Shipbuilding prices as huge capital investment is made in ordering these vessels. The paper analyses asymmetric relationship between New Shipbuilding prices and Short Term Charter rates of LNG shipping using VECM-EGARCH model. The results show existence of long term relationship between new shipbuilding prices and Short term charter rates.

Keywords: LNG shipping; charter rates; EGARCH; volatility; asymmetric

JEL Classification: C01; C22; C32; L91

1. Introduction

Since 2011 LNG spot charter rates have been fluctuating as an outcome of a number of major global incidents in Asia, which contributes in approximately 70% of world LNG demand. From the (Union 2017) it is evident that Fukushima crisis in 2011 has seen demand for a spot LNG which had seen time charter rates of shipping touching 1,50,000 USD/day. The spot rates dropped from US$ 93000/day in the first quarter to US$ 41000/day in the third quarter of the year 2014. In spite of overall trade and number of spot fixtures remained at all-time high in 2016, still the LNG vessel chartering rates remained flat (Union 2017). On the other hand, new ships are arriving till 2018; it becomes reasonable to investigate the relationship between charter rates and ship building prices in LNG shipping markets. Certainly, increment in liquefaction capacity and exports create an ambiguous spot chartering environment for investors. Hence the present study is objectified to discuss spillover effect of charter rates on LNG shipbuilding prices. For the investigation, the paper takes account of new ship building prices and short-term charter rates for vessel size of 1,70,000 cbm. The current study also investigates the relationship between volatility of New Ship Building prices and short-term time charter rates for LNG shipping.

2. Literature review

There have been limited studies regarding application of VECM-EGARCH models in shipping freight markets however in (Kavussanos and Visvikis 2004) the authors have used VECM GARCH models to study lead-lag relationships and volatilities between spot and derivative markets in Freight Forward Agreements in various

shipping markets. GJR-GARCH has also been used by Kavussanos in (Kavussanos, Visvikis, and Batchelor 2004) to analyze price volatility between panama vessels spot prices and Freight forwarding agreements. The spill overs between tanker freight markets and dry-bulk freight markets were studied using DCC-GARCH model in (Tsouknidis 2016). The stationarity in dry bulk freight rates was studied in (Tvedt 2003) by testing using unit root tests. The relationship between price and volume in the sale and purchase of dry bulk vessels was investigated using VAR and EGARCH models were used in (Alizadeh and Nomikos 2003)and the results were found to be consistent across the markets for different size vessels.

GARCH (1,1) model has been used in (Xu, Yip, and Marlow 2011) in understanding the systematic risk of shipping markets where study was done freight volatility and fleet size growth. GARCH model also have been used in (Fan, Xing, and Yang 2014) to find the volatility and forecasting in Baltic capsize freight indexes. GARCH-X and EGARCH models have been used to study the asymmetric effects in time varying volatility in tanker and dry bulk freight markets. The results were found to have important implications in freight rate risk management. To study the leverage effects, EGARCH was also used in (Chen and Wang 2004) to study in international bulk shipping markets.

Cointegrating error correction ARCH models were used to investigate in operating and owning vessels of different vessels. The Time charter rates and Spot rates were used for analysis and time varying risks were calculated (Kavussanos 2003). The SARIMA, GARCH, EGARCH and ARCH models have been studied in ship prices of dry cargo sector (Kavussanos 1997) and LNG ships (Raju *et al.* 2016). Markov stochastic models have also been used to understand the dynamics of freight rates in tanker markets in (Adland and Cullinane 2006) and results show that the freight rates behave like a Martingale mostly in the empirical range. Value at risk models were used to evaluate the asymmetric volatility in dry bulk freight rate in (Chang, Chih Chou, and Chou Wu 2014) and FIGARCH, Hyperbolic GARCH, Fractionally integrated APARCH models were used to find the performance of Value at Risk models.

Comparative studies between multivariate models like VAR , VECM and univariate models like GARCH, E-GARCH, ARIMA (Geomelos and Xideas 2014) were studied for forecasting spot prices of tankers and bulk carriers. It was found that VECM model was more accurate in many cases as compared to other models. The lead-lag relationship and volatility transmission between container freight markets and dry bulk shipping markets after 2008 financial crisis was investigated in (Hsiao, Chou, and Wu 2013) using GARCH-BEKK model where the results shows that the Baltic dry index leads the container freight index during financial crisis and vice versa after the financial crisis.

3. Methodology

The stationarity of the series is tested with the help of Unit root tests which are, Augmented Dickey Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. Thereby, (Søren Johansen 1988) Vector Error Correction Model (VECM) is employed to investigate the causal linkages between Short-Term Rates (STR) and New Building Shipping Rates (NBS). Besides, the Bivariate Exponential Generalized Auto Regressive Conditional Heteroscedasticity (Bivariate EGARCH) model is employed to examine the volatility spill over among short-term rates and new building shipping rates.

3.1. Unit root test

Let us consider an Auto regression process (1):

$$Y_t = \rho\, y_{t-1} + x_t\, \delta + \varepsilon_t \qquad (1)$$

where: x_t could be a constant trend or a constant; the parameters ρ and δ are to be estimated; ε_t is the white noise which is assumed $|Y|$.

If $|\rho| \geq 1$, then Y is a nonstationary series and variance of the *Y* increases with time and approaches infinity. If $|\rho| < 1$, then *Y* series is stationary. Therefore, the hypothesis that the series is stationary is evaluated by testing the value of ρ if it is less than one.

3.2. Augmented Dicky Fuller test

The Augmented Dicky Fuller has discussed in research paper (Dickey and Fuller 1981) in regard unit root test for testing stationarity of a time series. The standard Dickey Fuller F test is done by estimating the equation (1) by subtracting yt-1 from both the sides of the equation, then:

$$\Delta y_t = \alpha y_{t-1} + x_t\, \delta + \varepsilon_t \qquad (2)$$

where: α = ρ-1.

The null hypothesis and alternative hypothesis may be written as:

H_0: α = 0

H_1: α< 0 (3)

And is evaluated by using t- ratio for α:

$t_\alpha = \hat{\alpha} / (se(\hat{\alpha}))$ (4)

In the above equation (4) $\hat{\alpha}$ is the estimate of α and *se* $(\hat{\alpha})$ is the coefficient of standard error.

Dicky Fuller had brought forward the concept that under the null hypothesis of a unit root, the conventional student's *t*- distribution is not followed and these derive asymptotic results along with critical values for sample sizes and various tests are simulated. This is to note that the unit root test by dicky Dickey Fuller is valid when the series is Auto Regression (1) process. But if the series is correlated at higher lags then the assumption of white noise ε_t is violated. Then the Augmented Dickey Fuller test can be used to where it constructs a parametric correction for higher order correlation thereby assuming that *Y* series is an Auto Regression (*p*) process. By adding *p* Lagged difference to the independent variable *y* to the equation on the right hand of the regression, then:

$\Delta y_t = \alpha\, y_{t-1} + x_t \delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \beta_3 \Delta y_{t-3} \ \ldots + \beta_p \Delta y_{t-p} + u_t$ (5)

Thereby, this new augmented condition is used to test equation (3) by using *t*- ratio in equation (4). Fuller had obtained an important result that the asymptotic distribution of the *t*- ratio for α is independent by the number of lagged first differences which are included in the Augmented Dickey Fuller regression. From (Said and Dickey 1984) research paper, the authors demonstrate that the Augmented Dickey Fuller test is asymptotically valid when a moving average component is present and if in the regression sufficient lagged differences terms are included.

3.3. Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test

Kwiatkowski, Phillips, and Peter Schmidt and Yongcheol Shin (1992) brought forward new test where y_t is assumed to be stationary under the null. The test id based on the residuals from the original least square regression of y_t on the exogenous variables x_t:

$Y_t = x_t' \delta + u_t$ (6)

The definition of Linear Model statistic is given by:

$LM = \sum_t S(t)^2 / (T^2 f_0)$ (7)

where: f_0 is an estimator of the residual spectrum at zero frequency and *where S(t)* is residual function which is cumulative:

$S(t) = \sum_{r=1}^{t} \hat{\mu}_r$ (8)

Now, based on the residuals $\hat{\mu}_r = y_t - x_t \delta(0)$. This is to note that the estimator δ used in the above calculation is different from the δ used by the GLS since this is based on a regression relating the original data and not the quasi-differenced data.

3.4. Johansen's Cointegration and Vector Error Correction model (VECM)

Given the nature of the time series data, In the analysis the first step is to determine the order of integration of each time-series using Augmented Dickey-Fuller (Dickey and Fuller 1981) test. Given a set of two I(1) series[1], (Søren Johansen 1991, Søren Johansen 1988) tests can be used to determine in a long-run whether the series stand in a relationship between them, *i.e.,* they are cointegrated. The subsequent VECM (Søren Johansen 1988) is estimated:

$$\Delta X_t = \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t \ ; \quad \varepsilon_t \mid \Omega_{t-1} \sim distr(0, H_t) \tag{9}$$

where: 2x1 vector is the X_{t-1} $(STR_t, NBS_t)'$ of log-Short-term Rates and log-New Building Shipping Rates, respectively.

[1] I (1) stands for a time-series which is integrated of order 1; that it is needed to be differenced once to become stationary.

The difference operator is denoted by Δ, ε_t is a 2x1 vector of residuals ($\varepsilon_{S,t}$, $\varepsilon_{F,t}$) that follow an as-yet-unspecified conditional distribution with mean zero and time-varying covariance matrix, H_t. The specification of VECM contains information about the on the Long run and short run adjustments in X_t, through the parameters estimated in Γ_i and Π, respectively.

The cointegration in both the series can be identified by using two likelihood tests. By presence of only single cointegrating equation, we can state that the variables are co integrated. The presence of number of cointegrating vectors is whether one or zero can be found by λ_{trace} tests. Whether, one or two cointegrating equations is required can be found by λ_{max} test. If the cointegrating vector is correct is correct, the test statistic can be constructed as shown below,

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{n} 1n\left(1-\widehat{\lambda}_i\right) \quad (10)$$

$$\lambda_{max}(r, r+1) = -T1n\left(1-\widehat{\lambda}_{r+i}\right) \quad (11)$$

where number of observations is denoted by T and eigen values obtained from estimate of Π matrix is denoted by $\widehat{\lambda}_i$.

The null hypothesis that there are at most r cointegrating vectors is tested by λ_{trace}, against the alternative that the number of cointegrating vectors is greater than r and the λ_{max} tests the null that the number of cointegrating vectors is *r*, against the alternative of r + 1. From (Osterwald-Lenum 1992) the critical values of λ_{trace} and λ_{max} of the statistics are provided.

From (Soren Johansen and Juselius 1990), we can derive that the essential relationship information between STR_t and NBS_t is contained in coefficient of matrix Π. Especially, if rank (Π) =0, then Π is 2x2 is a zero matrix which suggests there is cointegration between STR_t and NBS_t,. Thereby, the VECM reduces to a VAR model in first difference. If rank (Π) = 2, that is if Π has a full rank, then all variables in X_t are I (0) and to estimate VAR model in levels would be the right strategy. If rank(Π) = 1, that is if Π is a reduced rank, then there would be a presence of single cointegrating relationship between STR_t and NBS_t, which is represented by matrix Π of any row and error correction term is given by ΠX_{t-1}. The Π be factored in two matrices α and β where both are of dimensions 2X1. Here 1 signifies the rank of Π and Π = αβ, where α is the vector of error-correction coefficients which measure the speed of convergence to the long-run steady state and β signifies the vector of cointegrating parameter.

From (Granger 1988), if short term rates and New building ship prices are cointegrated then there must exist Granger causality in direction. Whether two variables move contemporaneously can be identified by Granger Causality. When they move one after the other, each variable provides no information for characterizing the other. If "X causes Y", then changes in X should precede changes in Y. Consider the VECM specification of Equation (1), which can be written as follows:

$$\Delta STR_t = \sum_{1=1}^{p-1} a_{STR,i}\Delta STR_{t-i} + \sum_{1=1}^{p-1} b_{STR,i}\Delta NBS_{t-i} + a_{STR}z_{t-1} + \varepsilon_{STR,t} \quad (12)$$

$$\varepsilon_{i,t} \mid \Omega_{t-1} \sim distr(0, H_t)$$

$$\Delta NBS_t = \sum_{1=1}^{p-1} a_{NBS,i}\Delta_{STRt-i} + \sum_{1=1}^{p-1} b_{NBS,i}\Delta NBS_{t-i} + a_{NBS}z_{t-1} + \varepsilon_{F,t} \quad (13)$$

where: $a_{S,i}$, $b_{S,i}$, $a_{F,i}$, $b_{F,i}$ are the short-run coefficients, $z_{t-1} = \beta' X_{t-1}$ is the error- correction term (ECT) from equation (12) and (13), and $\varepsilon_{S,t}$ and $\varepsilon_{F,t}$ are residuals.

In the above equations of Vector Error Correction Model, the unidirectional causality from NBS-to-STR (NBS_t Granger causes STR_t) requires: (i) that some of the $b_{STR,i}$ coefficients, i = 1, 2, …, p-1, are non-zero and/or (ii) a_S, the error-correction coefficient in Equation (4), is significant at conventional levels. Similarly, unidirectional causality from STR-to-NBS (STR_t Granger causes NBS_t) requires: (i) that some of the $a_{NBS,i}$ coefficients, i = 1, 2, …, p-1, are non-zero and/or (ii) a_F is significant at conventional levels. From (Granger 1988) there could be a two way feedback relationship between STR_t and NBS_t if the both variables Granger cause each other. Wald tests can be used to test this hypothesis on the joint significance of the lagged estimated coefficients of ΔSTR_{t-i} and ΔNBS_{t-i}. When the

residuals of the error-correction equations exhibit heteroscedasticity, the t-statistics are adjusted by (White 1980) heteroscedasticity correction.

3.5. Bivariate Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) model

Besides, the present study uses the Bivariate EGARCH (1, 1) model to examine the volatility spill over mechanism. Although the GARCH-type models are popular in modelling the volatility process in financial series, the empirical results investigated provide evidence that the EGARCH model can more accurately explain the volatility dynamics (Bhar 2001, Watkins and McAleer 2002). This model is proposed by (Nelson 1991) to capture asymmetric features of time-series. This model expresses the conditional variance of a given variable as a non-linear function of its own past values of standardized innovations that can react asymmetrically to good and bad news. Thus, the present study proposes the following bivariate EGARCH (1,1) model to examine the volatility spill over mechanism:

$$\ln(\sigma^2_{STR,t}) = \omega_{STR} + \alpha_{STR}\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \sqrt{\frac{2}{\Pi}}\right| + \tau_{STR}\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \gamma_{STR}\ln(\sigma^2_{2,t-1}) + \gamma_{STR}\ln(\varepsilon^2_{NBS,t-1}) \quad (14)$$

$$\ln(\sigma^2_{NBS,t}) = \omega_{NBS} + \alpha_{NBS}\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \sqrt{\frac{2}{\Pi}}\right| + \tau_{NBS}\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \gamma_{NBS}\ln(\sigma^2_{2,t-1}) + \gamma_{NBS}\ln(\varepsilon^2_{STR,t-1}) \quad (15)$$

The un auto correlated residuals, $\varepsilon_{NBS,t}$ and $\varepsilon_{STR,t}$ in equation (12) are obtained from the VECM (12) and (13), and Ω_{t-1} is the information set at $_{t-1}$. Equations (14) to (15) are then simultaneously estimated by maximizing the log-likelihood function:

$$L(\theta) = -\sum_{t-1}^{T}(\ln[\Omega_t] + \varepsilon_t\,'\Omega_t^{-1}\varepsilon_t) \quad (16)$$

where: Θ is the 13X1 parameter vector of the model.

This two-step approach (the first step for the VECM and the second step for the bivariate EGARCH model) is asymptotically equivalent to a joint estimation of the VECM and EGARCH models. In practical sense, a large number of parameters should be involved in estimating VECM and EGARCH model simultaneously in one step and it will be intricate task. Moreover, for estimating the volatility spill over the residuals of Error Correction Term should be included in the conditional variance equation. Otherwise the model will be mis specified and the residuals obtained in VECM will be biased. The left-hand side of the equation is the log of the conditional variance. This suggests that the leverage effect is exponential, rather than quadratic and that forecasts of the conditional variance are guaranteed to be nonnegative. The presence of leverage effects can be tested by the $\gamma_i < 0$. If $\gamma_i \neq 0$ then impact is asymmetric.

Equation (14) and (15) explains a conditional variance which defines the generating process for the natural logarithm of conditional variance. EGARCH emphasizes that the asymmetric function of past innovation shocks. γ refers to the magnitude of persistence of variance. When the closer magnitude approaches unity, the greater persistence of shocks to the volatility. The positive and negative anticipates excess the returns determine the future variance, measured by β and α. α represents the magnitude effect. If α >0, innovation in log (σ) is then positive when magnitude of (σ_{-j}) is larger than its expected value and vice versa. β is a sign of effect. If β is 0, then there is a non-existence of asymmetric volatility. If β > 0 and statistically significant, which signifies the volatility of return's shock is asymmetric. The positive volatility innovations are greater than the same magnitude of negative innovations. If β<0, and statistically significant, the volatility of return's shock is asymmetric and negative volatility innovations is larger than same magnitude of positive shocks. The negative β represents the persistence of leverage effect.

Data

For the study, a specific class of LNG vessels with a volume carrying capacity of between 160,000 to 173000 cbm have been considered. For the identified class, monthly short term charters rates from April 2005 till August 2015 are obtained for the study. Simultaneously, monthly new ship building prices for the same class and time period are obtained. The rates and prices are collected from Drewry Maritime Consultants, India.

4. Empirical results and discussion

Table 1 shows the presence of unit root in the series tested using ADF and KPSS tests. The critical value of ADF test for the short-term rates and new building shipping rates are greater than computed test statistics at levels,

which lead to conclude that the data of the time series for the entire study period are non-stationary. And the critical value of KPSS test for the short-term rates and new building shipping rates are lesser than computed test statistics at levels, implying the selected series are non-stationary during the study period. Both the ADF and KPSS test statistics reject the hypothesis of non-stationary once the time-series are first differenced. Hence, the results of both the tests confirm that the series are stationary and integrated at order, I (1).

Table 1. Results of Unit Root Test

Model	STR		NBS		Critical Value	Critical Value	Critical Value
	Test Statistic						
	Level	1st difference	Level	1st difference	1%	5%	10%
Augmented Dickey-Fuller	-1.85	-10.77*	-1.85	-11.05*	-3.48	-2.88	-2.57
Kwiatkowski-Phillips-Schmidt-Shin	0.35***	0.10	0.52**	0.14	0.73	0.46	0.34

Notes: *, ** & *** indicates significance at 1%, 5% and 10% level, respectively. STR and NBS are the short-term rates and new building shipping rates, respectively. Optimal lag length is determined by the Schwarz Information Criterion (SIC) and Newey-West using Bartlett kernel criteria for the Augmented Dickey-Fuller Test and Kwiatkowski-Phillips-Schmidt-ShinTest, respectively.

Once the short-term rates and new building shipping rates are integrated at same order, the Cointegration test is employed to examine the long-run relationship between them and the results are reported in Table 2. The results of Johansen's maximum eigen (λ_{max}) and trace statistics (λ_{trace}) indicate the presence of one cointegrating vector between the short-term rates and new building shipping rates at 5% level. Henceforth, the empirical results suggest that there exists long-term equilibrium relationship between short-term rates and new building shipping rates during the study period. It can be concluded that the short-term rates and new building shipping rates lead in the long run.

Table 2. Results of Johansen Cointegration test

Name of the variables	Vector(r)	Trace test statistics (λ_{trace})	Maximal Eigen value (λ_{max})	5% Critical value for trace statistics	5% Critical value for Max-Eigen statistics	Remarks
Short-term Rates & New Building Prices	H_0: r = 0	26.63356**	21.40467**	25.87211	19.38704	Cointegrated
	H_1: r ≥ 1	3.228885	3.228885	12.51798	12.51798	

Notes: ** indicates significance at 5% level. The significant of the statistics is based on 5% critical values obtained from Johansen and Juselius (1990). *r* is the number of cointegrating vectors. H0 represents the null hypothesis of presence of no cointegrating vector and H1 represents the alternative hypothesis of presence of cointegrating vector.

The Granger Representation Theorem (Engle 1987) states that if a set of variables are cointegrated, then there exist valid error correction representations of the data. The estimation results of Vector Error Correction Model (VECM) have been presented in Table 4. Besides, the Vector Error Correction Model is sensitive to the selection of optimal lag length and the results of lag length selection criteria are reported in Table 3. On the basis of Schwarz Information Criterion (SIC), the table results reveal that necessary lag length of short-term rates and new building shipping rates is one.

Table 3. Results of VAR Lag Length Selection

(I) Lag	LogL	LR	FPE	AIC	SC	HQ
0	106.2799	--	0.000577	-1.782562	-1.735345	-1.763393
1	363.2376	500.7380*	7.64e-06*	-6.106625*	-5.964975*	-6.049117*
2	363.7544	0.989476	8.11e-06	-6.047083	-5.811000	-5.951236
3	364.8114	1.987613	8.53e-06	-5.996777	-5.666260	-5.862591
4	366.9902	4.022287	8.80e-06	-5.965644	-5.540694	-5.793119
5	372.1406	9.332444	8.63e-06	-5.985310	-5.465927	-5.774447
6	373.4409	2.311602	9.05e-06	-5.939161	-5.325344	-5.689959
7	374.8878	2.522895	9.46e-06	-5.895519	-5.187269	-5.607978
8	376.7688	3.215243	9.82e-06	-5.859295	-5.056612	-5.533416

Notes: * indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at 5% level). FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion.

In Table 4, the coefficient of error correction term (ECT) provide some insight into the adjustment process of short-term rates and new building shipping rates towards equilibrium. The table result shows that coefficient of the error correction term in the short-term rates equation is statistically significant and negative (-0.0763) at five percent significant level, implying that the short-term rates makes the greater adjustment in order to re-establish the equilibrium. Similarly, the coefficient of the error correction term in the new building shipping rates equation is statistically significant and negative (-0.0059) at ten percent significant level, implying that the new building shipping rates makes the lesser adjustment in order to re-establish the equilibrium. This indicates bidirectional relationship between the short-term rates and new building shipping rates during the study period. However, the absolute value (size) of the error correction coefficient of short-term rates is relatively greater than new building shipping rates; therefore, it can be concluded that new building shipping rates leads to the short-term rates. This may be because of new building shipping rates seem to be more innovative that enables them to expose the all available new information with respect to the short-term rates. This shows that new building shipping rates have the capability to expose the all new information through the channel of its new innovation.

Table 4. Results of Vector Error Correction model

Parameters	ΔSTR_t	ΔNBS_t
ECT	-0.076346** (0.03057) [-2.49783]	-0.005972*** (0.00341) [-1.75145]
ΔSTR_{t-1}	0.135163 (0.08592) [1.57315]	-0.000153 (0.00959) [-0.01591]
ΔNBS_{t-1}	0.625428 (0.82551) [0.75762]	0.020366 (0.09210) [0.22114]
C	-0.000300 (0.01459) [-0.02059]	0.000194 (0.00163) [0.11948]

Notes: Optimal lag length is determined by the Schwarz Information Criterion (SIC), STR and NBS are the short-term rates and new building shipping rates, respectively. ** and *** denote the significance at 5% and 10% level, respectively. [ ] & ( ) - Parenthesis shows t-statistics and standard error, respectively.

The descriptive statistics of the short-term rates and new building shipping rates are presented in Table 5. The STR and NBS are positive, indicating the fact that rates have increased over the period. The descriptive statistics shows that the rates are positively skewed and kurtosis values are not equal to three, indicating that the series does not follow normal distribution and is further confirmed by Jarque-Bera test statistics, which is statistically significant and hence the null hypothesis of normality is rejected.

Furthermore, (Engle 1982) ARCH-LM test statistics was conducted to test the null hypothesis of no ARCH effects on the short-term rates and new building shipping rates and its result are shown in Table 5. The ARCH-LM test statistics are found to be statistically significant, confirming the existence of significant ARCH effects on the short-term rates and new building shipping rates during the study period.

Table 5. Descriptive statistics

Statistics	STR	NBS
Mean	10.97679	5.356635
Standard Deviation	0.476446	0.056963
Skewness	0.212009	1.260564
Kurtosis	1.999860	4.013311
Jarque-Bera Statistics	6.146204** (0.046277)	38.45252* (0.00000)
ARCH-LM Test Statistics	4.046535** (0.046484)	3.108647*** (0.096066)

Notes: *, ** and *** denote the significance at the one, five and ten per cent level, respectively.

Figure 1 and 2 shows the volatility clustering of short-term rates and new building shipping rates, respectively. The graphical representation of the residuals obtained from the short-term rates and new building shipping rates exhibits significant ARCH effects *i.e.* volatility clustering or volatility persistence. This implies that the

period of low volatility tends to be followed by period of low volatility and the period of high volatility is followed by period of high volatility, which signifies the volatility is clustering.

By and large, the evidence from the ARCH LM test statistics as well as Graphical representation suggests that the Bivariate EGARCH model is capable with generalized error distribution (GED) is deemed fit for modelling the volatility of short-term rates and new building shipping rates, as it sufficiently captures the volatility clustering and heteroscedastic effects. Table 6 shows the estimates of Bivariate EGARCH model to determine the volatility spill over mechanism takes place between short-term rates and new building shipping rates.

Figure 1. Volatility clustering of short-term rates

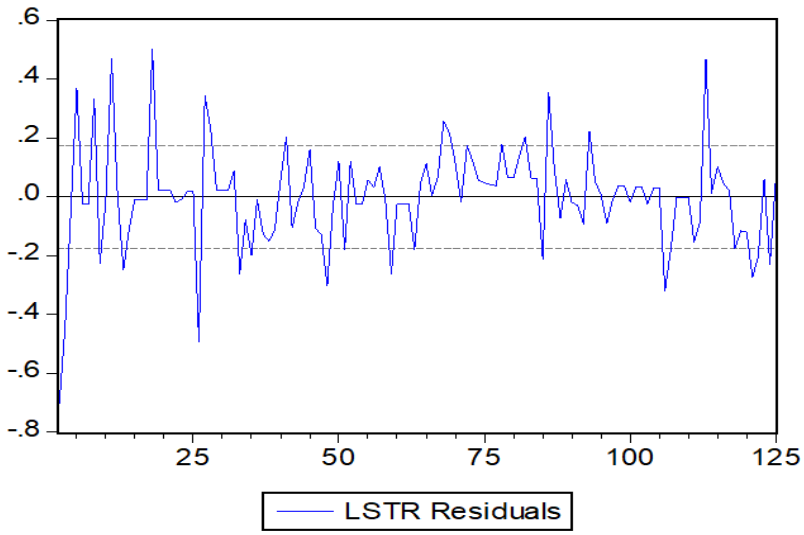
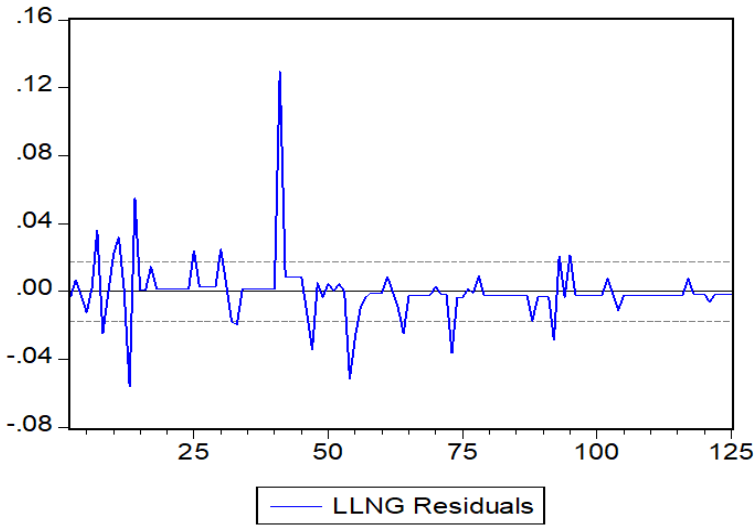


Figure 2. Volatility clustering of new building shipping rates



The empirical evidence reveals that the GARCH effects (measured by α_i) for short-term rates is statistically significant, implying the degree of volatility is persistent. This suggests that once a shock has occurred, volatility tends to persist for long periods in the case of short-term rates. The leverage effect parameters (τ_i) are statistically significant for both short-term rates and new building shipping rates, indicating existence of leverage effect. This indicates that negative shocks have a greater impact on conditional volatility than positive shocks of equal magnitude in the case of short-term rates and new building shipping rates. This signifies that volatility is higher after negative shocks (bad news) rather than after positive shocks (good news) of the same magnitude.

Most importantly, the table result shows that the spill over coefficient (γ_i) of new building shipping rates in the short-term rates equation is statistically significant, implying that unidirectional spill over exists from the new building shipping rates to short-term rates. The evidences from Bivariate EGARCH show that volatility spill over effect exists from the new building shipping rates to short-term rates during the study period.

Table 6. Results of bivariate EGARCH model for volatility spill over

Parameters	Short-term rates	New Building Shipping rates
ω_i	-1.503838* (-3.378195)	-10.54364* (-3.800650)
ψ_i	-0.298032** (-2.202460)	0.086741 (0.988879)
τ_i	-0.307527* (-3.572429)	-0.311357* (-3.765906)
α_i	0.551040* (4.429149)	0.291901 (0.867991)
γ_i	11.35897** (2.149476)	0.308123 (0.424805)
Residual Diagnostics		
ARCH-LM Statistics	0.010355 (0.919117)	0.008684 (0.925910)

Notes: Figures in parenthesis are z-statistics. * and **- denote the significance at one and 5% level, respectively. ARCH-LM is a Lagrange Multiplier test examines the null hypothesis of ARCH effects in the residuals (Engle 1982).

To check the robustness of Bivariate EGARCH estimates for the short-term rates and new building shipping rates, the ARCH-LM (Engle 1982) test was employed to test the absence of any further ARCH effects. As can be seen in Table 6, the ARCH-LM statistics indicate that no serial dependence persists left in squared residuals. Hence, the results suggest that Bivariate EGARCH model was reasonably well specified and most appropriate model to capture the ARCH (time-varying volatility) effects in the time series analyzed for short-term rates and new building shipping rates.

Conclusion

From the above results, it is clear that there exists a long term relationship between new shipbuilding prices and Short term charter rates in LNG shipping. The VECM results in Table 4 it is clear that new shipbuilding prices are affecting the short term charter rates. It is evident that LNG new ship order book looks promising. Increased supply and falling new shipbuilding prices are influencing the short term charter rates. Thus, there is a need for the investors to wait for a while for new orders of LNG vessels until the short term charter rates gain over a period of time.

From the analysis, we could find presence of leverage effects in short term charter rates. The negative shocks in short term charter rates are impacting on volatility for a longer time than the positive shocks *i.e.* sudden fall in the charter rates are likely to stay for longer time than sudden rise in charter rates. This implies that vessel owners are likely to be affected by sudden fall in charter rates which in turn would put pressure on the profits. From the Figure 1, we could find persistent negative shocks which are significant and presence of volatility asymmetry indicating new ship building prices are affect ted by negative news as compared to positive news. This indicated that volatility spill over is asymmetric. Therefore, the vessel owners could be cautious and wait to avoid the risk of high and low returns in the new ship building prices.

Disclosure statement

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Selected Aspects of the Corporate Income Tax in Slovakia

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Abstract:

Since its establishment in 1993, the Slovak Republic has been undergoing gradual changes that did not leave out the area of tax policies. The aim of the paper is to examine the tax system of Slovakia, focusing primarily on corporate income tax, which is an important part of direct taxes and which affects all the incomes of legal entities subject to this tax. We outline the issue of taxes including the identification of the importance of corporate income tax in the tax system of the country. Our analyses are based on the structure of government revenues in Slovakia, the structure of tax subjects, but also on corporate income tax per one entity, while we also identify and characterize the selected legislative provisions covering the taxation of corporate income and their development since the establishment of independent Slovakia arose. Based on observations for the last available year 2017 on a sample of 1315 Slovak companies, we investigate and evaluate the intensity and tightness of the statistical dependence between the corporate income tax payable and the indicators: the profit or loss, the revenues and the value of the legal entity's assets.

Keywords: taxable income; corporate income tax; tax entity; tax base; income current tax

JEL classification: H25; H21; M48

1. Introduction

Taxation of economic activities of legal entities can be viewed from two points of view. One is the effort of the state and the self-government bodies to maximize the income to the public budgets, the other is the interests of taxpayers and their attitudes towards taxation. Taxes are an important part of business rules because they influence the choice of business forms and the majority of economic decisions of business entities.

The corporate income tax in Slovakia must be calculated and paid by the legal entity itself. The basis for determining the tax base is the accounting profit/loss, which is transformed on a tax base in accordance with the law by the system of tax deductible items and tax non-deductible items. Due to the complexity of the correct calculation of the tax base it is necessary to get a thorough knowledge of the tax regulations, which change very often in the conditions of Slovakia. It is also necessary to carry out a thorough tax analysis of cost account and revenue accounts. Some items of costs and revenues will be included to the tax base only after they have been paid, some are limited by law or special regulations, the application of some of them is totally excluded. Based on our experience, transforming the profit/loss before tax into a tax base often causes problems for legal entities.

Some other variables may also have a significant impact on the amount of the corporate income tax payable. In the paper, we investigate and evaluate the intensity and tightness of the statistical dependence between corporate income tax payable and selected indicators, which in this case will be the revenues, the profit or loss and the value of the assets of the legal entity.

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2. Literature review

From the legal point of view, the tax system is seen as a summary of tax laws and the related legal standards, tax authorities and similar institutions, and the relationship between these bodies and tax subjects. General requirements for tax systems: fairness, economic efficiency, transparency and legal perfection, flexibility, positive economic impact on subjects, tax security (Korečko and Suhányiová 2012). The tax system of each state, according to Baštincová (2016), is the result of state's political, economic and cultural development, and therefore the result of prevailing opinions and needs. The aforementioned thus forms a basis for various elements of these taxes - the subject matter of the tax, tax subjects, the tax base and the tax rate.

The literature on this topic offers different definitions of taxes. From a historical point of view, taxes could be seen as a form of state coercion. Today, taxes can be viewed from a political point of view (taxes as a tool of a ruling class, parties, etc.), from a social point of view (the impact of the tax on tax subjects and the population, the consequences of taxation, etc.), from the international point of view (international aspects of taxation, in particular tax harmonization), from a legal point of view (tax as a compulsory payment and its enforceability) and from an economic and financial point of view (fiscal relations between the tax entity and the state) (Vlachynský *et al.* 2012, 60).

Harumová (2002, 8), Jakúbek and Tej (2015) see taxes from two points of view – formal and economical. They state that, from a legal point of view, taxes are a compulsory, lawful, non-purposeful and non-equivalent payment paid by taxpayers within the pre-set deadlines to the relevant public authority. From an economic point of view, taxes are seen as a fiscal (financial) relationship between the taxpayer and the state which is governed by the law. The government secures its objectives through taxes.

Schultzová *et al.* (2011, 12) states that taxes belong to a group of indirect economic management tools as they are a tool for reallocating already created products, and significantly affect the size of disposable income of individual entities. Taxes and their use are governed by tax policies in every economy. Tax policy, which is very closely related not only to the fiscal but also to the economic policy of the state as such, governs the application of tax principles and measures so that taxes can help achieve the economic, social and political objectives of the state.

Through taxes, the state affects many microeconomic as well as macroeconomic variables such as unemployment, economic growth in the country, inflation, foreign investment, population consumption and the like (Korečko and Suhányiová 2012, 20).

According to Vlachynský *et al.* (2012, 59) taxes can be broken down according to the following criteria:

1. the form in which they are implemented - natural taxes (in the past) and monetary taxes;
2. regularity of their payment - one-off taxes and recurring taxes;
3. tax entity - taxes paid only by natural or legal persons or taxes paid by both natural and legal persons;
4. subject of the tax - income tax, property tax, excise duties, etc.;
5. what is taxed - value taxes, specific taxes and neutral taxes;
6. impact on the income of a taxed person - direct taxes and indirect taxes;
7. whether the subject to tax is a person or thing - personal taxes and real estate (property) taxes;
8. budget law - national taxes and local taxes;
9. influence on market mechanism and behaviour of economic subjects – distortion and neutral taxes;
10. the place and significance of taxes in the tax system - decisive (major) taxes, additional taxes and registration taxes;
11. method - contingency taxes and quota-based taxes.

To a lesser extent, taxes can be broken down into expenditure tax and withholding taxes, fair and unfair taxes, emission taxes, taxes on non-built-up land, taxes on housing, etc.

The most important types of taxes are income taxes because they represent a significant part of the revenues of the state budget and are paid by both natural and legal persons. Income tax is a direct tax and is found in the tax system of all developed countries. Income tax can be further broken down into:

- personal income tax;
- corporate income tax.

In terms of volume and impact on business entities, we consider the corporate income tax to be the most important one. That is why every country pays due attention to it. The subject of this tax according to Jakúbek and Tej (2016) is all income and revenues from all activities and assets, unless they are exempt from tax. Usually, the tax base in case of corporate income tax is the difference between income (revenues) and expenses incurred to

achieve, secure and maintain revenues. Tax rates and tax systems can be set differently in different tax systems - progressive, sliding, proportionate.

Corporate income tax is seen as a part of the company's costs in Slovakia and, like any other cost, directly affects the amount of profit after tax on income. The corporate income tax, pursuant to Act no. 595/2003 Coll. on Income Tax (hereinafter the Income Tax Act) can have two forms:

- income current tax;
- deferred income tax.

The purpose of the income current tax is to capture the current tax effect of business transactions carried out during the current accounting and taxation period. The purpose of the deferred income tax is to capture the future tax effect of current business transactions. Baštincová (2016) defines the issue similarly. She claims that income current tax is a tax liability for the current accounting and taxation period that a legal person has to pay to the tax office within specified deadline. Deferred income tax is not disclosed in the tax return and is not paid to the tax office. Deferred income tax arises from different legislative approaches to some items affecting the tax base.

3. Methodology

In order to achieve the main objective of the contribution, which is to "examine the tax system of Slovakia with an emphasis on the corporate income tax which forms an important part of direct taxes and affects the income of legal entities subject to tax", we set partial objectives.

The first partial objective is to examine the structure of government revenues in Slovakia, the structure of tax subjects and the corporate income tax of the entity. We have collected data from source documents published by the Ministry of Finance of the Slovak Republic as well as data published by the Statistical Office of the Slovak Republic. We analysed the collected data from a quantitative point of view and evaluated it from a qualitative point of view. We evaluated the government revenues for the period of the last 15 years - from 2003 to 2017. We also focused on the assessment of the number of economic subjects in Slovakia in 2017. On the basis of obtained information, we have identified income from corporate income tax per legal entity.

The second partial objective is to examine selected legislative provisions regarding corporate income tax. In fulfilling the second partial objective, we based our observations on the Income Tax Act of the Slovak Republic. Using the descriptive method, we divided the taxpayers (legal persons) according to tax liabilities. We also defined the term taxpayer, the subject to income tax, the tax base, the transformation of the profit before tax into the tax base, tax advance payments. We paid close attention to the corporate income tax rate where we addressed its development since the establishment of the Slovak Republic in 1993.

The third partial objective is to examine and evaluate the intensity of statistical dependence between selected indicators. We used the correlation analysis to investigate the intensity of statistical dependence between the selected quantitative variables. The analysis does not reflect the relationship between causes and consequences, that means that the variable y is independent of the variable x, but rather whether the two random variables x and y change with each other. The correlation coefficient measures the linear relationship of the two variables (Šoltés 2008).

The test data set consists of 1,315 Slovak companies, which were randomly selected from approximately 200,000 companies in the Fin Stat database (2018). The database processes data from the Business Register, Financial Statements Register and the like. Our aim was to identify the relationship between selected quantitative variables - income, profit/loss, property and corporate income tax. Using Spearman's correlation coefficient, we tested whether there was a statistically significant relationship between the variables. We were mainly interested in the relationship between the three selected variables and the corporate income tax.

To test normal distribution of random variables we used Shapiro-Wilk normality test ($\alpha = 0.05$). The test proved that the variables are distributed normally. To determine the strength of the relationship between the observed variables we used Pearson's correlation coefficient which takes values from the interval <-1, 1>. The analyses were performed using the statistical software "R" (version 3.4.1) and its packages: *Hmisc, polycor, corrgram* and others. The subsequent regression analysis of selected variables ($\alpha = 0.05$) was performed in the MS Excel using the "Data Analysis" and "Regression". The point estimate of the linear regression line is the following function:

$$y_j' = b_0 + b_1 x_j \quad (1)$$

where: b_0 the intercept; b_1 the regression coefficient; y_j' theoretical values of the dependent variable; x_j independent variable values.

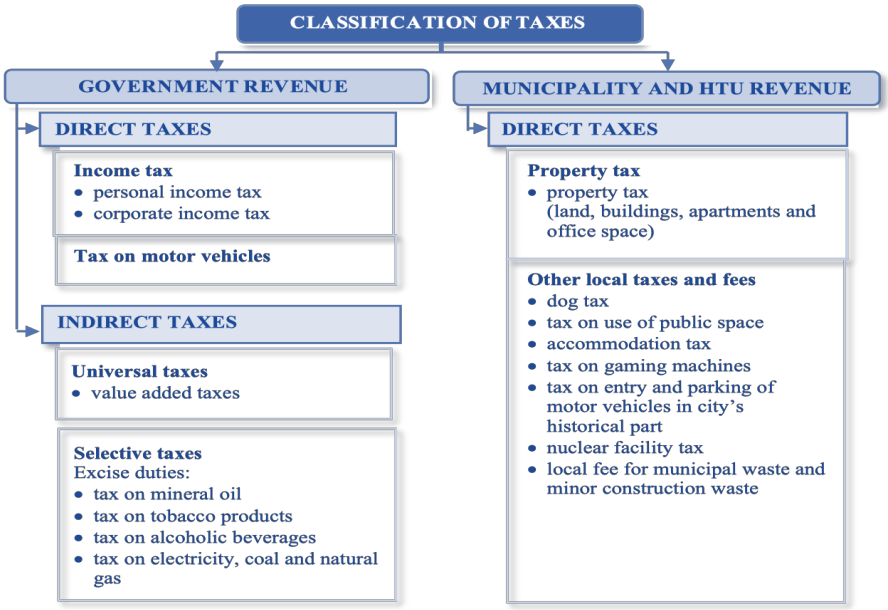
In our analysis, the dependent variable is the corporate income tax.

4. Corporate income tax in Slovakia

4.1 Analysis of the tax system in Slovakia and the structure of tax subjects

We generally understand the tax system as the sum of all taxes that are levied in the territory of a country at a certain time. Its role is to secure income to cover all necessary state expenditures. The Slovak tax system is the result of the tax reform made in 1993 as part of the transformation of our economy into a market economy. The tax systems changed dramatically over the last 26. Other major amendments, or completely new tax laws, were drawn up in line with the requirements of the European Union. The current tax system of Slovakia corresponds to the tax systems of the developed market economies in the European Union (Suhányiová and Petrišová 2011).
The current tax system of Slovakia is made up by the direct and indirect taxes, as shown in Figure 1.

Figure 1. Tax classification in Slovakia according to the tax recipient



Source: own processing

The tax system of the Slovak Republic is defined in the Income Tax Act, the Motor Vehicle Tax Act, the Value Added Tax Act, four Acts on excise duties and the Local Taxes Act and Local Fees for Municipal Waste and Small Construction Waste Act. At present, Slovakia imposes 15 taxes (see Figure 1) which are governed by individual tax laws. According to their nature, taxes are divided into direct taxes and indirect taxes. Direct taxes are levied directly from a taxpayer whose income or assets are subject to tax (income tax and property tax). Indirect taxes (also called excise duties) are usually paid by the payer of the tax - value added tax and excise duties. Tax collection is secured by:

- financial administration (state budget revenues - income tax, motor vehicle tax, value added tax, excise duties);
- municipalities (budget of municipalities - local taxes).

It should be noted that the income tax of natural persons is collected by the financial administration which subsequently redistributes it as follows:

- 70% of the total personal income tax income goes to municipalities;
- 30% of the total personal income tax goes to higher territorial units. Slovakia has 8 higher territorial units and 2,890 municipalities, of which 140 are towns.

As far as tax on motor vehicles is concerned, by 2015 the money from this tax went to higher territorial unit. However, from 1 January 2015 tax on motor vehicles is the revenue of the state. It means that the tax on motor vehicles is no longer regarded as a local tax.

As can be seen from the above, tax revenues are considered public revenues in Slovakia. Public revenues are the revenues of all public budgets - the state budget, budget of higher territorial unit, municipal budgets, extra-budgetary funds (*e.g.* social insurance) and budgets of public organizations.

The main source of Slovakia's income are the taxes that the individual entities pay at the stipulated amount and within certain deadlines. Taxes are one of the most important instruments of the country's economic policy. The tax revenues consist mainly of income tax, value added tax and excise duties (see Table 1).

Table 1. State's revenues (ESA 2010) in mil. EUR

	2003	2004	2005	2006	2007	2008	2009	2010
Tax revenues *of which:*	7,636	7,808	9,017	9,461	10,644	11,270	9,954	10,083
-personal income tax	1,304	931	1,302	1,530	1,810	2,073	1,708	1,691
-corporate income tax	1,095	1,098	1,472	1,576	1,878	2,104	1,614	1,623
-value added tax	3,031	3,507	3,880	4,165	4,166	4,654	4,231	4,186
-excise duties	1,268	1,499	1,804	1,597	2,178	1,809	1,763	1,931
-other tax revenues	938	773	559	593	612	630	638	652
Social security contributions	5,549	5,689	6,111	6,607	7,228	8,070	7,993	8,183
Non-tax revenues (fees, fines, penalties)	2,466	2,904	2,030	2,804	2,248	2,829	2,657	2,548
Grants and transfers	7	296	488	230	261	327	595	736
TOTAL REVENUES	15,658	16,697	17,646	19,102	20,381	22,496	21,199	21,550
	2011	2012	2013	2014	2015	2016	2017	Change between 2003- 2017
Tax revenues *of which:*	10,897	10,997	11,565	14,579	14,158	14,568	15,344	7,708 (200.9%)
-personal income tax	1,873	2,065	2,072	4,195	2,657	2,695	2,605	1,301 (199.8%)
-corporate income tax	1,659	1,689	1,808	2,211	2,717	2,942	2,635	11,540 (240.6%)
-value added tax	4,651	4,322	4,664	5,013	5,416	5,415	5,913	2,882 (195.1%)
-excise duties	2,000	1,973	1,985	2,015	2,108	2,174	2,252	984 (177.6%)
-other tax revenues	714	948	1,036	1,145	1,260	1,342	1,939	1,001 (206.7%)
Social security contributions	8,514	8,973	10,040	10,075	10,761	11,435	12,534	6,985 (225.9%)
Non-tax revenues (fees, fines, penalties)	2,925	2,982	3,695	5,136	5,007	5,093	4,922	2,456 (199.6%)
Grants and transfers	875	875	810	1,217	2,638	670	666	659 (9514.3%)
TOTAL REVENUES	23,211	23,827	26,110	31,007	32,564	31,767	33,466	17,808 (213.7%)

Source: Ministry of Finance of the Slovak Republic, 2018.

In the period under review, the amount of collected taxes more than doubled. In relative terms, the most significant tax collection increase was recorded for corporate income tax (more than 140%). The amount of social and health insurance contributions increased as well. The first reason why the amount of collected taxes increased is a good performance of the economy. Other possible factors include the increase in the tax rates and improved efficiency of tax collection thanks to more thorough inspections.

After 2004, the amount of tax collected increased significantly thanks to a flat tax (linear tax) which, however, has been abolished in 2013. By introducing the flat tax, the tax burden was shifted from direct taxes to indirect taxes. This simple system was designed to minimize tax evasion. In addition, the economy marked an increase in the inflow of foreign capital into the Slovak economy thanks to the introduction of the flat tax as well as to the implementation of the economic and institutional reforms.

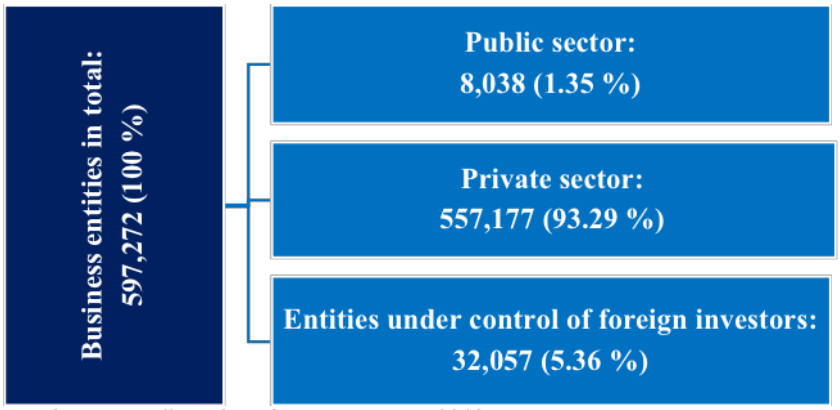
It should be also mentioned that the tax reform of 2004 also abolished the donation tax, inheritance tax, and real estate transfer tax.

After the 2009 crisis, the amount of collected taxes fell by more than 10%. The situation lasted for almost three years. The amount of collected taxes rose again after 2012 (possibly thanks to the abolition of the flat tax) and in 2017 the amount of collected taxes exceeded the amount collected in 2008 by almost 37%. In 2017, the

amount of collected taxes reached 15.34 billion EUR. The largest part of collected taxes consisted of the value added tax - 5.91 billion EUR, then the corporate tax 2.64 billion EUR, and the personal income tax - 2.61 billion EUR. Excise taxes amounted to 2.25 billion EUR.

The amount of collected taxes depends on the number and structure of economic subjects. The number and structure of economic entities in Slovakia are outlined in Figure 2.

Figure 2. Number of business entities in the Slovak Republic by sectors (ESA 2010) in 2017



Source: Statistical office of the Slovak Republic, 2018a.

Of all business entities, more than 93% belong to the private sector. The public sector consists of more than 8,000 entities representing 1.35% of the total number of business entities. An important factor in terms of the ownership structure is also the foreign controlled enterprises operating in our economy (5.36%, *i.e.* 32,000 entities).

Table 2. Number of business entities by economic activity (SK NACE Rev.2) in 2017

Business activities	Entities in total	Business sphere			Non-business sphere
		Legal Person	Natural Person	*In total*	Legal Person
A. Agriculture, forestry and fishing	25,064	7,372	17,687	25,059	5
B. Mining and quarrying	230	196	34	230	-
C. Industrial production	73,382	21,605	51,771	73,376	6
D. Electricity, gas, steam and air-conditioning supply	535	513	21	534	1
E. Water supply, sewerage, waste management and remediation	1,585	1,047	483	1,530	55
F. Construction	94,706	19,801	74,893	94,694	12
G. Wholesale and retail trade, repair of motor vehicles and motorcycles	120,181	48,490	71,688	120,178	3
H. Transportation and storage	21,659	10,710	10,931	21,641	18
I. Accommodation and food service activities	19,651	8,060	11,547	19,607	44
J. Information and communication	23,201	11,982	11,197	5,761	22
K. Financial and insurance activities	12,258	728	11,525	12,253	5
L. Real estate activities	18,426	13,152	1,998	15,150	3,276
M. Professional, scientific and technical activities	79,601	37,653	41,836	79,489	112
N. Administrative and support service activities	36,047	22,406	13,608	36,014	33
O. Public administration and defence, compulsory social security	3,233	13	-	13	3,220
P. Education	11,809	3,000	4,976	7,976	3,833
Q. Human health service and social work activities	12,676	6,655	4,516	11,171	1,505
R. Arts, entertainment and recreation	8,886	2,819	2,341	5,160	3,726
S. Other services	34,142	3,264	17,275	20,539	13,603
TOTAL	597,272 (100%)	219,466 (36.74%)	348,327 (58.32%)	567,79 (95.06%)	29,479 (4.94%)

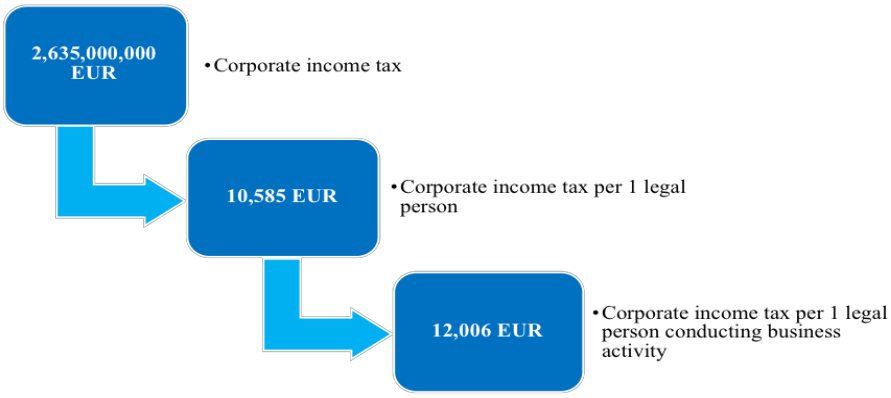
Source: Statistical office of the Slovak Republic, 2018b.

Of the nearly 600,000 business entities, more than 95% operate in the business sphere. They can either be legal persons or natural persons (doing business under a trade license or special licenses). Natural persons-

entrepreneurs make up 58.32% and the rest are legal persons, of which more than 219,000 operate in the business sphere. In the non-business sphere, there are almost 30,000 entities which are of minor importance from the point of view of corporate income tax.

From the point of view of business subjects and their economic activity, the largest share belongs to the wholesale and retail sector - repair of motor vehicles and motorcycles (up to 20.12%). Other significant contributors are "construction sector" (15.86%), "professional, scientific and technical activities" (13.33%) and "industrial production sector" (12.29%). Most legal persons - entrepreneurs in Slovakia operate in the sector "wholesale and retail - repair of motor vehicles and motorcycles" (22.09 %; *i.e.* a share of 8.12% when considering all business entities). As already mentioned above, the amount of collected corporate income tax is the second highest after the value added tax. With regard to the number of legal persons listed in Table 2, the corporate income tax per one legal person amounts to 10,585 EUR / 12,006 EUR per legal person carrying out business activities.

Figure 3. Corporate income tax in Slovakia in 2017



Source: own processing of authors, based on Table 1 and 2

4.2. Analysis of selected legislative regulations of the Slovak Republic related to corporate income tax

Income tax is a direct tax payable in Slovakia by both natural persons and legal persons (business and non-business entities). Taxation of income of legal persons and natural persons is governed by Act no. 595/2003 Coll. on Income Tax, as amended.

The third part of the aforementioned law deals with the corporate income tax and defines the taxpayer. According to its wording, Act requires tax payments from the following legal persons: associations of natural and legal persons; purposeful property associations; units of territorial self-government; other entities under the law.

The largest share of corporate income tax is paid to the state budget by associations of natural and legal persons, which are mainly trading companies (Joint Stock Company, Limited Liability Company, limited partnership, public company, legal entity established under EU law) and cooperatives. Persons who have a registered office in Slovakia or do business in Slovakia are treated differently than others. Therefore, it is important to break down taxpayers into tax residents and tax non-residents, as outlined in Table 3.

Table 3. Classification of taxpayers according to the extent of the tax liability in the Slovak Republic

A legal person as a taxpayer in the Slovak Republic may have:	
UNLIMITED TAX LIABILITY ⇩ TAX RESIDENT A tax resident is any legal entity having a registered office or a managing office in the Slovak Republic (where management and commercial decisions of statutory bodies, supervisory bodies of legal entities are adopted, even if the address is not entered in the Business Register). ⇧	LIMITED TAX LIABILITY ⇩ TAX NON-RESIDENT A tax non-resident is any legal entity that has neither a registered office nor a a managing office in the SR. ⇧
Income from sources in Slovakia and abroad are subject to income tax	Income from sources in Slovakia are subject to income tax

Source: own processing of authors in accordance with the Art. 2 of Act no. 595/2003 Coll. on Income Tax

The subject to corporate income tax is the income (revenues) from the activities of the taxpayer and management of taxpayer's assets. The Act also defines those types of income that are not subject to tax, for example:

- income from donation or inheritance;
- the share of the profit (dividends) to the extent that the dividend is not the tax expense of the taxpayer who pays out this share of the profit, the equity, the share of the liquidation balance;
- the acquisition of new shares and an increase in the share capital from the undivided profits of a joint stock company, a limited liability company or a cooperative and the like.

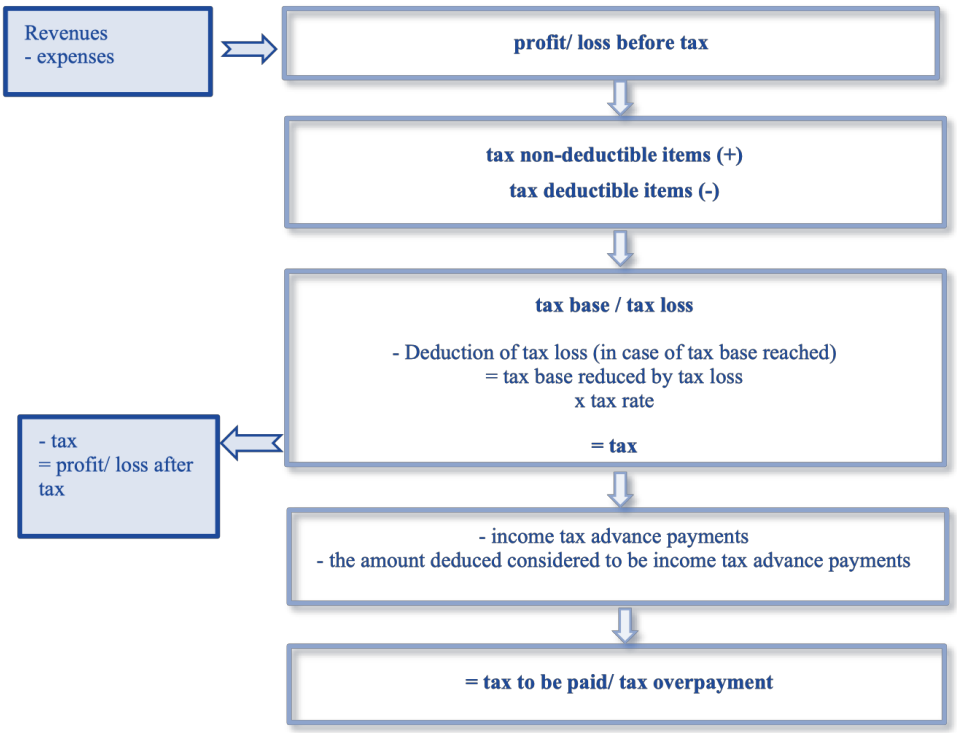
In the case of taxation of profits (dividends), the change has taken place in 2017. Profit shares paid out of profits of a company or cooperative to a taxpayer were not subject to income tax between 2004 and 2016. Now, the profit is subject to tax again. It should be noted that if the profit share is received by a legal person (a resident and a non-resident) from a source in Slovakia, it is not subject to tax, but if it is received from a non-EU state, it becomes subject to 35% tax. If the profit share is received by a natural person from a source in Slovakia, it is subject to 7 % tax. If the profit share is received from a non-EU state, it becomes subject to 35%.

The current tax is calculated from *the tax base* using the tax rate. Based on the wording of the Income Tax Act, the tax base is understood to mean the difference between the taxable income and tax expenses accrued during the taxable period. When determining the tax base within the double-entry bookkeeping system, the profit or loss statement is crucial. The pre-tax profit or loss is a synthetic statement of the relationship between costs and revenues that allows for evaluation of the economic performance of a company by comparing the expenses that were demonstrably incurred to achieve specific performance (s) and revenues for the outputs. Expenses such as the reduction in the economic value of a property are a measure of consumption, wear and tear, work of the company's employees, and consumption of external services expressed in money. Revenues cover the outputs of enterprise (Krištofík, Saxunová, and Šuranová 2009).

In the transformation of the profit/ loss to the tax base, the profit before tax is adjusted by items increasing (tax non-deductible items) and decreasing (tax deductible items) the profit/ loss and the rate of the tax loss.

The transformation of the profit/ loss to the tax base is shown in Figure 4.

Figure 4. Transformation of the profit/ loss before tax into tax base, tax calculation



Source: own processing of authors

Items that increase the profit/loss (tax non-deductible costs) include, for example:

- representation expenses, except for advertising items worth no more than 17 EUR per item;

- cash short and damages exceeding the received compensation, except for damage caused by natural disasters (*e.g.* floods, hail, avalanches, earthquakes) or caused by an unknown perpetrator;
- the positive difference between accounting and tax depreciation of tangible fixed assets (accounting depreciation is higher than tax depreciation);
- donations provided;
- fuel cost over the limit laid down in the technical certificate;
- travel expenses paid over the limit set by the travel allowance law;
- brokerage commissions, including ones under mandate contracts or similar contracts, up to 20% of the value of the brokered transaction (not applicable to a bank, insurance company, reinsurance company and entities under special law); the tax base may be reduced only after payment has been made;
- fines, penalties and interest on late payments put into expenses; the tax base may be reduced only after payment has been made;
- costs incurred for advisory and legal services; the tax base may be reduced only after payment has been made;
- costs incurred for marketing and other studies and for market research; the tax base may be reduced only after payment has been made;
- the cost of obtaining standards and certificates; the tax base may be reduced only after payment has been made;
- creation of reserves, except for those that the Income Tax Act recognize as tax expenses, such as the emission reserve, the reserve for unused holidays payments;
- creation of adjustment items, except for those that the Income Tax Act recognizes as tax expenses, such as adjustment items to receivables from debtors in bankruptcy proceedings and the restructuring proceedings.

Items that reduce the profit/ loss (non-taxable income) include, for example:

- the negative difference between accounting and tax depreciation of tangible fixed assets (accounting depreciation is lower than tax depreciation);
- fines, penalties and interest on late payments put into expenses; they may increase the tax base only after they have been collected;
- income from which the tax is withheld (withholding tax).

Thus, we can say that when determining the tax base, it is possible to adjust it using off-balance sheet costs and revenues that are not tax deductible under the Income Tax Act. This is shown in Figure 4. Using the tax base and the specified tax rate, the amount of tax due is calculated. The tax rate is only one of the factors determining the level of taxation, yet its importance is often overvalued. On the other hand, its psychological aspect is undervalued. According to Marec (2018), the recent tax reform in the US (reduction of corporate income tax from 35 to 21%) and a significant reduction in corporate tax since 2017 in Hungary from 16% to 9% had such psychological effects.

Currently, the Slovak Republic has a corporate income tax flat rate of 21% for the calculation of the income tax. The tax base may be reduced by the potential tax loss reported for the previous period. If a legal person incurs a tax loss, the loss may be deducted evenly over the four consecutive tax periods starting from the taxable period immediately following the taxable period for which the tax loss was incurred. For example, a tax loss of 8,000 EUR for 2017 will allow the taxpayer to deduce 2,000 EUR per year from the tax base during the period 2018-2021.

The development of the corporate income tax rate in the Slovak Republic since the establishment of the Slovak Republic in 1993 until present is shown in Table 4.

Table 4 Development of corporate income tax rate in Slovakia

Tax	1993	1994-1999	2000-2001	2002-2003	2004-2012	2013	2014-2016	since 2017
rate	45%	40%	29%	25%	19%	23%	22%	21%

Source: own processing

Tax rates over the course of 26 years of independent Slovakia have been gradually changing. It is almost unbelievable that the system was able to operate at 45% corporate income tax in 1993 and then taxed profits at 15% tax rate. In 2002, the tax rate was reduced to 25%. The best tax system was in place during the period after 2004 when the business environment greatly improved. Structural reforms took place, including the introduction of the flat tax rate of 19% (corporate income tax, personal income tax and value added tax). Since 2013, the tax rate has risen from 19% to 23%, a year later to 22%, and since 2017 the corporate tax rate has been set to 21%.

Due to the even distribution of revenues flowing to the state budget, the defined taxpayers are obliged to pay *tax advance payments* (income tax advance payments) during the tax period. The tax advance payment is a

tax payment that is payable during the tax period if the actual tax rate for that period is not yet known. After the end of the tax period, tax advances paid for this tax period are offset against the actual tax for that taxable period.

The obligation to pay tax advance payments for corporate income tax depends on the amount of tax for the previous year, *i.e.:*

- if the amount of tax for the preceding year is more than 2,500 EUR and less than or equal to 16,600 EUR, the taxable person shall pay the quarterly advance payments in the amount corresponding to 1/4 of the previous year's payable tax,
- where the tax rate for the preceding year is higher than 16,600 EUR, the taxpayer pays tax advance payments in the amount corresponding to 1/12 of the previous year's payable tax per month.

The corporate income must be calculated and paid by the taxpayer himself. *The taxable period* is a calendar year or an economic year that may not be the same as a calendar year. The tax return is submitted by the end of the third month after the end of the tax period, and the tax administrator may extend this period for further three months.

4.3. Results and discussion

Figure 5 shows the relationships between the variables. It indicates a positive linear relationship between the economic result and the income tax. Both the minimum and maximum values of the test variables are shown in the text boxes. We also used other statistical tests to verify the results.

Figure 5. Pair correlation chart

Source: own processing of authors (processed in R 3.4.1)

The test confirmed the positive linear relationship between the income tax and profit before tax (r = 0.819) and revenues (r = 0.815). Thus, it can be concluded that the relationship between these variables is not accidental and the correlation coefficient is statistically significantly different from zero, see Table 5.

When examining relationships between these variables, it is necessary to state what led us to the idea of doing research in this field. Logically, there must be a strong positive dependence between some variables (such as the profit before tax and corporate income tax). If there were no adjustment options in the Slovak legislation (for

example, tax non-deductible items and tax deductible items) and there would be a 100% tax discipline, in this case the relationship should be expressed as r =1. We were interested to what extent the legislative options for adjusting the profit before tax affect the examined dependence. The higher the value of r, the greater the impact of the transformation of the profit before tax on the amount of the current tax (*i.e.* the tax base).

The relationship between revenues and income current tax is almost the same as the relationship between the current income tax and profit before tax. When examining the dependencies, we found out that for the purpose of this paper we do not have to focus on the relationship between the income current tax and assets.

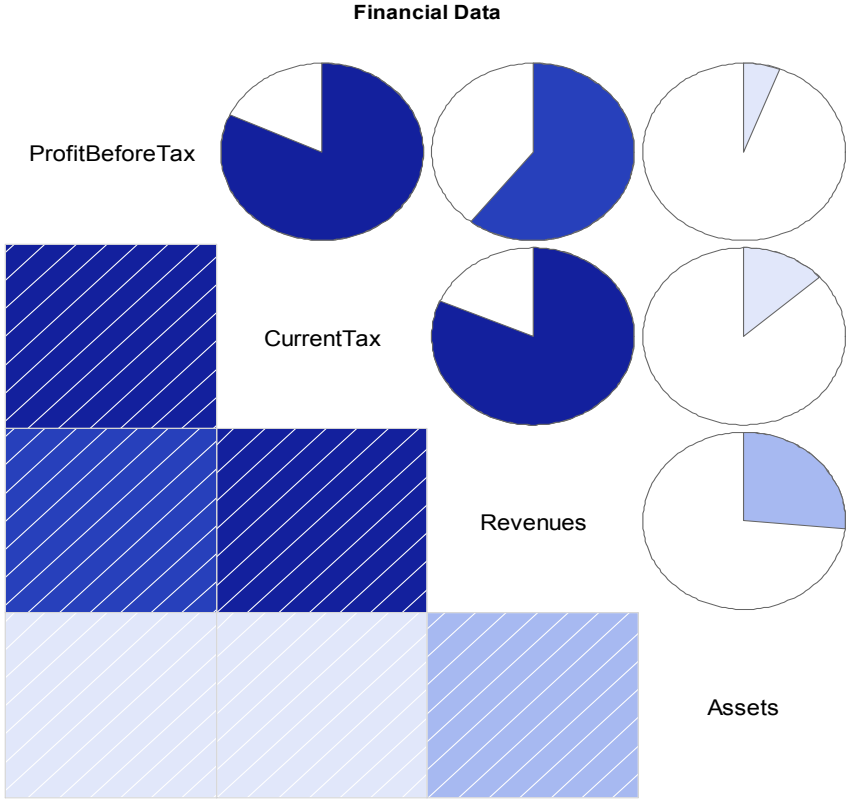
Table 5. Pearson's coefficient

	ProfitBeforeTax	CurrentTax	Assets	Revenues
ProfitBeforeTax	1.00000000	0.8191416	0.05805341	0.6051537
CurrentTax	0.81914157	1.0000000	0.13439356	0.8152161
Assets	0.05805341	0.1343936	1.00000000	0.2633448
Revenues	0.60515368	0.8152161	0.26334479	1.0000000

Source: own processing of authors

Figure 6 below shows the correlogram which contributes to a better visualization of the relationships between the examined variables in the correlation matrix. At the centre of the correlogram are the variables with the statistically most significant relationship. Statistical dependencies get weaker as we move further from the middle of the correlogram. The strength of dependencies is expressed as the segment size in the cake chart.

Figure 6. Financial data – correlogram



Source: own processing of authors (processed in R 3.4.1)

To determine the relationship between the selected variables, we made use of the linear regression method. (α = 0.05) The following table and figures show the interdependence of the variables. Dependent (explained) variable was the current corporate income tax.

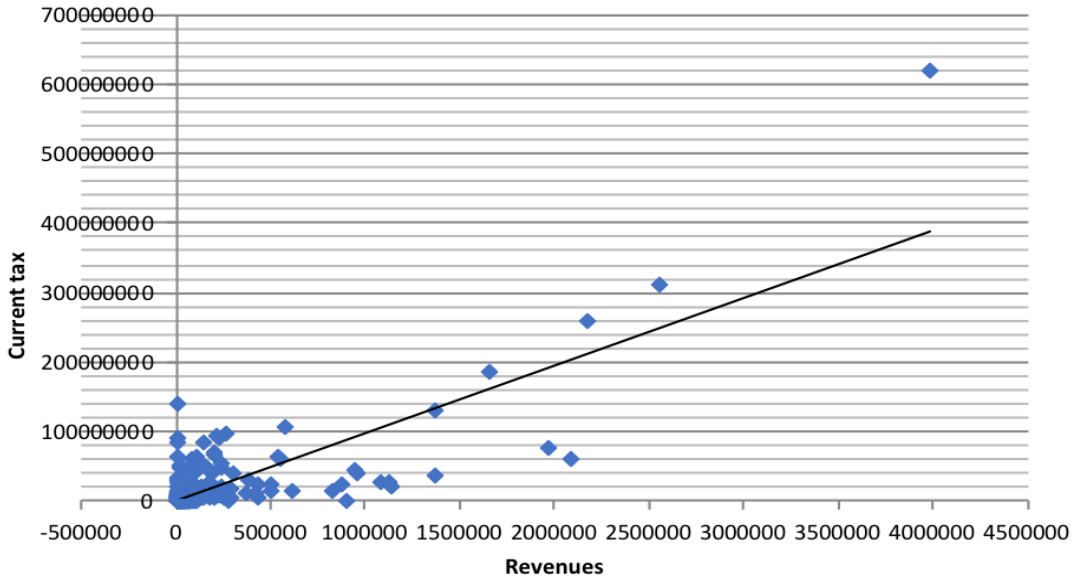
Table 6. Partial regression outputs (x variable – Revenues)

Multiple R	0.815216112			
R Square	0.66457731			
Adjusted R Square	0.664321847			
Standard Error	115915.0818			
Observations	1315			
	Coefficients	Standard Error	*t Stat*	*P-value*
Intercept	6867.513277	3248.581457	2.114003718	0.034703078
X Variable 1	0.006836063	0.000134028	51.00454745	0

Source: own processing of authors

In Figure 7, the regression analysis is processed by graphical analysis using a dependency figure. P-value of the intercept and the regression coefficient confirmed their statistical significance. The regression function has the form y = 6867.5133 + 0.0068 x. The x value says that if the value of revenues increases by one unit of measure (EUR), the income tax will increase by 0.0068 units (EUR). The value of the coefficient of determination (R square) 0.6643 says that the regression line explains the tax variability at 66%.

Figure 7. Linear relationship between Revenues and Current tax



Source: own processing of authors

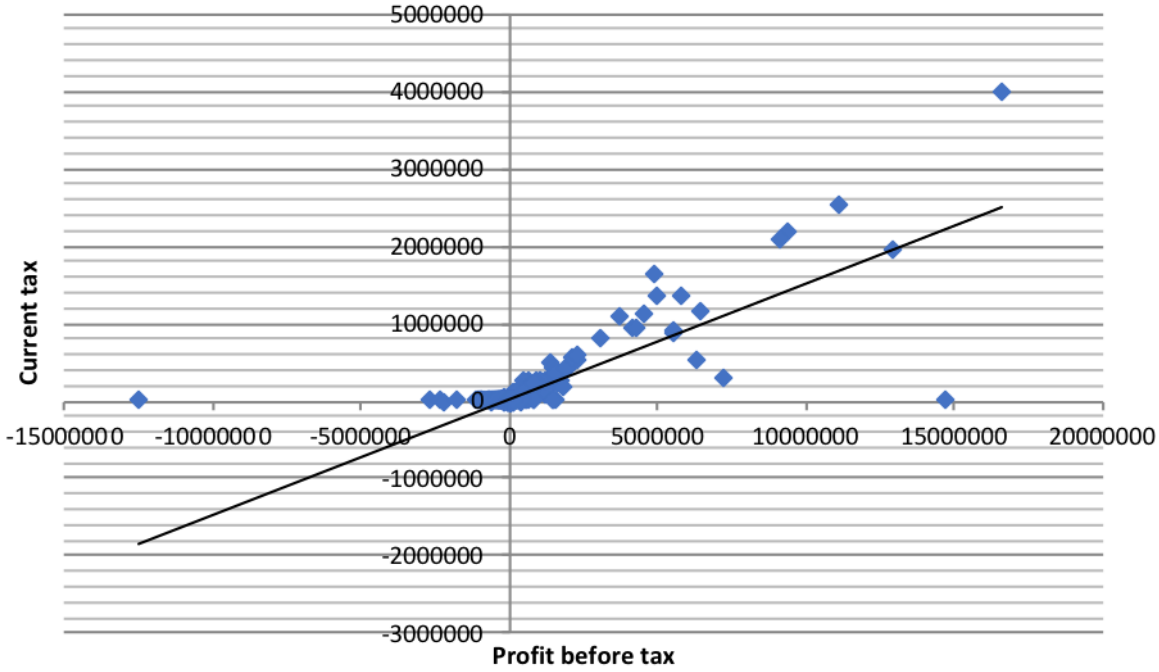
Table 7 below shows the results of the regression analysis examining the tax and profit/ loss relationship. Figure 8 shows a regression line.

Table 7. Partial regression outputs (x variable – Profit before tax)

Multiple R	0.819141568			
R Square	0.670992909			
Adjusted R Square	0.670742332			
Standard Error	114801.181			
Observations	1315			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	15790.09715	3190.78639	4.948654	8.44E-07
X Variable 1	0.150001696	0.00289873	51.74742	0

Source: own processing of authors

Figure 8. Linear relationship between Profit and Current tax



Source: own processing of authors

The regression function has the form y = 15790.5133 + 0.15 x. The x value says that if the profit/loss increases by 1 EUR, the income tax will increase by 0.15 EUR. P-value <0.05 confirmed the statistical significance of the intercept as well as the regression coefficient.

Over the last years, Volkswagen, Kia and PSA Peugeot Citroën have been considered the most important companies to the Slovak economy. In 2017, US Steel Košice (active in metal and metallurgy industry) became the company with the highest gross profits (approximately 449.9 mil. EUR). US Steel Košice was followed by Eustream (a natural gas transmission network operator) with a gross profit of 352.4 mil. EUR and the company Slovenský plynárenský priemysel (operating in the energy and mining industry) with 318.8 mil. EUR. The most successful car maker in terms of this indicator was KIA Motors Slovakia (approx. 210 mil. EUR in 2017). The biggest tax payer of 2017 was Eustream - approximately 155 mil. EUR. Eustream was followed by these companies:

- Kia Motors Slovakia – 68.8 mil. EUR,
- SPP – distribution (owner and operator of a gas distribution network) – 65.8 mil. EUR,
- Slovenská sporiteľňa (the largest commercial bank in Slovakia) – 54.5 mil. EUR,
- Volkswagen Slovakia – 50.5 mil EUR,
- U.S. Steel Košice – 44.7 mil. EUR,
- Slovak Telecom – 44.3 mil. EUR, *etc.*

Thus, it can be concluded that in addition to the traditional contributors (car industry) to the development of the Slovak economy, companies operating in the sectors dealing with strategic raw materials such as steel, natural gas, oil and companies operating in the field of banking and telecommunications are also important. From the point of view of the structure of the national economy and the largest contributors to the state budget it can be said that Slovakia follows the development trends of the developed European countries.

In 2017 the Slovak economy marked a sharp increase in the establishment of new companies. This can be seen as a signal of the improving business environment. State measures against tax evasion, artificial tax cuts, as well as more effective work of the Financial Administration have also led to higher accountability of companies. The company's willingness to pay corporate income taxes, however, depends on the flexibility of tax policies and the business support measures implemented by the state.

The analyses carried out on the sample of Slovak companies confirmed that with the increasing sales and profits of the companies, the amount of tax due is naturally increasing as well. The state should consider the option to offer some form of tax relief to companies with good tax discipline.

Tax optimization in Slovakia is one of the factors in the whole spectrum of factors that currently have a positive impact on the development of the economy. Demand for goods and services is rising, companies improve their revenues and profits, thus affecting the development of employment in the country in a positive way.

Conclusion

Taxes are an important economic, financial, social and political instrument of the state. Taxes are one of the most important sources of public budget revenue. The current system corresponds to the tax system of developed market economies of the European Union countries.

Tax regulation should take into account the interests of taxpayers and their attitudes towards taxation. The natural reaction of every business entity to taxes is to search for tax optimizing solutions.

On the basis of the findings of the analyses we can state the following:

- Tax revenues are crucial for the budget of the Slovak Republic as they represent the largest share of public revenues, for example, in 2017 it was 45.85%, followed by social security contributions, which represent 37.45% of the revenues. The share of corporate income tax on the total tax revenues of the country is 17.17%, which means that they make up 8% of the total revenues of the state.
- When examining tax regulations, we found that the amount of the tax base of legal persons in the double-entry accounting system is not the same as the amount of the profit or loss. That means that the profit before tax is transformed into the tax base. We also assumed that current corporate income tax also depends on indicators such as the profit/loss, the size of the asset or revenues. Based on the results, however, we found that the current income tax does not depend on the size of the property, but on the profit/loss.

Acknowledgements

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Sustainability of Agricultural Industries in Bulgaria

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Abstract:

In Bulgaria, like in most countries, the comprehensive assessments on agrarian sustainability are mostly at sectoral or farm levels while there is practically no in-depth study on sustainability at sub-sector (industry) level. This paper tries to fill the gap and assess the sustainability of different sub-sectors in Bulgarian agriculture. First, a holistic hierarchical framework for assessing the integral, economic, social and ecological sustainability of Bulgarian agriculture is suggested, including 17 principles, 35 criteria, and 46 indicators and reference values. After that, an assessment, on the overall and aspects sustainability of major crop, livestock and mixed subsectors of Bulgarian agriculture, is made. It is based on first-hand information collected though in-depth interviews with the managers of "typical" farms in analyzed industries.

The study has found out that there is a considerable differentiation in the level of integral and aspects sustainability in individual sub-sectors in Bulgaria, with mixed livestock-breeding, mixed crop-growing, and perennial crops sub-sectors having the highest integral sustainability, while pigs, poultry and rabbits; vegetables, flowers and mushrooms, and mixed livestock-crops subsectors the lowest one. There are also substantial variations in the levels of economic, social and ecological sustainability of different agricultural sub-sectors and individual indicators with the highest and lowest values showing (critical) factors enhancing and deterring particular or overall sustainability of evaluated agro-industries. Results on the integral agrarian sustainability level of this study based on the micro sub-sector (farm) data are similar to the previous assessment based on the aggregate sectoral (statistical, *etc.*) data.

Keywords: sub-sectors; agriculture; sustainability; economic; social; ecological; Bulgaria

JEL classification: D02; D23; L14; L22; Q13

1. Introduction

The goal of this paper is to assess the sustainability of different subsectors in Bulgaria based on a large study, included more than 180 farms. Subsectors are arable crops, vegetables, flowers and mushrooms, perennials, grazing livestock, pigs, poultry and rabbits, mixed crops and mixed livestock breeding. Our view is that sustainability is a broad issue including not only environmental aspects but also economic and social sides. Moreover, we do believe that sustainability is an integral issue. No one of its elements could exist without the others. For example, a farm could not be environmentally sustainable if it is not sustainable in economic sense, and vice versa. That is why the areas of research interest in this study were: general characteristic of farms; economic indication for agrarian sustainability; social indication for agrarian sustainability: environmental indication for agrarian sustainability. We also left the world of the popular entire-sector analyses and tried to find sub-sectoral specific characteristics of farm sustainability and to make cross-sub-sectoral comparisons.

2. State–of–arts in the area

The issue of assessment of level of agrarian sustainability and its economic, social and ecological aspects is among the most topical in developed and developing countries a like (Bachev 2010, 2018; Bachev, *et al*. 2016, 2017; Bachev and Terziev 2018, Bohlen and House 2009, Candido *et al.* 2018, De Oliveira 2018, FAO 2013, Hayati, *et al.* 2010, Ikerd 2015, Ivanov, *et al*. 2009, Gliessman 2016, Gemesi 2007, Gitau, *et al.* 2009, Jalilian 2012, Irvin *et al.* 2016, Lopez-Ridauira *et. al.* 2002, Ramírez-Carrillo *et. al.* 2018, Sauvenier *et al.* 2005, Terziev *et*

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al. 2018, Todorova and Treziyska 2018, Van Loon *et al.* 2005, Zvyatkova and Sarov 2018). Despite enormous progress in the theory and practice of this new evolving area, still there is no consensus on how to assess agrarian sustainability due to diverse understandings, approaches, methods, employed data, *etc*. In Bulgaria (like in most countries), comprehensive sustainability assessments are mostly on sectoral (Bachev *et al.* 2017) or farm (Bachev 2016, 2017; Bachev and Terziev 2017) levels while there is practically no in-depth study on sustainability at subsector (industry) level.

3. Methodological framework

In order to assess agrarian sustainability of agricultural subsectors in Bulgaria, a hierarchical system is developed, including 17 principles, 35 criteria, and 46 indicators and reference values. Principles are the highest hierarchical level associated with the "universal" functions of agricultural system and represent the state of sustainability in 3 main pillars/aspects of sustainability (economic, social, and ecological). Criteria represent a resultant state when the relevant principle is realized. Indicators are quantitative and qualitative variables of different types (behavior, activity, input, effect, impact), which can be assessed allowing the measurement of compliance with particular criteria. Reference Values are the desirable levels for each indicator according to the specific conditions of each subsector that assist the assessment giving guidance for achieving (maintaining, improving) sustainability. The approach for formulating and selecting principles, criteria and indicators for assessing sustainability level are presented in details in our previous publications (Bachev 2016, 2017, 2018).

In Bulgaria, like in most countries, there are no official aggregate data for calculating most of the socio-economic and ecological sustainability indicators at sub-sector level. In order to assess the level of sustainability of major agricultural industries (sub-sectors) in-depth interviews with the managers of 80 commercial farms of different types and locations in 4 major administrative and geographical regions of Bulgaria (North-Central, South-Eastern, South-Central and South-Western) were held in 2017. "Typical" farms for different regions and industries were identified with the assistance producers' professional associations, National Agricultural Advisory Service, Executive Agency for Vine and Wine, processing, bio-certification and service organizations, and local government. Farmers of various types were surveyed - different legal entities (natural persons, sole traders, cooperatives, companies); different sizes (semi-market, small size for the sector, average size for the sector, large sizes for the sector; and different production specialization (arable crops, vegetables, flowers and mushrooms, perennials, grazing livestock, pigs, poultry and rabbits, mixed crops and mixed livestock breeding).

The survey includes many questions in 4 major areas: general characteristic of farms; primary information for calculating economic indicators for agrarian sustainability; primary information for calculating social indicators for agrarian sustainability; and primary information for calculating environmental indicators for agrarian sustainability. Calculated quantitative and qualitative levels for each indicator are further transformed into a unit less index of sustainability. After than the integral index for a particular criterion, principle, and aspect of sustainability, and the integral sustainability index for each surveyed farm is calculated as arithmetic average applying equal weight for each indicator in a particular criterion, of each criterion in a particular principle, and each principle in every aspect of sustainability. The composite sustainability index of a particular sub-sector is an arithmetic average of the indices of relevant farms belonging to that industry.

For assessing the level of sustainability of agricultural sub-sectors the following scales defined by the experts in the area are used: 0,85 - 1 - a high level of sustainability; 0,50 - 0,84 - a good level of sustainability; 0,25 - 0,49 - a satisfactory level of sustainability; 0,12 - 0,24 - an unsatisfactory level of sustainability; 0 - 0,11 - non-sustainable level.

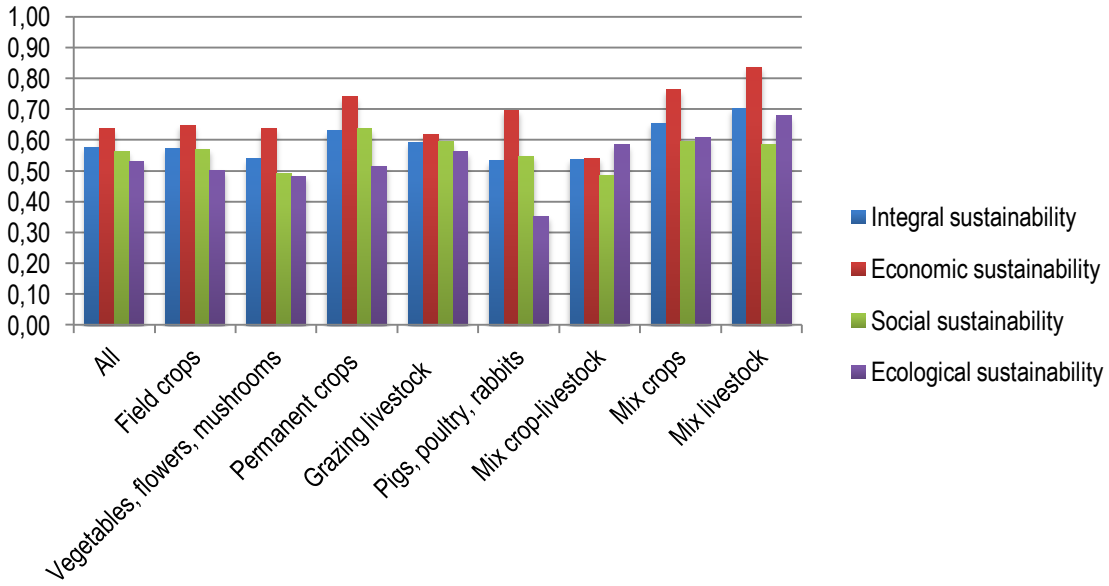
3. Integral, economic, social and ecological sustainability in different sub-sectors

The assessment has found out that with the highest integral sustainability is the mixed livestock-breeding (0,7) and mixed crop-growing (0,66) sub-sectors, followed by the perennial crops (0,63). (Figure 1). Therefore, the mixed livestock-breeding and crop-growing farms and the farms with perennials contribute in highest degree for improving the integral sustainability of Bulgarian agriculture. From the other hand, the farms specialized in pigs, poultry and rabbits (0,53), vegetables, flowers and mushrooms (0,54) and mixed livestock-crops (0,54) have the lowest integral sustainability. This means that these subsectors decrease to the biggest extent the agrarian sustainability in the country.

Similar to integral sustainability, the sub-sectors with the highest economic sustainability are: mixed livestock breeding (0,84), mixed crop growing (0,76) and perennial crops (0,74). The mixed crop-growing production has the highest ecological sustainability (0,61) and one of the best social sustainability (0,6). The perennial crops sector has high social sustainability (0,64), but lower than the average and almost satisfying

ecological sustainability (0,51). The social sustainability of farms specialized in grazing livestock has comparatively high level of social sustainability (0,6). The social sustainability in mixed crop-livestock farms has satisfying level (0,49). The pigs, poultry and rabbits' farms have lowest and satisfying level (0,35), like the farms for vegetables, flowers and mushrooms (0,48). The field crops farms have good, but relatively low ecological sustainability (0,5), close to the satisfying level.

Figure 1. Sustainability level in different sub-sectors of agriculture



Source: survey with managers of farms, 2017 and author's calculations

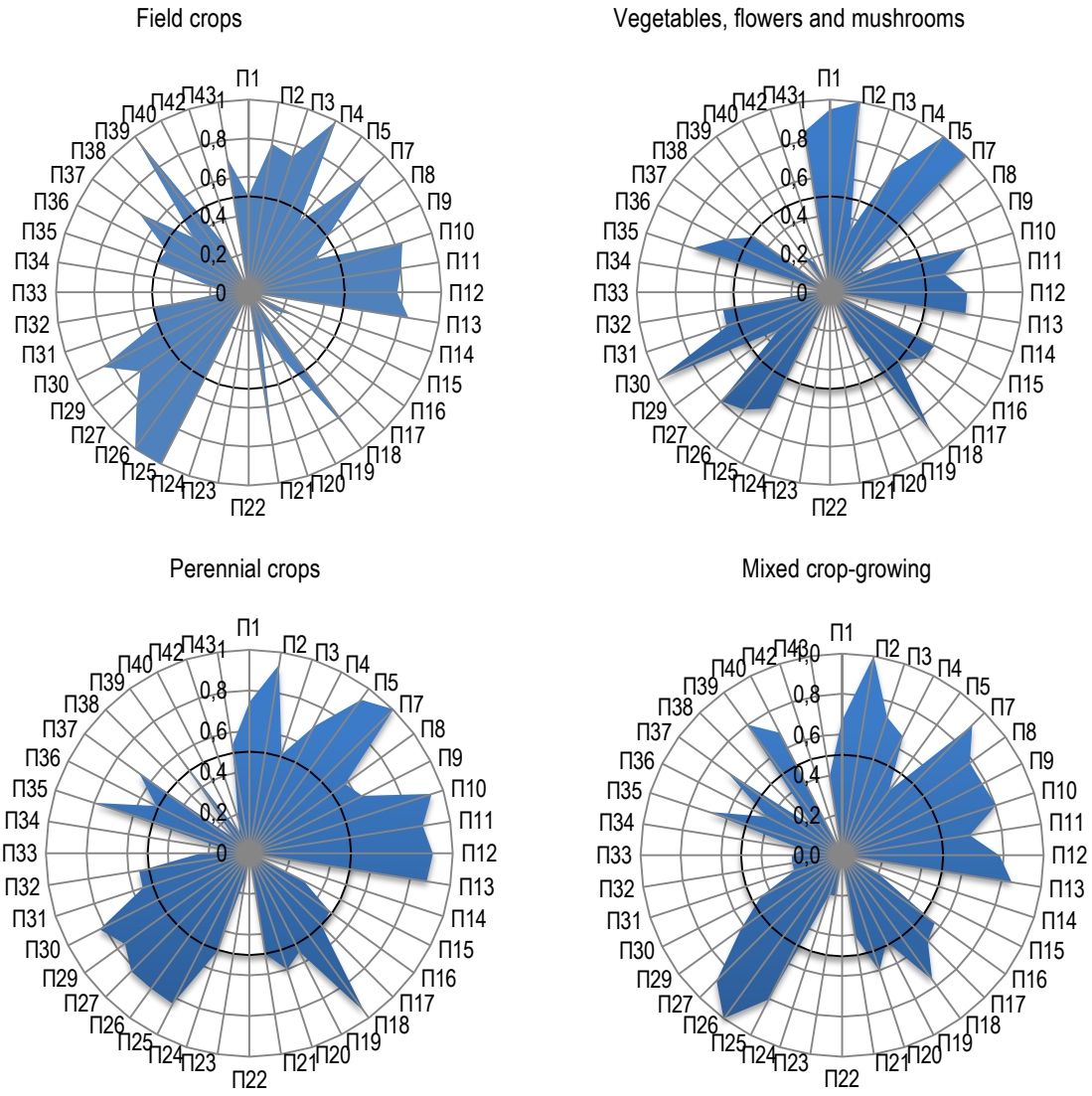
The different agricultural sub-sectors are characterized by important variation of levels of indicators for agricultural sustainability. The productions specialized in field crops have high economic sustainability for:

- labor productivity (1) and share of sold output in the total (0,87);
- high social sustainability for net farm income/ average income in the region (0,84), degree of compatibility to normative labor conditions (0,84), education level of the manager (0,88), share of unoccupied permanent work positions in the total number of employed (1) and share of unoccupied seasonal work positions in the total number of employed (1);
- high ecological sustainability for dynamics of used agricultural land in last 5 years (0,82), compliance to norms of nitrate fertilization (0,85) and protection of natural biodiversity (1) (Figure 2).

The sub-sector of field crops has satisfying economic sustainability for land productivity (0,45) and investments growth in last 5 years (0,38). The social sustainability of field crops productions has satisfying levels for number of family members working in the farm (0,27) and share of employed with special agricultural education/qualification (0,38); unsatisfying levels for manager's age (0,15) and degree of participation of women in the farm management (0,2). The field crops are socially unsustainable in relation to: presence of a family member ready to take the farm; participation in education programs in the last 3 years, share of hired workers, members in trade unions; public position of the farmer, manager or owner and participation in local initiatives. The ecological sustainability of field crops farms is satisfying for level of fuel consumption (0,48), presence of protected species on the farm territory (0,4) and number of cultural species (0,28); unsatisfying for share of arable land in the total agricultural land (0,13) and keeping of landscape maintenance practices (0,2); and unsustainable regarding the application of the principles for organic production.

Productions, specialized in vegetables, flowers and mushrooms have high levels of indicators for: economic – share of direct payments in the net income (0,95), share of own capital in the total (1), land productivity (1) and share of sold production in the total (1); social – education level of manager (0,9); and ecological – compliance to norms of nitrate fertilization (1) (Figure 2).

Figure 2. Sustainability indicators[3] in different crop-growing sub-sectors of agriculture



Source: Survey with managers of farms, 2017 and author's calculations

[3] The П1-Direct payments in the net income; П2-Share of own capital in the total one; П3-Profit/production costs; П4-Labour productivity; П5-Land productivity; П6-Livestock productivity; П7-Share of sold production in the total one; П8-Sales growth in the last three years; П9-Investments growth in last 5 years; П10-Net farmer's income/ average income in the region; П11-Payment of hired labour/ average income in the region; П12-Degree of satisfaction from farmer's activity; П13-Degree of compliance to normative labour conditions; П14-Presence of a family member ready to take the farm; П15-Number of family members working in the farm; П16-Age of manager; П17-Participation of training programs in the last 3 years; П18-Education level of manager; П19-Share of occupied with special agricultural education / qualification; П20-Degree of participation of women in the farm management; П21-Number of participation in professional organizations and initiatives; П22-Share of hired workers, members of trade unions; П23-Public positions occupied from the farmer, manager and owner; П24-Participation in local initiatives; П25-Share of non-occupied permanent work positions in the total number of employed; П26-Share of non-occupied seasonal work positions in the total number of employed; П27-Change of UAA in last 5 years; П28-Change of livestock number in last 5 years; П29-Soil erosion; П30-Compliance of nitrate fertilization to norms; П31-Compliance of potassium fertilization to norms; П32-Compliance of phosphorus fertilization to norms; П33-Share of arable land in the total UAA; П34-Keeping the practices of landscape maintenance; П35-Degree of pollution of underground waters with nitrates; П36-Level of fuel consumption; П37-Level of electricity consumption; П38-Presence of protected species on the farm territory; П39-Natural biodiversity protection; П40-Number of cultural species; П41-Respecting of animal welfare norms; П42-Implementation of principles for organic production; П43-Yield variation of main crops for 5 years; П44-Percentage of mortality of livestock for 5 years.

At the same time these productions have satisfying levels of sustainability regarding the economic indicators profit/ production costs (0,34) and investment growth in last 5 years (0,33); social: for the share of employed with special agricultural education/qualification (0,26); and ecological: soil erosion (0,33) and level of electricity consumption (0,49). The sub-sector of vegetables, flowers and mushrooms has unsatisfying levels of economic sustainability regarding the sale growth in last 3 years (0,15) and for ecological sustainability: natural biodiversity protection (0,25) and number of cultural species (0,17). This production is unsustainable in relation to many social and ecological indicators: presence of a family member ready to take the farm, degree of participation of women in the farm management, number of participation in professional organizations and initiatives, share of hired workers, members of trade unions, public positions of the farmer, manager or owner, participation in local initiatives, share of arable land in the total agricultural land, keeping of practices for landscape maintenance, presence of protected species on the farm territory and implementation of principles for organic production.

The sub-sector of perennial crops has high economic sustainability regarding the share of own capital in the total (0,93), land productivity (0,93) and share of sold output in the total one (1) (Figure 2). The social sustainability of perennial crops is also high for some indicators: net farm income/ average income in the region (0,94), payment of hired labor/average income in the region (0,86), degree of satisfaction from farm activity (0,9), compliance degree of normative labor conditions (0,88), education level of manager (0,96), share of unoccupied permanent work positions in the total number of employed (0,83) and share of unoccupied seasonal work positions in the total number of employed (0,82). This sub-sector is with high ecological sustainability only for the dynamics of the used agricultural land in the last 5 years (0,82) and the compliance to norms of the nitrate fertilization (0,82). Satisfying is the social sustainability in relation to the number of family members, working in the farm (0,3) and manager's age (0,49), and socially unsustainable for: presence of a family member ready to take the farm, share of hired workers, members of trade unions and public position of the farmer, manager or owner. Unsatisfying is the ecological sustainability for share of arable land in the total agricultural land (0,24), number of cultural species (0,11) and implementation of principles for organic production (0,18). They are ecologically unsustainable regarding the keeping of practices for landscape maintenance and presence of protected species on the farm territory.

The mixed crop-growing productions have high sustainability for the following economic indicators: share of own capital in the total (1) and share of sold production in the total (0,91); the social indicators – degree of compliance to normative labor conditions (0,85) and share of unoccupied seasonal work positions in the total number of employed (1); and the ecological indicator – dynamics of UAA in last 5 years (0,88) (Figure 2).

The mixed crop-growing productions have satisfying levels of sustainability for the economic indicator – land productivity (0,4); social indicators: share of employed with special agricultural education/ qualification (0,48) and number of participation in professional organizations and initiatives (0,4); and ecological indicators: compliance to norms of nitrate fertilization (0,45), level of fuel consumption (0,42) and variations of yield from main crops for 5 years (0,4).

The level of sustainability is unsatisfying regarding some social and ecological indicators: number of family members working in the farm; public position of the farmer, manager or owner and participation in local initiatives (0,2 each); compliance to norms of the potassium fertilization , compliance to norms of the phosphorus fertilization and share of arable land in the total agricultural land (0,25 each), and keeping of practices for landscape maintenance and presence of protected species on the farm territory (0,2 each). This productions' type is socially and ecologically unsustainable for: presence of a family member ready to take the farm, share of hired workers, members in trade unions and implementation of organic production principles.

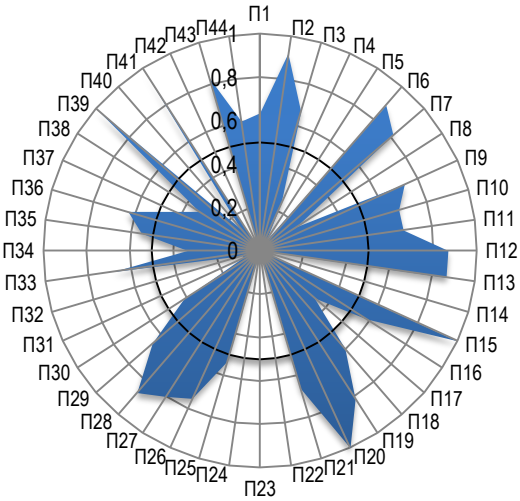
The sub-sectors with livestock productions also have big differences in the levels of indicators for agricultural sustainability. The herbivore livestock's productions have high economic sustainability for the share of own capital in the total (0,92), livestock productivity (0,89) and share of sold output in the total (0,81); high social sustainability for degree of satisfaction from farming activity (0,87), degree of compliance to normative labor conditions (0,87), number of family members working in the farm (1), share of employed with special agricultural education/ qualification (0,81) and degree of participation of women in the farm management (1); and high ecological sustainability for the dynamics of the number of raised animals in the last 5 years (0,87), natural biodiversity protection (1), meeting of norms for animal welfare (1) and variation of yield from main crops for 5 years (0,83) (Figure 3).

Specialized productions from herbivore livestock have satisfying social and ecological sustainability for: participation in education programs in the last 3 years (0,33), public position of the farmer, manager or owner

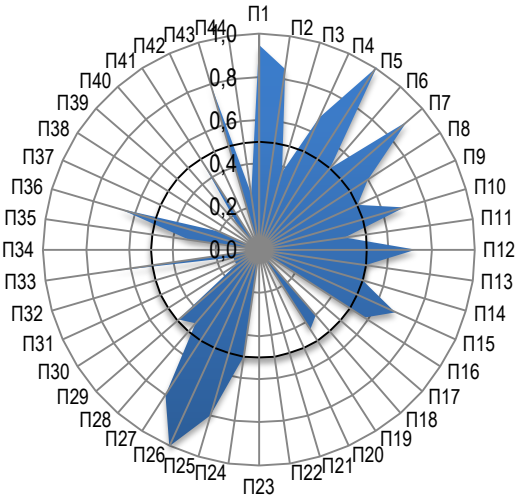
(0,33), compliance to norms of nitrate fertilization (0,42), keeping of practices for landscape maintenance (0,33), level of consumption of electricity (0,43) and presence of protected species on the farm territory (0,33).

Figure 3. Sustainability indicators[4] in different livestock sub-sectors of agriculture

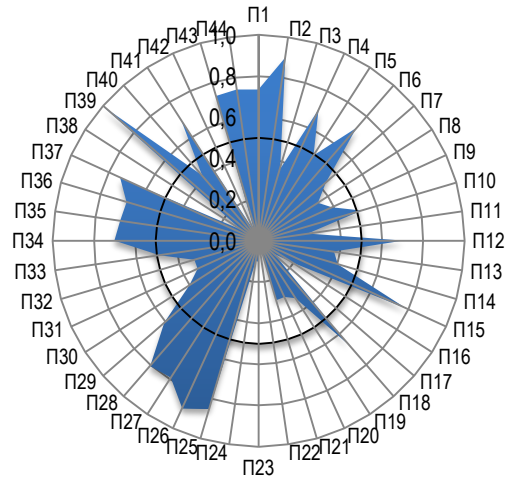
Grazing livestock



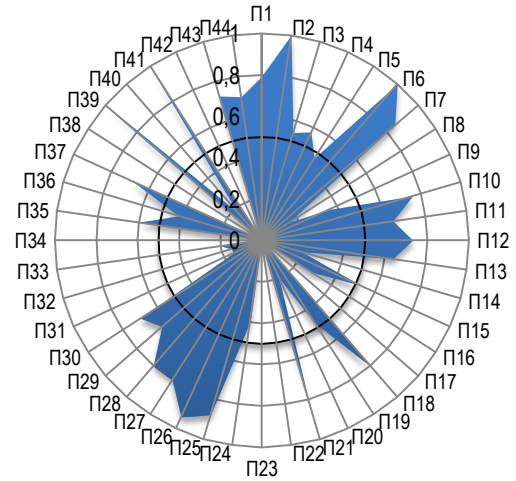
Pigs, poultry and rabbits



Crop-livestock (mixed)



Mixed livestock-breeding



Source: Survey with managers of farms, 2017 and author's calculations

The sustainability is unsatisfying in relation to the following economic, social and ecological indicators: labor productivity (0,24), land productivity (0,06), sales growth in last 3 years (0,2), compliance to norms of potassium fertilization (0,08), compliance to norms of phosphorus fertilization (0,08), number of cultural species (0,13). The productions of grazing livestock are socially unsustainable for: presence of a family member ready to take the farm; share of hired workers, members of trade unions; participation in local initiatives and ecologically unsustainable for the implementation of principles for organic production.

The production specialized of pigs, poultry and rabbits has high economic sustainability regarding the share of direct payments in the net income (0,95), the share of own capital in the total (0,84), the land productivity (1) and the share of sold output in the total (0,91) (Figure 3). In social aspect this type of production is strongly sustainable for the share of unoccupied seasonal work positions in the total number of employed (1), and from ecological aspect, for: variations of the yields of main crops for 5 years (0,81). Satisfying degree of sustainability have the following indicators: payment of hired labor/average income in the region (0,4), education level of the manager (0,4) and share of employed with special agricultural education/qualification (0,44).

[4] The meaning of indicators is the same as in Figure 2

There is a social unsustainability for: participation in education programs in last 3 years, degree of participation of women in the farm management, number of participation in professional organizations and initiatives, share of hired workers, members of trade unions and public position of farmer, manager or owner. From ecological aspect the pigs, poultry and rabbits' productions have satisfying level of sustainability for: dynamics of the number of raised livestock in last 5 years (0,45), degree of pollution of underground waters with nitrates (0,33), and mortality percentage of animals for 5 years (0,26). This sub-sector has unsatisfying ecological sustainability for: compliance to norms of nitrate fertilization (0,13), compliance to norms of potassium fertilization (0,13), compliance to norms of phosphorus fertilization (0,13), level of consumption of electricity (0,2) and number of cultural species (0,15). These productions are unsustainable for: meeting of practices for landscape maintenance, presence of protected species on the farm territory, natural biodiversity protection and implementation of principles for organic production.

The mixed crop-livestock productions are economically sustainable only regarding the share of the own capital in the total (0,9); highly sustainable from social aspect for the share of unoccupied permanent work positions in the total number of employed (0,85) and share of unoccupied seasonal work positions in the total number of employed (0,89); and ecologically highly sustainable for: dynamics of the number of raised livestock in last 5 years (0,81) and protection of natural biodiversity (1) (Figure 3).

The sustainability of crop-livestock holdings has satisfying levels of economic indicators for profit/ production costs (0,37), land productivity (0,49), share of sold production in the total (0,43), sales growth in last 3 years (0,34) and investments growth in last 5 years (0,39); social indicators: degree of compliance to normative labor conditions (0,37), presence of a family member ready to take the farm (0,4), share of employed with special agricultural education/qualification (0,33), degree of participation of women in the farm management (0,3), number of participation in professional organizations and initiatives (0,3); and ecological indicators for compliance to norms of nitrate fertilization (0,4), compliance to norms of potassium fertilization (0,33), compliance to norms of phosphorus fertilization (0,33), share of arable land in the total agricultural land (0,49) and number of cultural species (0,42). These productions have unsatisfying levels of sustainability for the ecological indicator presence of protected species on the farm territory (0,1) and for several social indicators: payment of hired labor/average income in the region (0,24), manager's age (0,2), participation in education programs in last 3 years (0,1), public positions of farmer, manager or owner (0,1) and participation in local initiatives (0,1). These productions are socially unsustainable regarding the share of hired workers, members of trade unions and ecologically unsustainable for the implementation of principles of organic production.

The production of the mixed livestock is highly sustainable in relation to: share of own capital in the total (1), livestock productivity (1), share of sold output in the total (0,94), sales' growth in last 3 years (1) and investments growth in last 5 years (1) (Figure 3). This sub-sector is socially strongly sustainable for: net farm income/average income in the region (1), degree of satisfaction from farming activity (1), number of family members working in the farm (0,86), participation in education programs in last 3 years (1), number of participations in professional organizations and initiatives (1), and share of unoccupied seasonal working positions in the total number of employed (1). In ecological aspect the production sustainability is high for lot of indicators: dynamics of UAA in last 5 years (0,95), dynamics of the number of raised livestock in last 5 years (1), soils erosion (1), share of arable land in the total agricultural land (1), keeping of practices for landscape maintenance (1), degree of pollution of underground waters with nitrate (1), presence of protected species on the farm territory (1), natural biodiversity protection (1) and meeting the norms for animal welfare (1).

The mixed livestock productions have satisfying social sustainability regarding the share of employed with special agricultural education/ qualification (0,39); and unsatisfying ecological sustainability for level of fuel consumption (0,25) and number of cultural species (0,1). This type of productions are unsustainable for several social-economic and ecological indicators: land productivity, presence of a family member ready to take the farm, degree of participation of women in the farm management, share of hired workers, members of trade unions, public position of the farmer, manager or owner, participation in local initiatives, compliance to norms of the nitrate fertilization, compliance to norms of the potassium fertilization, compliance to norms of the phosphorus fertilization and implementation of principles for organic production.

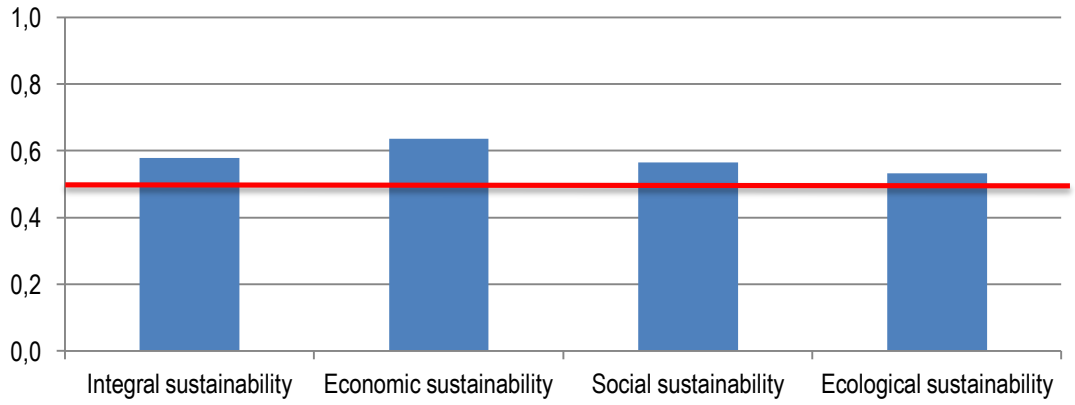
3. Comparison of assessment of agrarian sustainability with the previous studies in the area

The multi-indicator assessment of agricultural sustainability in the surveyed 4 geographical regions of the country shows that the integral indicator of overall sustainability is 0,58, which expresses a good sustainability level of agriculture (Figure 1). The biggest value has the indicator of economic sustainability (0,64), the social sustainability shows lower value (0,57) and the ecological sustainability is close to the unsatisfying value level

(0,53). Therefore, the improvement of the last two indicators is critical for maintaining the good agricultural sustainability of the country.

According to the precious study based on aggregate sectoral (statistical, *etc.*) data using the same methodological approach (Bachev *et al.* 2017) the integral sustainability index of the Bulgarian agriculture is 0.58 that correspond to a Good sustainability. The same study has found out that the Economic sustainability of the Bulgarian agriculture is Good (index of sustainability 0.7), while the Social and the Environmental sustainability are also as Good but with a lower index (for both of them is 0.53) close to satisfactory level. Therefore, integral assessment results based on the "micro" subsectors (farm) data are similar with the results based on aggregated sectoral (statistical, *etc.*) data. It means that both approaches are reliable and could be simultaneously used for assessing agrarian sustainability at various levels – sector, subsector, region, and farm. The analysis of private indexes on basic principles, criteria and indicators of the sustainability gives also opportunity to identify components contributing for the levels of different aspects of agricultural sustainability in the country.

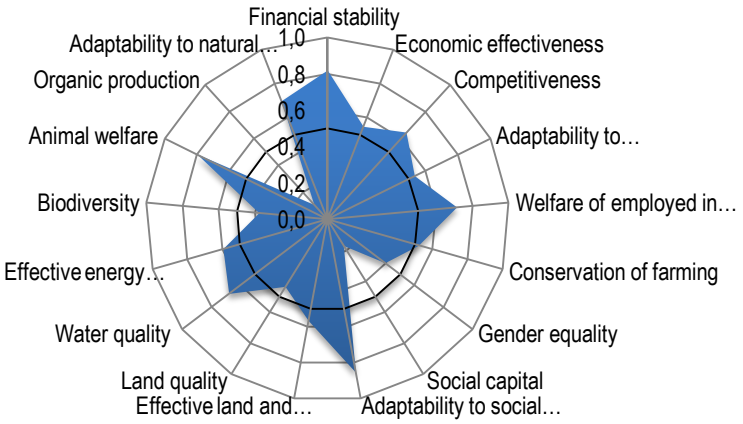
Figure 4. Integral, economic, social and ecological sustainability in four administrative regions of Bulgaria



Source: Survey with managers of farms, 2017 and author's calculations

The current assessment ascertained that the ecological sustainability is relatively low due to the fact that the indicators for the principles "land quality" (0,44), "biodiversity" (0,38) and "organic production" (0,11) are low (Figure 5). Thus, the improvement of these low levels of above-mentioned principles is a factor for maintenance and rising of ecological and integral sustainability in the sector. Also it becomes clear that despite the relatively high integral economic sustainability, the indicator of adaptability to economic environment is relatively low (0,54) and critical for maintaining the reached level. Analogically, for the social sustainability improvement would contribute mostly the increase of low levels of indicators for the principles "farming conservation" (0,52), "gender equality" (0,40) and "social capital" (0,17).

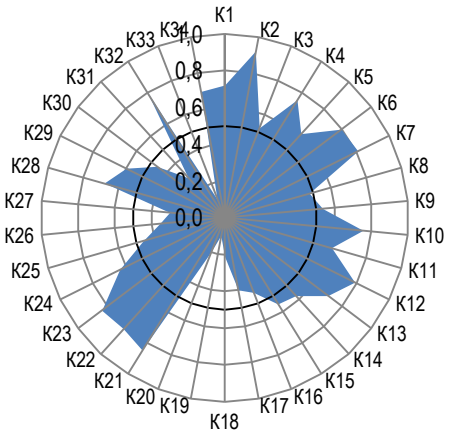
Figure 5. Sustainability index according the main sustainability principles in analyzed administrative regions of Bulgaria



Source: Survey with managers of farms, 2017 and author's calculations

The profound analysis according different criteria and indicators gives opportunity for detailed analysis of elements contributing for/or decrease the agricultural sustainability level. For example, the low levels of ecological sustainability are determined from the low criteria "conservation and improving of soil fertility" (0,46); "balanced land use structure maintenance" (0,35; "landscape elements conservation" (0,30); "natural biodiversity maintenance and improvement" (0,46); "cultural biodiversity maintenance and improvement" (0,29) and "organic production increase" (0,11) (Figure 6).

Figure 6. Sustainability index according the main criteria[5] in analyzed administrative regions in Bulgaria

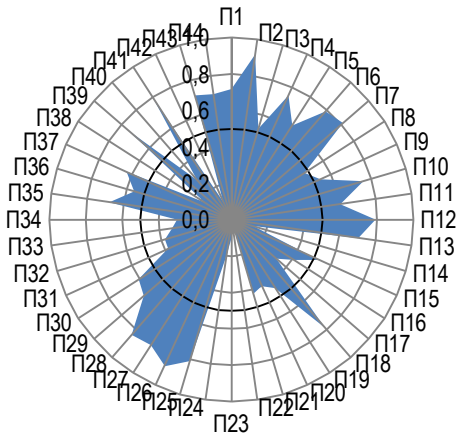


Source: Survey with managers of farms, 2017 and author's calculations

The unsatisfying levels according these criteria for ecological sustainability are (pre)determined of low levels of indicators for eco-sustainability, as: insufficient conformity of norms for fertilization with potassium (0,38) and phosphorus (0,38), high share of arable land in the total agricultural land (0,33), low degree of compliance with practices for landscape conservation (0,3), insufficient protected species on farms' territory (0,18), limited number of cultural species in farms (0,29) and low degree of application of organic production principles (0,11) (Figure 7).

[5] K1-Decrease of dependence on subsidies; K2-Minimization of dependence on exterior capital; K3-Positive or high profitability; K4-Maximal or increasing labour productivity; K5-Maximal or increasing land productivity; K6-Maximal or increasing livestock productivity; K7-Conservation or increase of sold output share ; K8-Conservation or increase of sales; K9-High investment activity; K10-Incomes parity with other sectors; K11-Equitable distribution of income in agriculture; K12-Sufficient satisfaction of farmer activity; K13-Satisfying labour conditions; K14-Keeping the number of family farms; K15-Knowledge and skills increase; K16-Conservation and improvement of agricultural education; K17-Equality of relations man-woman; K18-Participation in professional organizations and initiatives; K19-Participation in public management; K20-Contribution for the development of region and communities; K21-Sufficient potential for reaction to activity cession and to demographic crisis; K22-Keeping or increase of UAA size; K23-Keeping or increase of livestock number; K24-Minimization of soil losses; K25-Keeping and improvement of soil fertility; K26-Keeping of balanced land-use structure; K27-Protection of landscape elements; K28-Keeping and improvement of water quality; K29-Minimization of conventional energy use; K30-Keeping and improvement of natural biodiversity; K31-Keeping and improvement of cultural biodiversity; K32-Implementation of principles of animal welfare; K33-Organic production increase; K34-Sufficient adaptability to climatic changes.

Figure 7. Indicators[6] for sustainability in analyzed administrative regions in Bulgaria



Source: survey with managers of farms, 2017 and author's calculations

Social sustainability in agriculture is usually decreased almost by: lack of family member, ready to continue the farm work (for individual and family farms) (0,13), elderly age of managers and farm owners (0,41), insufficient participation in training programs in the last years (0,33), low share of employed with special agricultural education and qualification (0,44), insufficient participation of women in the farm management (0,4), low participation of farms in professional organizations and initiatives (0,43), lack of membership of hired workers in trade unions (0), weak participation in the public governance from the side of farmers, managers and owners (0,1), and insufficient involvement of farms in local initiatives (0,2).

Critical for the keeping and improvement of the sector's economic sustainability are the increase of production profitability (0,52) and the keeping and increase of sales (0,48). The low levels of indicators for sustainability show also the specialized areas for agricultural sustainability improvement through adequate change of farms strategies and/or of public policies in relation to the sustainable development of the sector, of different sub-sectors, ecosystems and farms types. On the other hand, the high levels of some indicators express the absolute and relative advantages of Bulgarian agriculture regarding the sustainable development. On the actual stage they are expressed in: high share of own capital in the total capital of farms (0,92), high share of sold production in the total output (0,81), lower share of non-occupied permanent (0,81) and seasonal (0,88) work places in the total number of employed, increase of UAA (0,82) and livestock number (0,84) in the last years and respect of norms for animal welfare (for the livestock breeding farms) (0,8).

Conclusion

This first in kind assessment on agrarian sustainability at sub-sectoral level in Bulgaria let make some important conclusions about the state of their sustainability, and recommendations for improvement of managerial and assessment practices. Elaborated and experimented holistic framework gives a possibility to improve general and aspects sustainability assessment. That novel approach has to be further discussed, experimented, improved and adapted to the specific conditions and evolution of each sub-sector as well as needs of decision-makers at various.

There is a considerable differentiation in the level of integral and aspects sustainability in individual sub-sectors in Bulgaria. With the highest integral sustainability is the mixed livestock-breeding, mixed crop-growing, and perennial crops sub-sectors while pigs, poultry and rabbits; vegetables, flowers and mushrooms, and mixed livestock-crops subsectors have the lowest integral sustainability. There are also substantial variations in the levels of economic, social and ecological sustainability of different agricultural sub-sectors and individual indicators with the highest and lowest values show (critical) factors enhancing and deterring particular or overall sustainability of evaluated agro-industries.

Results on the integral agrarian sustainability level of this study based on the micro sub-sector (farm) data are similar to the previous assessment based on the aggregate sectoral (statistical, *etc*.) data. Having in mind the importance of holistic assessments of this kind for improving agrarian sustainability, farm management and agrarian policies, they are to be expended and their precision and representation increased.

[6] The meaning of indicators is the same as in Figures 2 and 3

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Real Option to Defer Investment in Wind Farm in Colombia

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Abstract:

The traditional method of valuation of projects such as the Net Present Value does not manage to quantify the managerial flexibility. Among the methods, the Real Options Approach (ROA) stands out. The ROA is an adaptation to the theory of financial options applied to the valuation of real or physical assets. The ROA is ideal for valuing investment projects in uncertain environments because it is capable of determining the economic value of the management flexibility that is carried out through management options that modify, abandon or differ the investment project. This paper uses the ROA in the valuation of a wind farm in Colombia considering the Real Option to defer. The price of electric power and the price of CER bonds were modeled with the Geometrical Brownian Motion, these variables were identified as the main source of risk in wind farms in Colombia. The results show that the cash flow of the wind farm has a high volatility, so the Real Option to defer the project for up to ten years takes a value greater than the Net Present Value.

Keywords: real options; wind farm; geometric Brownian motion; renewable energy

JEL classification: Q42; Q48; K32; D81

1. Introduction

The generation of electric power in Colombia is of water source in approximately 80%, thermal sources are used in approximately 19% and wind energy in 0.14%. Hydroelectric companies are the main generators of energy due to favorable conditions in Colombia and low costs. However, in the future, we do not have a high percentage of adequate capacity due to the high costs that impede investment in these projects, despite the appropriate weather conditions. The above describes the current conformation of the energy of the basket in Colombia. This is what it means to diversify the basket with other renewable sources and not in the future (Contreras and Rodríguez 2016)

The objective of this paper is to apply the Real Options Approach on a wind farm in Colombia to determine if these projects by this methodology are economically viable or not. The price of energy and the price of CER bonds are considered as a source of uncertainty.

2. Research background

Wind farms are ideal for diversifying the energy basket because the climatic conditions of Colombia are changing and are affected by the El Niño phenomenon where there is scarce rainfall and wind is abundant. However, despite having favorable weather conditions, the financial conditions are not for the wind farms in Colombia because this technology is expensive and with the current value of energy, these projects are not profitable since the valuation of traditional methods valuation of projects such as the Net Present Value (NPV). For this reason, the application of the Real Options Approach (ROA) method is important because it is part of the non-traditional valuation methods that quantify the uncertainty to determine economic viability. In this way, obtaining an economic valuation of the wind farms that quantify uncertain factors that the NPV does not quantify, contributes to making these investment projects profitable for investors and this would increase the reliability in the electricity sector and would result in a diversified energy basket (Gómez, Prins, and López 2016).

The ROA is a conceptual extension of financial options, but applied to real or physical assets. Financial options are financial instruments that allow the buyer to have a right to buy or sell certain assets at a certain price. Likewise, a Real Option grants the right to make a decision about a real physical asset at a certain cost. Decisions about the asset are made taking advantage of the opportunities of the environment and what is called investment management flexibility (Pringles, Olsina, and Garcés 2015, Santos, Soares, Mendes, and Ferreira 2014). In other words, a Real Option is the right to abandon, postpone or adjust an investment project in response to the evolution of uncertainty. So the projects are flexible if they can be abandoned, postponed or adjusted, and this flexibility is what is capable of quantifying the ROA (Martínez-Ceseña, Mutale, and Rivas-Dávalos 2013).

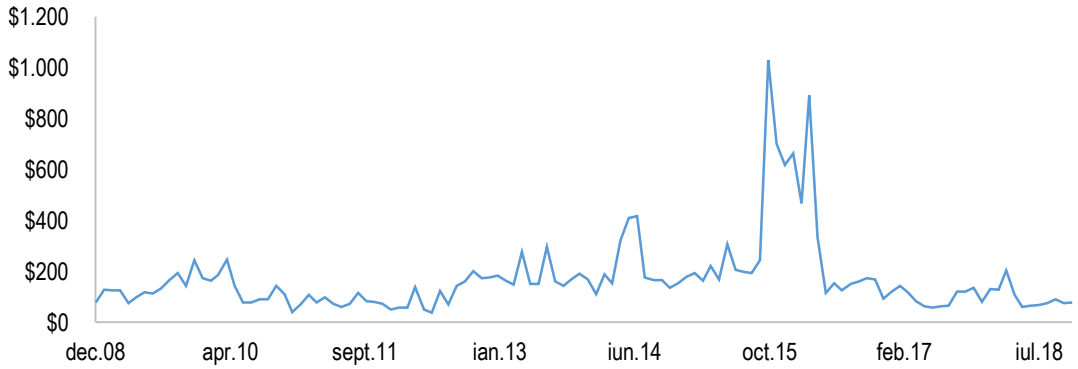
3. Methodology

The ROA is ideal for investment projects where speculation and uncertainty are high. The term of the Real Options was used by Myers in 1977 to quantify the components of flexibility that are decisive in the decision making of long-term projects and high volatility (Myers 1977). In this way, ROA starts from the combination of the traditional method such as the NPV and the relation of purchase options and related sale options in the financial options (Mendez-Suarez and Lamote-Fernández 2013). In this paper, the ROA is applied to the Jepírachi wind farm in Colombia. First the projection of the cash flow of the project is made, then the uncertain variables are modelled and, finally, the Real Option to defer the construction of the project is applied for up to 10 years.

The Jepírachi wind farm is located in the northern part of Colombia in the province of La Guajira. The park was built with 15 wind turbines with an installed capacity of 19.5 MW. It is the first wind farm built in Colombia since 2004 (Pinilla, Rodriguez, and Trujillo 2009). The average annual energy production of the wind farm is approximately 82,000 MWh/year (IRENA 2017). The initial investment was 27.8 million dollars; however, for 2018 the investment is approximately 28.8 million dollars with an average investment of 1,477 USD/kW and the annual operation and maintenance costs for these projects are 0.06 USD/kWh (IRENA 2017).

The average stock price will be used as the sale price of electric power to calculate operating income. This price for November 12, 2018 is 77.42 USD/MWh. For the application of the Real Option, the price of electric power will be modelled with the Geometric Brownian Motion (GBM). Figure 1 shows the behaviour of the monthly price of electricity in Colombia from December 12, 2008 to November 12, 2018. The price of energy has periods of high volatility where the price increases, but it takes little time decrease again. These peaks in price are caused by the seasons of drought in Colombia or sometimes by the El Niño phenomenon where water is scarce in hydroelectric dams.

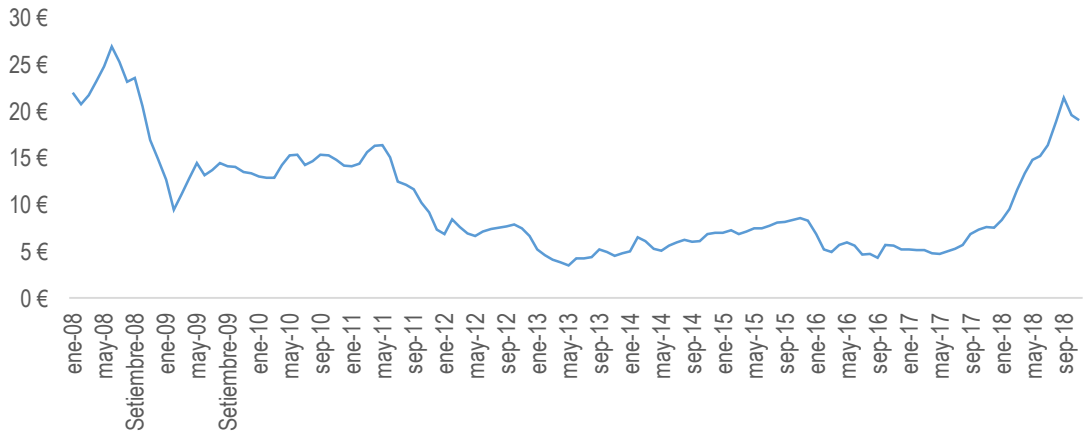
Figure 1. Price of energy in the Colombian stock exchange (USD/MWh)



Source: Own elaboration based on data from (Derivex 2018)

Wind farms can sell CER bonds, it is expected that each year 15,277 tCO2 can be sold at the current CER price (IRENA 2017). This additional income is determined by the capacity of tons of CO2 for the price of the bonds modelled with the GBM, the result is converted into dollars. Figure 2 shows the behavior of the monthly price of CER bonds in Euros from January 2008 to November 2018.

Figure 2. CER bond price (EUR / tCO2)



Source: own elaboration based on data from SENDECO2 (2018)

The correlation coefficient between the price of energy and CER bonds is used to model the two correlated variables. This is done with the formula of Equation (1).

$$\epsilon_1 = u \quad and \quad \epsilon_2 = \rho u + \sqrt{1-\rho^2}v \tag{1}$$

where: ε1 is the random value of variable 1; ε2, is the random value of variable 2 correlated with variable 1; ρ, coefficient of correlation between the variables.

3.1. Geometric Brownian Motion

The Geometric Brownian Motion (GBM) is the continuous time stochastic process that is mainly used for future pricing simulation of a financial asset based on the databases of it (Dunbar 2016, Sengupta 2004). It is important to note that each of these assumptions influences the GBM model and its inputs. The mathematical formulation for the GBM is shown below (Equation (2)):

$$S_T = S_0 * e^{\left(\mu - {}^{\sigma^2}/_2\right)\Delta t + \sigma\sqrt{\Delta t}\,\epsilon} \tag{2}$$

where: ST is the spot price of the asset; S_0 is the last known price, it corresponds to the last data of the historical series of the price of energy or price CER bonds; μ and σ represent the average of returns and volatility, respectively (both are constant); Δt represents the period of time in which the prices will be presented; finally, ε is a random number that follows a normal distribution with zero mean and standard deviation of 1 (Reddy and Clinton 2016).

3.2. Exponentially Weighted Moving Averages – EWMA

An Exponentially Weighted Moving Average or EWMA (Exponentially Weighted Moving Averages) gives more weights to the most recent observations. That is, as extreme returns move more toward the past when the data window moves, they become less important in the average. An EWMA can be defined in any time series of data. Suppose that on date t the data is recorded up to time t - 1. The exponential weighted average of these observations is defined as shown in the Equation (3) (Alexander 2008).

$$\sigma_t^2 = (1-\lambda)r_{t-1}^2 + \lambda\sigma_{t-1}^2 \tag{3}$$

Equation (3) has two terms on the right side. The first term is $(1-\lambda)r_{t-1}^2$. This term determines the intensity of the reaction of volatility to market events: the lower is λ the more volatility reacts to market information in yesterday's performance. The second term is $\lambda\sigma_{t-1}^2$. This determines the persistence of volatility: regardless of what happens in the market, if yesterday's volatility was high, it will still be high today. The closer λ is to 1, the more persistent the volatility is after a market shock (Alexander 2008).

There are statistical methods to determine the value of λ, it could be chosen to minimize the Root Mean Square Error (RMSE) between the variance estimation of EWMA and the square yield as shown in Equation (4) (Medina, Restrepo, Urrego, and Héliodore 2015), but frequently λ values are chosen suggested by the RiskMetrics methodology of using λ of 0.94 for daily data and λ of 0.97 for monthly data (Riskmetrics 1996).

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}[r_{t+1}^2 - \sigma_{t+1}^2\lambda]^2} \quad (4)$$

Volatility EWMA is used for the two uncertain variables modeled with the GBM. The lambda for the EWMA volatility of the energy price is determined by minimizing the RMSE with which a lambda value of 0.999674462138723 was obtained, but for the price of the CER bonds a lambda of 0.97 is used.

The projection of the cash flow of the wind farm is carried out for 15 years with the aforementioned variables and parameters. The variable sources of risk are the price of electricity and the price of CER bonds. The discount rate for wind farms is 7.50% per year from the perspective of an investor in the United States (IRENA 2017), but for the application for Colombia the country risk is added corresponding to 2.04% per year, for what the discount rate that applies to the NPV is 9.54% per year.

After performing the cash flow and modeling the uncertain variables, a Monte Carlo simulation with 50,000 iterations is performed to determine the expected NPV of the wind farm and the standard deviation of the present value of the projected cash flows. Then the Real Option to defer is assessed.

3.3. Real Option to defer

The Real Option to defer the construction of the investment project takes into account the ability to wait or invest. This means that if the current market conditions are favorable, then it is invested now or else it is expected to obtain more information about the investment (Fernandes, Cunha, and Ferreira 2011). The Real Option to defer is similar to a call option on the present value of the wind farm cash flows with the strike price equal to the cost of the initial investment. This Real Option acts as an opportunity cost, by buying the anticipated investment in the project with respect to the value of not doing so and expecting market conditions to favor investment (Mascareñas, Lamothe, López Lubian, and De Luna 2004).

The Real Option valuation is carried out as an American call option with the binomial tree method. With this method it is decided if it is better to exercise the option in advance or wait until the expiration date, this is done at every moment in time. This method of valuation of financial options divides the time to maturity of the option in discrete periods, in this case it is divided by year until the tenth year, each dimension of time is represented by ΔT. In addition, the price of the underlying asset of the financial options that for the Real Options is the present value of the cash flows, subject to a behavior that depends on a coefficient of ascent u and a coefficient of decrease d, in each period of time ΔT. These changes in each node of the binomial tree reflect the favorable and unfavorable market conditions in the investment project. These depend on the standard deviation (σ) of the project cash flow projection. The coefficient of ascent (u) and descent (d) are given by Equations (5) and (6) (Hull 2012).

$$u = e^{\sigma\sqrt{\Delta T}} \quad (5)$$

$$d = e^{-\sigma\sqrt{\Delta T}} \quad (6)$$

The probability that the present value of the cash flows ascends or falls is given by the theory of neutral probabilities to the risk. These increases and decreases have a probability of rise p and a probability of decrease q given by Equations (7) and (8), respectively (Hull 2012).

$$p = (e^{r\Delta T} - d)/(\mu - d) \quad (7)$$

$$q = 1 - p \quad (8)$$

After determining the parameters u, d, p and q, the 10-step binomial tree is constructed from right to left with the possible values of the present value of the cash flows. Then, the value of the option is calculated in each node, but from left to right. For the call options, this value is given by the maximum value between the difference between the spot price and the strike price, and zero, that is, max (S – K; 0). For the Real Option to defer the spot price corresponds to each possible value of the present value of the cash flows and the strike price to the initial investment cost of the wind farm. With the values of the call option to the right of the tree, the values on the left are determined by applying the neutral probabilities to the risk (Hull 2012). Mathematically it is represented by Eq. (9).

$$C_t = \left[pC_u^{t+1} + (1-p)C_d^{t+1}\right]e^{-r\Delta T} \quad (9)$$

Finally, the value of the wind farm including management flexibility is determined as the value of the wind farm without flexibility using the NPV, plus the value of the Real Option to defer, as shown in Equation (10).

$$NPV_{Real\ Option} = NPV_{Traditional} + Real\ Option\ value \quad (10)$$

The value of the Real Option corresponds to the value of the flexibility. This is the way to quantify the impact of the opportunities that arise during the development of the project (Pringles *et al.* 2015).

4. Results

The modelling of the price of electric power and the price of CER bonds with the Geometric Brownian Motion was carried out. These two variables were considered as the two sources of risk with the greatest impact on wind farms in Colombia. In this way, the logarithmic returns of the energy price presented an average of - 0.1108% continuous annual compound and an EWMA volatility of 20.08% with an annual continuous composition. Likewise, for the logarithmic returns of the price of the CER bonds, the average was -1.3303% and the EWMA volatility of 35.76%, both with a continuous annual composition. With the above data, the expected values of the modelling of the two uncertain variables will result in a downward trend, because the drift of the two variables is negative. The drift of the GBM model is equal to $\mu - \sigma^2/2$ which for this case, the price of energy has a drift of - 2.1268% and the price of the CER bonds of – 7.7232%, the drift has an annual continuous composition.

From the Monte Carlo simulation, the average of the present value of the cash flows is 17,132,914 USD and the average of the NPV is 11,668,586 USD. This negative NPV result shows that the investor's decision is to reject the project and not to build the wind farm. The current conditions do not favor the start-up of these wind farms. This decision is made under the traditional methodology of valuation of investment projects. However, under the unconventional methodology of Real Options, the VPN needs to quantify the managerial flexibility that project managers have when market conditions change. In this case, managerial flexibility is associated with postponing investment in the wind farm until market conditions improve and a positive NPV is obtained, but in order to do this, the Real Option must be evaluated to postpone wind farm investment.

The Real Option was postponed by means of the binomial tree methodology to evaluate American financial options. The initial data to assess the Real Option are shown in Table 1.

Table 1. Parameters to assess the call option

Variable	Value
Present value cash flows (S) [USD]	17,132,914
Strike price (K) [USD]	28,801,500
Expiration time real option [años]	10
Volatility cash flows (σ)	85.41%
Risk-free rate (Rf)	2.00%
Number of steps (n)	10
ΔT	1
u (coefficient ascent)	2.3493
d (decrease coefficient)	0.4257
p (probability of ascent)	0.3091

With the binomial trees method for American options it was obtained that the value of the Real Option to defer is of 13,608,605 USD. Figure 3 shows the binomial tree of 10 steps with the values of the present value of the cash flows and the values of the Real Option in each node.

The value of the Real Option corresponds to the quantification of managerial flexibility of expecting market conditions for wind farms to improve. In this way, the new VPN is of 1,940,018 USD, this corresponds to the traditional VPN (- 11,668,586 USD) plus the value of the Real Option (13,608,605 USD). Consequently, the NPV is positive so the project is not rejected, it is accepted, but the acceptance is conditioned to the expectation that the market conditions will change, that according to the model there are scenarios that this happens. Figure 4 shows that from the first year it is possible to obtain favorable conditions for the start-up of the wind farm, this is observed in the nodes of the decision tree where the word INVESTIG. However, there are also scenarios where it is recommended to postpone the investment and wait a longer time until reaching year 10 where the project is definitely carried out or not (NOT INVESTING).

Figure 3. Binomial tree call option

0	1	2	3	4	5	6	7	8	9	10
										$87.744.288.595
									$37.349.095.988	$87.715.487.095
								$15.897.957.502	$37.320.864.796	$15.897.957.502
							$6.767.099.605	$15.870.285.325	$6.767.099.605	$15.869.156.002
						$2.880.472.983	$6.739.975.374	$2.880.472.983	$6.738.868.413	$2.880.472.983
					$1.226.097.603	$2.853.885.848	$1.226.097.603	$2.852.800.806	$1.226.097.603	$2.851.671.483
				$521.898.779	$1.201.699.402	$521.898.779	$1.198.973.372	$521.898.779	$1.197.866.411	$521.898.779
			$222.150.614	$501.855.571	$222.150.614	$497.766.395	$222.150.614	$494.226.602	$222.150.614	$493.097.279
		$94.560.281	$207.419.614	$94.560.281	$203.469.492	$94.560.281	$198.650.984	$94.560.281	$193.919.422	$94.560.281
	$40.250.381	$84.720.411	$40.250.381	$81.774.873	$40.250.381	$77.771.460	$40.250.381	$72.240.065	$40.250.381	$65.758.781
$17.132.914	$34.172.060	$17.132.914	$32.310.749	$17.132.914	$29.728.467	$17.132.914	$25.972.617	$17.132.914	$19.921.708	$17.132.914
$13.608.605	$7.292.769	$12.559.520	$7.292.769	$11.128.792	$7.292.769	$9.106.720	$7.292.769	$6.035.307	$7.292.769	$0
		$3.104.229	$4.091.469	$3.104.229	$3.134.032	$3.104.229	$1.828.404	$3.104.229	$0	$3.104.229
		$1.480.955	$1.321.341	$1.063.108	$1.321.341	$553.917	$1.321.341	$0	$1.321.341	$0
			$356.500	$562.440	$167.810	$562.440	$0	$562.440	$0	$562.440
				$50.838	$239.407	$0	$239.407	$0	$239.407	$0
					$0	$101.906	$0	$101.906	$0	$101.906
						$0	$43.377	$0	$43.377	$0
							$0	$18.464	$0	$18.464
								$0	$7.859	$0
									$0	$3.345
										$0

Figure 4. Decision tree Real option to defer

0	1	2	3	4	5	6	7	8	9	10
										INVESTING
									INVESTING	
								INVESTING		INVESTING
							INVESTING		INVESTING	
						INVESTING		INVESTING		INVESTING
					INVESTING		INVESTING		INVESTING	
				INVESTING		INVESTING		INVESTING		INVESTING
			INVESTING		INVESTING		INVESTING		INVESTING	
		INVESTING		INVESTING		INVESTING		INVESTING		INVESTING
	INVESTING		INVESTING		INVESTING		INVESTING		INVESTING	
DEFER		DEFER		DEFER		DEFER		DEFER		NOT INVESTING
	DEFER		DEFER		DEFER		DEFER		DEFER	
		DEFER		DEFER		DEFER		DEFER		NOT INVESTING
			DEFER		DEFER		DEFER		DEFER	
				DEFER		DEFER		DEFER		NOT INVESTING
					DEFER		DEFER		DEFER	
						DEFER		DEFER		NOT INVESTING
							DEFER		DEFER	
								DEFER		NOT INVESTING
									DEFER	
										NOT INVESTING

It is highlighted that managerial flexibility has more weight in the new VPN because it is higher than the traditional VPN by 117%. This means that in this type of projects of high uncertainty, their valuation depends largely on managerial flexibility. This is why the single application of traditional VPN is not a good indicator for decision making for wind farms.

Conclusion

This paper assesses the Jepírachi wind farm in Colombia through the Real Options method (ROA). The main characteristics and the uncertain variables are identified in these investment projects that justify the application of the Real Option to defer. The NPV of the wind farm is negative, which by this traditional method of project valuation the project is rejected, but this method does not quantify the managerial flexibility that can be had in the wind farms through time when the uncertainty is resolved. On the other hand, the ROA allows to quantify the management flexibility and increase the value of the VPN in case it is possible that the market conditions favor the investment in these projects. Consequently, real options maximize profits in favorable situations and minimize losses in unfavorable ones.

None of the evaluation methods is considered absolute. However, this does not mean that there is no need to look for evaluation methods that take into account the characteristics of the investment, uncertainties and flexibility in the management. Although Real Options is a difficult and uncommon method for companies, it is the most current and appropriate method to apply to issues related to uncertainty. Therefore, if an analysis takes uncertainty into account over time and includes real options in the project, the decision-making process will be more realistic.

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Material and Immaterial Relations in a Local Agrifood Supply Chain: An Integrated Approach

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Abstract:

The structure of contemporary agrifood supply chains is very complex and consists of material and immaterial relations. In addition to internal ties and flows between each production stage and its immediate suppliers and customers, some authors argue as it is very important to investigate the network between firms and institutions supporting their production activity. Therefore, this study aims to propose a combined approach to the investigation of local agrifood supply chains. Specifically, the proposed approach merges the indexes adopted to study the economic structure of the supply-chain with Social Network Analysis. A direct survey was carried out in the area of Foggia, to study the organic durum wheat supply chain either for its material or immaterial relations. Their study shows as, notwithstanding the good structure of the institutional network, there is still little integration between the phases of the material supply chain hindering the valorization of the supply chain itself.

Keywords: food supply chain; social networks; organic durum wheat; material flows; institutional network

JEL classification: L14; Q13

1. Introduction

In rural areas, most of the development strategies move from the enhancement of the territory through an accentuation of the 'territory-food production' link (Perrier-Cornet and Sylvander 2000). Therefore, the presence and the structure of local agrifood supply chains become a key factor of rural development patterns. Starting from the idea of the synergistic effect and of the strict integration between firms and institutions for the competitiveness of a productive sector and of its territory, this study aims to propose a combined approach to the investigation of local agrifood supply chains. Specifically, the proposed approach merges the indexes adopted to study the economic structure of the supply chain with Social Network Analysis (SNA) that offers interesting contributions to understand the social network between institutions and with firms.

The area of study is the province of Foggia, characterized by a natural vocation for the production of organic durum wheat. The study was articulated in two stages. In the first step, the structural characteristics of the organic durum wheat supply chain and its degree of territorial integration were investigated. Afterwards, the structure of the institutional social network in which this supply chain is embedded was analyzed. This aimed to understand if it is the most suitable for the development of the local supply chain and of the territory itself. A direct survey was carried out through quantitative surveys and qualitative in-depth interviews. The data processing allowed us to reconstruct and describe the structure of the local agrifood supply chain and to investigate the institutional network supporting organic durum wheat production. The knowledge of these elements, together with the features of weakness of the network allowed us to highlight some factors that could strengthen its systemic connotation.

2. The complexity of material and immaterial flows inside and outside the local agrifood supply chain

The concept of agrifood supply chain (Malassis 1973), although its rather generic and indeterminate nature, has attracted a growing interest resulted in many theoretical-methodological contributions (Monfort and Dutailly 1983, Monfort 1983, Belletti *et al.* 1994).

A supply chain can be considered a complex system that is a supply network consisting of a set of entities/actors, activities, technological/physical infrastructures and policies involved with the procurement of raw materials, conversion of these raw materials in finished product, and logistics for the manufacturing-to-delivery of these products (Hakansson and Snehota 1995, Iacobucci *et al*. 1996).

Marsden *et al.* (2000) argue that the structure and the evolution of local agrifood supply chain is very variable. Some of them are highly ephemeral, others endure generating long-lasting benefits to rural areas. Some agrifood supply chains remain highly localized, servicing a dedicated but small group of consumers, others expand to meet consumer demand at a national or even global scale. Finally, some are highly dependent upon associational or institutional arrangements at local, national or international level, others are less closely interwoven with socio-political structures and are the result of individualistic entrepreneurialism.

On the other hand, the structure of contemporary agrifood supply chains is very complex and consists of material and immaterial relations. In addition to internal ties and flows between each production stage and its immediate suppliers and customers, very important is the network of ties and relationships of different nature and strength with the institutions supporting their production activity (Lopolito *et al.* 2015).

The Italian agrifood sector is mainly formed by small and very small-sized enterprises. Therefore, an important factor of competitiveness is represented by the relationships between firms and the institutions providing the necessary technical, financial and promotional support (Ratti 1991). This is particularly true for some specific local agrifood supply chains whose production is deeply rooted in the local territory as organic food (Ciccarese and Silli 2016) or Protected Designations of Origin (Perrier-Cornet and Sylvander 2000, Sparf 2010).

Through the supply chain it is possible to distinguish flows of different nature: product, financial, and information. The first, physical product flows, are unidirectional in most cases, starting with input supply and ending with consumption. Financial resources flows tend to move in the opposite direction of product flows, with payments going to upstream suppliers as products move downstream toward consumers. Information flows move in both directions throughout the supply chain. From any point in the chain, suppliers convey information about product attributes and availability to downstream customers, while receiving information about product demand, product inventories in downstream segments, and consumer reactions to product attributes, as well as universities and research centres, that create and transfer knowledge (King and Venturini 2005, Feenstra *et al.* 2011).

In this view, an extensive body of literature has highlighted as traditional approaches to Supply Chain Management (SCM) are inadequate to capture all the complex structural aspects and features (Beske and Seuring 2014, Miemczyk *et al.* 2012). In fact, only by mapping the whole chain and exploring interactions within that chain as a system, it will be possible to receive useful insights and suggestions on how to improve and sustain the development of local agrifood supply chain itself (Hawkes 2009, Feenstra *et al.* 2011).

3. The investigation of material and immaterial flows

For the purposes of this work, the meaning of the agrifood supply chain used was that of a 'production chain' that, starting from the agricultural raw material, considers all the subsequent phases up to the final use of the resulting product (Belletti *et al.* 1994). Subsequently, supplier/customer relationships, the downstream and upstream phases are investigated through the analysis of the degree of autonomy/dependence of each phase from the following one, by means the indexes proposed in their work, even if at a different territorial level.

In particular, the analysis is based on four indexes:

- the absorption index of the downstream phase;
- the dependence index of the upstream phase towards the downstream phase (U vs. D);
- the downstream phase towards the phase upstream (D vs. U) of each sector with respect to that with which it is connected;
- the index of Discrasia.

The first index expresses the quantity of raw material transformed by the provincial plants compared to the total quantities of raw material produced in the entire provincial territory. It is a way to compare the size of the supplier sector with the one of the customer.

The Upstream-Downstream Dependency Ratio measures the percentage of raw material produced in the province of Foggia and locally transformed with respect to the total production of the sector. The Downstream/Upstream Dependency Ratio expresses the ratio between purchases of local raw materials and the total availability of the industry after the phase, that is the percentage of supplies of the processing industry coming from the same area.

Finally, the Discrasia index between the phases provides a measure of the degree of openness of the upstream phase towards the rest of Italy and the world. The values assumed by this index vary between *1* if there is an absolute lack of exchange and *0* in the case of maximum exchange.

The index is obtained from the ratio between the interchanged volume with the rest of the world from the two phases (equal to the sum between the share of local agricultural production destined to extra-local markets

and the share of raw material purchased outside the province from one local plant) and the sum between the total agricultural production quota and the total share processed from local firms.

The investigation of the institutional network supporting firms in their production/exchange activities was made by means of SNA. Some Authors (Kamann and Strijker 1991, Choi and Kim 2008, Borgatti and Li 2009) argue as SNA concepts are particularly useful to identify the patterns of institutions-firm relationships in a local supply network that lead to competitive advantages through the diffusion of information.

Specifically, SNA aims at investigating how, in a network of actors, each one relates to the others and, the efficiency of information diffusion. The reticular analysis consists of two types of interpretations that can be used individually or jointly: graphic and matrix analysis. The graphic representation, while allowing a more immediate visualization of the characteristics of the network, proves to be inadequate when the number of actors and relationships increase. In this situation, to detect more precise information on the type of existing relationships, it would be appropriate to use the matrix analysis based on the adjacency matrix (Maggioni 1994), a square binary matrix, composed of as many rows and columns as there are actors. The adjacency matrix considers only direct relationships, whereas for indirect relations, the matrix of reachability or that of geodesic distances can be used according to the objectives.

A parameter widely used in the reticular analysis is the diameter of the network. It is equal to the maximum value assumed by the shortest connection between two actors and gives information on the macro characteristics of the network as a whole. If this distance is high it means that between two actors there are a lot of intermediaries, the information will spread very slowly throughout the network and the mutual influences will be quite contained (Lopolito *et al.* 2011).

The number of nodes or the subjects belonging to the network constitutes its size, while network density relates to the ratio between the actual relationships and the totality of those that could be activated among the network components. This index assumes values between 0 and 1.

The proximity of an actor measures the distance of an actor from all the other components of the network and represents his potential to be independent and efficient, to avoid external influences and at the same time to transmit an information, in the shortest possible time. One component of the network may be more influential than the others as it is more directly connected to the greater number of actors (greater number of minimum geodesic distances) than the others.

The paper contributes to the existing literature in two ways. First, it proposes an innovative approach based on two literature strands (the SCM and the SNA) that to the best of our knowledge, have never been applied if not singularly. This has allowed us investigate the whole structure of the complex network between farms, firms and, institutions involved in the food production. Second, it highlights the relevance to investigate the local supply chain not only from the traditional point of view of material flows but also in terms of immaterial (knowledge, information) flows between institutions and farms/firms.

4. The organic durum wheat supply chain in the area of Foggia

Apulia region is the first producer of durum wheat in Italy and the leader area is the province of Foggia with 240.00 hectares, of which 100.000 hectares at organic cultivation (De Vita and Pecchioni 2018). Therefore, we decided to investigate the structure of this local supply chain to better understand its weaknesses and strengths. To this aim, a direct survey was locally conducted by submitting questionnaires to the local stakeholders operating in this sector.

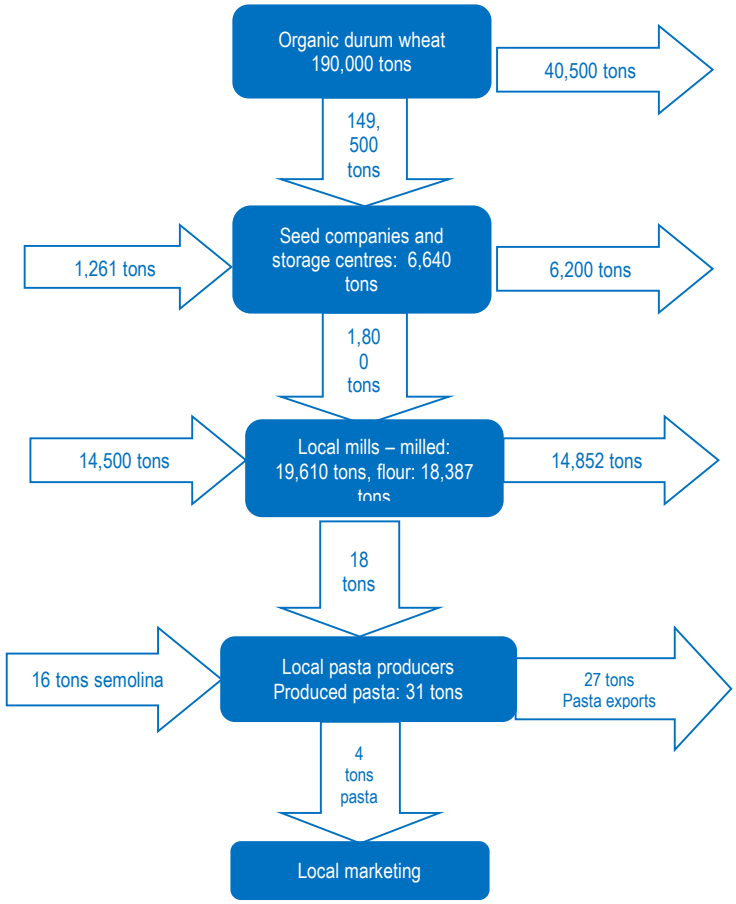
4.1. The wheat flows

Agricultural production identifies the first phase of the production process. Durum wheat is certainly the most important crop in the investigated area as this occupies almost 55% of the total provincial agricultural area and, almost 65% of the Apulian durum wheat is produced in the province of Foggia. Focusing the analysis on the organic production, in 2017 the production of organic durum wheat was of about 190.000 tons (De Vita and Pecchioni 2018) with an average productivity of about 19 quintals.

The production process consists of five phases which, starting from the agricultural production phase, articulate into: storage, milling, pasta-making and finally, the marketing of the finished product.

The flow chart in Figure 1, shows for each phase the flows in and out of the raw material and the products of each phase. The local supply chain structure indexes, are shown in Table 1. From the analysis carried out emerges a very strong connection within the provincial territory between agricultural production and local seed industries and storage center because the whole (100%) of the organic durum wheat from Foggia is directed to seeders and storage center in the same province, for which it constitutes 78% of the supply.

Figure 1. Organic durum wheat flows in the province of Foggia



Source: our elaborations

Also the level of Discrasia found or the exchanges with other economies, is not very high reaching a value of just 0.12. This value is mainly due to the over dimensioning of the storage structures compared to those of agricultural production or if it is preferred, to the little interest of local farmers to increase the production of organic durum wheat. Going to examine the next phase of the supply chain the situation is reversed.

Table 1. Some indexes of the local organic durum wheat supply chain

Stages of the supply chain		Absorption index	M vs. V	V vs. M	Discrasia
Agriculture	Storage	1.27	1.00	0.78	0.12
Storage	Mills	2.30	0.25	0.11	0.85
Mills	Pasta producers	0.00	0.00	0.55	0.99
Pasta producers	Marketing	ND	0.10	0.11	0.43

Source: our elaborations

In this case, the absorption index of the milling industry is equal to more than twice the stored production (absorption index equal to 2.30). Nevertheless, the link between storage and local mills is much weaker than could be expected because the dependence index of the upstream phase compared to the downstream one is only 0.25. In addition, the wheat locally sold by the constitutes only 11% of the supplies for the first processing industry (index equal to 0.11). Subsequently, the index of Discrasia cannot but assume a high value. In fact, this is around a value of 0.85.

The insufficiency of the volumes processed by the local pasta makers compared to the potential of the provincial milling industry (as shown by the almost zero absorption index) determines a strong flow of semolina to other regions and, therefore, little dependence on the upstream sector (mills) to that placed downstream (pasta makers). On the contrary, local zootechnical farms are fairly connected with the mills of their own region, as far as they are concerned for 55% of the raw material purchased.

On the whole, it is possible to observe that the total agricultural production is sold within the production territory. This situation changes in the next phase, the one involving the province's seed companies and storage

centers. In this phase, about 75% is sold outside the province of Foggia while only 25% is sold to local mills. In the milling phase it is possible to observe a flow of wheat entering from the outside of the province of Foggia much more important than the internal one. This situation is quite difficult to explain, considering that, as already noted, agricultural production is the only sufficiently developed phase. In reality, the consulted mill companies have declared a particular difficulty in finding organic durum wheat of satisfactory quality on the local market. On the other hand, the phase of pasta making shows once again all the incompleteness and inconsistency of the local supply chain.

Finally, it is possible to see how of the total production of pasta produced, only 15% is sold in the territory of the Province of Foggia while the remaining 85% is sold outside the area. This represents a further confirmation of how the scarcity of local demand represents, according to the operators, the main obstacle to the development of the local organic durum wheat supply chain.

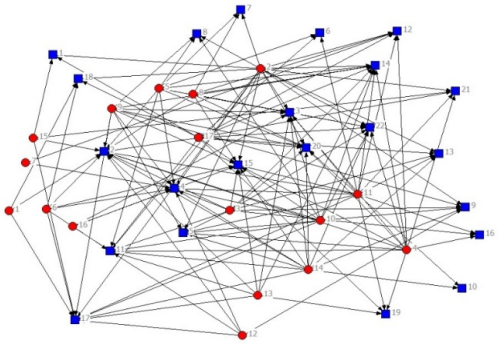
4.2. The firms-institutions network

The identification of the components of the network was the result of a focus group that outlined a first list of actors, subsequently integrated by submitting to each of the identified actors a questionnaire to verify the existence or not of the relationship, the nature and, eventually the causes of non-activation, as well as more relations with other partners.

The network between firms and institutions operating in the organic durum wheat sector consists of 49 actors (22 institutions[1] and 17 firms) two of which are outside the provincial territory but within the Apulia region, linked through 122 relationships. In Figure 2, the blue squares are Institutions, while the red circles represent the Firms.

The network analysis, was carried out using UCINET with which in addition to graphically representing the network, some of the most significant structural indices of the network were calculated (Borgatti *et al.* 2013).

Figure 2. The firms-institutions network



Source: our elaborations.

In Figure 2, the red circles are the firms, the blue squares the institutions supporting the organic durum wheat supply chain. The diameter of the network, equal to 5 (from the matrix of geodesic distances) is synonymous with a fairly dense network as expressed by the density index equal to 0.32. The absence of structural holes in the network means that even in case of the removal of a single connection, any actor would remain completely isolated from network. In confirmation of what is revealed by these indices, the graphical representation (Figure 2) highlights some actors who have a relevant role (Agriculture Regional Department, CCIAA, Daunia & Bio, Biogargano, University of Foggia, AIAB Puglia) in terms of management of information flows with respect to firms.

4.3. Results

The indicators we adopted to represent the exchange ratios in the local agrifood supply chains (absorption index, upstream downstream dependence ratio and downstream dependence index, discrepancy index) highlight the presence of a very close relationship only at the level of the agricultural phase and of the seed companies and storage firms.

In fact, going down along the successive stages of the pasta production process, there's a strong opening of the local supply chain more or less of the same intensity in all the other phases characterized in fact by less intense relationships. The low values of absorption indices, U versus D and D versus U, which are accompanied

[1] In particular, in the case study, institutions belong to Local Public Institutions, Research centres, University of Foggia, Entrepreneurial associations and Certification agencies. Interviewed firms are agricultural organic farms, organic durum wheat storage centres, mills, pasta producers and pasta retailers.

by very high values and close to the unity of the index of Discrasia especially for the phases of storage/milling and milling/pasta making reveal some interesting aspects regarding the characteristics of the sector. Surely, the first observation is related to the lack of interdependence between the phases, scarcely imputable to an unsuitable sizing in terms of work or production capacity of each phase compared to those downstream and upstream as regards the quality of the production carried out.

As can be seen from the flow chart, most of the production of each phase does not remain in the territory but is 'exported' and at the same time local businesses 'feed' on external raw material. The confirmation also comes from the index of dyscrasia, symptomatic of the high involvement of non-local operators in the exchanges, which takes on very high values and close to unity in the storage/milling phases (index of discrepancy 0.85) and milling/pasta making (index of dyscrasia 0.99).

From the reticular analysis, it emerged that in the governance structure it is not possible to identify a leader subject but the network is characterized by the presence of different poles of convergence of relationships. In fact, it is also to be considered that, being organizations, the different subjects hold different roles from the institutional point of view but contribute in a complementary way to support the activity of local firms. Therefore, in addition to representing the most valuable part of the network, they would be the first to be involved in any initiatives aimed at improving the local network (Bertini 2000).

Among the positive elements, the density of the existing network must be considered, in particular those taking part in the promotion and dissemination and research activities.

Furthermore, the presence of the university, of research centers highly specialized on durum wheat cultivation and of certification bodies can be considered symptomatic of the presence in this area of relevant technical and scientific skills. However, notwithstanding the presence of a good institutional network supporting each stage of the supply chain, it doesn't work still fluently.

Conclusion

The aim of the study was to propose a combined approach to better study the presence of the organic durum wheat supply chain in the province of Foggia and its embeddedness in the institutional network supporting the activity, the evolution and the competitiveness of the whole supply chain.

Although the territory under investigation is naturally and traditionally characterized by the cultivation of durum wheat according to both conventional and organic farming methods, the absence of a durum wheat supply chain has been highlighted.

Integrating perspectives from several types of stakeholders in local agrifood supply chains enriches the picture of how these chains function and what is needed to improve upon them or expand them further. Therefore, the integration of the SNA with traditional approaches to the study of Supply Chains are desirable because in each system, comparable to a network, actors are not independent but rather influence each other. In fact, as argued by Borgatti and Li (2009), network variables have consequences for nodes and for the network as a whole.

However, because SNA is not particularly concerned with vertically organized ties, but rather with horizontal relationships between firms belonging to a particular industry, the study of the complex system of a local agrifood supply chain can't leave aside the traditional approaches to supply chain analysis.

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Value at Risk Estimation in the Mexican Stock Exchange: A Comparison of Empirical Distributions

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Abstract:

The objective of this paper is to address the issue of VaR model selection for the Mexican equity market. To this end, we consider the family of stable distributions in VaR modeling as an alternative in the Mexican financial market and its performance is compared with the normal, NIG, GLD and GST estimations. We directed a statistical analysis to compare the suitability of these five distributions on the equity stock returns during a period of high volatility. The approaches are based on the maximum likelihood estimation of the parameters of a distribution. The estimation of the conditional variance of returns is based on the GARGH model with the innovation of α-stable, GST, GLD and NIG distributions to describe returns. In addition, the predictive power of the heteroscedasticity in VaR models is tested using the so called back testing and the Kupiec likelihood ratio test. The statistical results showed evidence that the α-stable model provides superior fit in modeling VaR at high confidence levels. In contrast, stable modeling is not satisfactory at low confidence level.

Keywords: heteroscedastic VaR models; stable distributions; generalized Skew *t* distribution; normal inverse Gaussian distribution; generalized Lambda distribution

JEL classification: G17; C22; C13

1. Introduction

Over the past decades the financial theory has been developed under the assumption that asset returns follow a normal distribution. The Gaussian hypothesis was not seriously questioned until the seminal papers of Mandelbrot (1963) and Fama (1965a-b) were published. The excess of kurtosis that Mandelbrot and Fama found in their investigations led them to reject the normal assumption and to propose the stable Paretian distribution as a statistical model for asset returns.

Later, the stable Paretian assumption was supported by numerous empirical investigations: Bawa *et al.* (1979), Janicki and Weron (1994), Panorska *et al.* (1995), Nolan (1997, 2003) and Rachev and Mittnik (2000). In the same line, Rachev and Han (2000) compared the stable Paretian hypothesis to the normal hypothesis using three hundred eighty-two US daily stock returns. They used two models: the homoskedastic independent and identically distributed model and the conditional heteroskedastic ARMA-GARGH model. They found that the stable Paretian distribution describes clearly better the tails and the central part of the distribution of returns than the normal distribution for both models.

Curto *et al.* (2009) discussed alternative conditional distributional assumptions for the daily returns of the American, German and Portuguese main stock market indexes. They assumed that the innovation of the ARMA-GARGH models follows a Gaussian, Student's *t* and stable Paretian distribution. They found that a GARGH model under the stable Paretian hypothesis fits returns strongly better than the Gaussian and slightly better than the Student's t hypothesis. However, the Student's t outperforms the Normal and stable Paretian distributions when the out-of-sample density forecasts are considered.

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Harris and Küçüközmen (2001) considered the skewed generalized-t distribution (GST) and the exponential generalized beta distribution (EGB) using daily US and UK equity returns. They noticed that the distributions belonging to the GST family outperform the normal distribution in both markets. More recently, Bali and Theodossiou (2007) proposed a conditional model for VaR estimation based on the GST distribution. They analyzed the performance of ten popular variations of the GARGH model. The results indicated that the TS-GARGH and EGARGH models had, in general, the best performance.

Eberlein and Keller (1995) used the normal inverse Gaussian (NIG) distribution to model compound returns of DAX 30. Prause *et al.* (1997) estimated the parameters of the NIG distribution for the German stock and the American Stock Index data and evaluated the goodness of the fit. Moreover, Bolviken and Benth (2000) described a numerical procedure to estimate the parameters of the NIG distribution and used it to model eight Norwegian stocks.

Finally, Corlu *et al.* (2016) provided an extensive survey regarding the performances of alternative distributions in modelling unconditional distributions of daily equity index returns over the period 1979-2014. Including the GST distribution, the GLD, the Johnson system of distributions, the NIG distribution, and the g-and-h distribution, they concluded that GDL is the best alternative.

The objective of this paper is to address the issue of VaR model selection for the Mexican equity market. Dimitrakopoulos *et al.* (2010) investigated VaR modeling for emerging and developed market equity. The results indicate that in the case of the emerging equity market portfolios with heavy tails, most VaR models provide conservative risk forecasts, in contrast to developed equity market portfolios, most models underestimate the VaR. Furthermore, VaR estimation during periods of financial crisis seems to be more complex, particularly in the case of emerging markets and especially for the higher loss quartiles. Alonso and Chaves (2013) evaluate the performance of twenty different methods, as well as the historical simulation method, to estimate the next-trading-day VaR of a portfolio for five different Latin American countries. Aguirre *et al.* (2013) analyzed different VaR estimations of the Mexican stock exchange index (IPC). They used ARMA models, ARCH models, symmetric and asymmetric GARCH models and the extreme value theory (EVT).

However, some of them employed traditional VaR approaches and excluded GARGH models for VaR estimation. Other studies do not consider the Mexican market and use indices as proxies for the emerging equity markets portfolios. According to this, our goal in this document is to fill this gap in the literature analyzing which distribution is best for modeling daily equity return data in the Mexican market. To this objective, we consider several flexible distributions that are commonly used in finance: the α-stable distribution, the GST distribution, the NIG distribution, the GLD distribution, and we also include the normal distribution as a benchmark.

Investigating VaR modeling for the Mexican equity market is especially interesting for the following reasons:

- global economic stability;
- market risk quantification for the Mexican market, to our knowledge has not been extensively studied.

We conduct a statistical analysis to compare the suitability of these five distributions on the equity stock returns of the Mexican Stock Exchange. The sample period chosen for the analysis (2002-2009) is a period of high volatility which makes the period ideal for the empiric VaR evaluation.

The suitability of a specific distribution is compared using the Kolmogorov–Smirnov (KS) and the Anderson–Darling (AD) test statistics. The approaches are based on the maximum likelihood estimation of the parameters distribution. The estimation of the conditional variance of returns is based on the GARGH model with the innovation of α-stable, GST, GLD and NIG distributions to describe returns. Moreover, the predictive power of the heteroscedasticity VaR models is tested using the test called backtesting and the Kupiec likelihood ratio test given in Kupiec (1995). According to previous research, we found that normality was rejected on financial returns.

The paper is organized as follows. Section 2 describes the methodology employed in the present work. Section 3 presents the data and descriptive statistics. Section 4 presents the empirical results. This paper ends with concluding remarks.

2. Methodology

The core activity of financial institutions is risk management. Calculating capital reserves given a comfortable level of risk is essential to ensure viability and good reputation for financial institutions. Therefore, it is necessary to have an accurate model and a proper measurement that describes the risks.

2.1. Value at Risk

A commonly used methodology for estimation of market risks is the Value at Risk (VaR). It became a key measure of market risk since the Basle Committee established in 1996 that commercial banks should cover losses on their

trading portfolios over a 10-day horizon, 99% of the time. Financial firms usually use VaR for internal-risk control, considering a 1-day horizon and a 95% confidence level. A VaR measure is the highest possible loss over a certain period of time at a given confidence level, without abrupt changes in the market conditions. More formally, VaR is defined as the upper limit of the one-side upper interval:

$$P\{X \leq -VaR_{1-q}^{X}\} = q \tag{1}$$

where: $1-q$ is the confidence level and $X = \Delta\Pi_t(\tau)$ is the relative change (return) in the portfolio value over the time horizon τ.

The time horizon should be determined from the liquidity of assets and the trading activity. The confidence level should be chosen to provide a hardly ever exceeded VaR value. From the definition (1), the VaR values are obtained from the probability distribution of portfolio value returns:

$$q = F_X(-VaR_{1-q}^{X}) = \int_{-\infty}^{-VaR_{1-q}^{X}} f_X(x)dx \tag{2}$$

where: $F_X(x) = P(X \leq x)$ is the cumulative distribution function (cdf) of portfolio returns in one period; $f_X(x)$ is the probability density function (pdf) of X.

The VaR methodologies mainly differ in how to construct $f_X(x)$. VaR is widely accepted by financial institutions, regulators, non-financial corporations, and institutional investors because it is easy to understand. The traditional techniques of approximating the distribution of $\Delta\Pi$ are: the parametric approach, the historical simulation and the Monte Carlo Simulation.

2.2. Flexible Probability Density functions

Finding a proper distribution to describe the financial data is essential in risk management. It is known that financial returns are deficiently described by Normal distributions because empirical results show that financial data are usually asymmetric and fat-tailed (Fama 1965b, Champagnat *et al.* 2013). However, we can consider heavy-tailed parametric families for this purpose. Here we introduce some families of distributions: generalized skewed t (GST) distribution, Normal Inverse Gaussian (NIG) distribution, the generalized lambda (GLD) distribution and α-stable distribution, which can describe the skewness and kurtosis characteristics of financial data.

Hansen's Skew t distribution

In previous research, a number of skewed Student-t distributions have been proposed. In this study, due to its simplicity, we follow the parametrization used in Hansen (1994). He suggests an alternative parametric approach to modeling the conditional density of the normalized error. He proposed a simple skewed generalization of the student's t density.

$$f(z;\eta,\lambda) = \begin{cases} bc\left(1+\frac{1}{\eta-2}\left(\frac{bz+a}{1-\lambda}\right)^2\right)^{-\frac{\eta+1}{2}} & z < -a/b \\ bc\left(1+\frac{1}{\eta-2}\left(\frac{bz+a}{1+\lambda}\right)^2\right)^{-\frac{\eta+1}{2}} & z \geq -a/b \end{cases} \tag{3}$$

where: $|\lambda| < 1, 2 < \eta < \infty$ and the constants a, b, c are defined as $a = 4\lambda c\left[\frac{\eta-2}{\eta-1}\right], b = \sqrt{1+3\lambda^2-a^2}$ $c = \Gamma((\eta+1)/2)/\sqrt{\pi(\eta-2)\Gamma(\eta/2)}$. The parameter η controls the heaviness in the tails and λ drives the skewness in distribution (Hansen 1994).

Normal Inverse Gaussian distribution (NIG)

The NIG distribution is a particular case of the generalized hyperbolic distribution with $\lambda = -1/2$, whose density function is given by:

$$f(x;\lambda,\alpha,\beta,\delta,\mu) = \frac{k_{\lambda-1/2}\left((x-\mu)^2+\delta^2,\alpha^2\right)}{\sqrt{2\pi}k_\lambda(\delta^2,\alpha^2-\beta^2)} exp[\beta(x-\mu)] \tag{4}$$

where: $\alpha, \delta \geq 0$, $\mu, \beta \in \mathbb{R}$ with $\beta \in [-\alpha, \alpha]$ and k_λ is the third order modified Bessel function (Eberlein and Keller 1995) The parameter β measures the asymmetry, α the heaviness of the tails, λ defines the form of the distribution, μ is a location parameter and δ measures the dispersion (Ptaff *et al.* 2013).

Generalized Lambda distribution (GLD)

The GLD presents different specifications, but the simplest parameterization to use is the Freimer-Mudholkar-Kollia-Lin (FMKL) given by:

$$F^{-1}(u;\lambda_1,\lambda_2,\lambda_3,\lambda_4)=\lambda_1+\frac{1}{\lambda_2}\left(\frac{u^{\lambda_3}-1}{\lambda_3}-\frac{(1-u)^{\lambda_4}-1}{\lambda_4}\right) \quad (5)$$

where: $\lambda_2 > 0$ and it must be fulfilled that $\min\{\lambda_3,\lambda_4\} > -1/k$ for the existence of kth moment. The parameters $\lambda_1,\lambda_2,\lambda_3,\lambda_4$ determine the shape and heaviness in the tails of the probability distribution.

α-stable distribution

Stable distributions are a rich class of probability distributions that allow skewness and heavy tails. There are multiple definitions and notations of stable random variables (Nolan 2003). In this paper we follow the Nolan's notation and definition. A stable random variable X is described by its characteristic function:

$$E[\exp(iXt)]=\begin{cases}exp[-\gamma^{\alpha}|t|^{\alpha}[1+i\beta sgn(t)\tan(\pi\alpha/2)(|\gamma t|^{1-\alpha}-1)]+i\delta t] & \alpha\neq 1\\ exp[-\gamma|t|[1+i\beta(2/\pi)sgn(t)\ln[\gamma|t|]]+i\delta t] & \alpha=1\end{cases} \quad (6)$$

This function called the 0-parameterization is continuous and it is recommended for numerical work and statistical inference. For this reason, we used this parameterization in the present investigation instead of the 1-parameterization described by Nolan. The skewness parameter $|\beta| \leq 1$ measures the asymmetry, the index of stability $0 < \alpha \leq 2$ the heaviness of the tails, $\gamma \geq 0$ is the scale parameter, and $\delta \in \mathbb{R}$ is the location parameter (Nolan 1997).

3. Data

Daily closing prices for fifteen stocks in the Mexican Stock Exchange Index (MEXBOL) plus the index were collected between January 2, 2002 and December 31, 2009. There were approximately two thousand and eighteen observations for each stock. The reference currency used is the Mexican peso as it is the currency of listing companies. As usual, we consider the daily log returns for each stock.

3.1. Descriptive statistics

Descriptive statistics of daily log returns are shown in Table 1. From this table, we can see that the skewness of the data is not zero, meaning that the data is asymmetric. The kurtosis of the data suggests that the data is fat-tailed. In addition, the Jarque-Bera statistic is also very large and statistically significant, rejecting the assumption of normality. Therefore, Gaussian distribution is not the right choice to model the data.

Table 1. Descriptive statistics of scaled (100x) daily logarithmic stock returns

Ticker	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	p-value
AC	0.0330	1.4416	0.2899	7.1414	1,469.6720	0.0000
ALFAA	0.1067	2.3265	0.4070	12.3109	7,341.4720	0.0000
AMXL	0.1166	2.1735	0.1562	6.9494	1,319.0920	0.0000
BIMBOA	0.0775	1.9191	0.2238	6.6510	1,137.0790	0.0000
CEMEXCPO	0.0222	2.7712	0.0441	14.8086	11,719.7000	0.0000
ELEKTRA	0.1531	2.3355	0.2417	8.4162	2,484.9930	0.0000
FEMSAUBD	0.0879	1.9187	0.0162	8.1152	2,199.0890	0.0000
GCARSOA1	0.0712	2.2172	0.3402	11.2821	5,803.6210	0.0000
GFINBURO	0.0742	2.0858	0.6358	9.6786	3,884.5240	0.0000
GFNORTEO	0.1144	2.6948	0.0804	15.7093	13,577.0600	0.0000
GMEXICOB	0.1760	2.9748	-0.1803	7.5224	1,729.7350	0.0000
KIMBERA	0.0384	1.6526	0.1663	8.9620	2,996.5960	0.0000
TLEVICPO	0.0515	1.9511	0.3361	6.3437	977.5936	0.0000
PENOLES	0.1702	3.1493	-0.0873	7.4466	1,664.2670	0.0000
WALMEX	0.0764	1.8678	0.0535	6.7026	1,153.1050	0.0000
MEXBOL	0.0799	1.4491	0.1094	7.9301	2,046.7540	0.0000

Source: Authors' own elaboration with data from Bloomberg and MATLAB R2017a.

3.2. Goodness-of-Fit

In this section, we use the KS and AD statistics to compare the goodness-of-fit of a particular distribution. Both tests compute the difference between the fitted cumulative distribution function $F(x)$ and the empirical cumulative distribution function $\hat{F}(x)$. In particular, the KS test statistic computes the distance $D = \sup|F(x) - \hat{F}(x)|$, while the AD test statistic computes the weighted average of the squared differences, $A^2 = \left(F(x) - \hat{F}(x)\right)^2$. The distribution with a lower value of the KS and AD test statistics is judged to be preferable.

Table 2 presents the hypothesis test KS and AD to verify if the time series of the daily returns follow the proposed probability distribution. The p-value is reported in brackets and it can be seen that each time series, except for AC, is adjusted to some probability distribution under a significance level of 1%. There are cases, such as ALFAA where two different probability distributions are adjusted to historical yields.

Table 2. Goodness-of-fit of alternative distribution functions.

Series	Stable		GST		NIG		GLD	
	KS	AD	KS	AD	KS	AD	KS	AD
AC	0.0540 (0.0000)	16.9371 (0.0000)	0.1032 (0.0000)	12.8641 (0.0000)	0.0559 (0.0000)	4.6446 (0.0042)	0.0012 (0.0005)	11.4833 (0.0000)
ALFAA	0.0260 (0.1276)	6.7477 (0.0000)	0.0503 (0.0000)	4.0022 (0.0085)	0.0393 (0.0039)	0.5999 (0.6481)	0.0374 (0.0306)	5.2492 (0.0000)
AMXL	0.0323 (0.0290)	4.1156 (0.0077)	0.0350 (0.0138)	5.5390 (0.0000)	0.0341 (0.0186)	0.4159 (0.8328)	0.0398 (0.0601)	4.5367 (0.0086)
BIMBOA	0.0369 (0.0080)	2.7243 (0.0379)	0.0690 (0.0000)	4.1196 (0.0000)	0.0208 (0.3457)	0.2567 (0.7667)	0.1736 (0.0874)	2.9081 (0.0489)
CEMEXCPO	0.0133 (0.8638)	5.2787 (0.0021)	0.0302 (0.0491)	3.8591 (0.0000)	0.0379 (0.0060)	0.6897 (0.5675)	0.0206 (0.0443)	4.9501 (0.0000)
ELEKTRA	0.0340 (0.0186)	2.0481 (0.0865)	0.0676 (0.0000)	5.8703 (0.0000)	0.0119 (0.7341)	0.2149 (0.6858)	0.0412 (0.0917)	3.0161 (0.0087)
FEMSAUBD	0.0220 (0.2798)	7.9721 (0.0001)	0.0481 (0.0001)	6.1095 (0.0000)	0.0317 (0.0342)	0.6151 (0.4338)	0.0210 (0.0683)	7.3233 (0.0000)
GCARSOA1	0.0283 (0.0769)	4.6652 (0.0042)	0.0575 (0.0000)	7.1203 (0.0000)	0.0232 (0.2257)	0.6576 (0.5952)	0.0326 (0.0776)	4.5533 (0.0000)
GFINBURO	0.0292 (0.0629)	9.7761 (0.0000)	0.0437 (0.0008)	9.1213 (0.0000)	0.0374 (0.0071)	2.2861 (0.0743)	0.0434 (0.0243)	8.9233 (0.0000)
GFNORTEO	0.0282 (0.0787)	8.5372 (0.0000)	0.0503 (0.0000)	3.1279 (0.0000)	0.0259 (0.1311)	1.3312 (0.2225)	0.0543 (0.0550)	8.2112 (0.0000)
GMEXICOB	0.0214 (0.3134)	3.6424 (0.0131)	0.0422 (0.0014)	4.5792 (0.0000)	0.0134 (0.6634)	0.2109 (0.6871)	0.0329 (0.0899)	3.7367 (0.0245)
KIMBERA	0.0388 (0.0045)	9.3049 (0.0000)	0.0761 (0.0000)	3.9773 (0.0000)	0.0418 (0.0017)	1.3686 (0.2112)	0.0544 (0.0358)	8.1012 (0.0000)
PENOLES	0.0428 (0.0012)	9.6951 (0.0000)	0.0694 (0.0000)	3.3531 (0.0000)	0.0268 (0.1094)	0.8666 (0.4354)	0.0462 (0.0671)	6.2312 (0.0000)
TLEVICPO	0.0188 (0.4727)	2.3436 (0.0599)	0.0270 (0.1037)	5.8710 (0.0000)	0.0162 (0.4663)	0.5031 (0.7436)	0.0329 (0.0887)	2.4467 (0.0601)
WALMEX	0.0173 (0.5780)	9.3698 (0.0000)	0.0356 (0.0116)	3.4356 (0.0000)	0.0405 (0.0027)	1.7931 (0.1197)	0.0124 (0.0308)	5.5966 (0.0000)
MEXBOL	0.0187 (0.4787)	1.5308 (0.1693)	0.0303 (0.0482)	6.9363 (0.0000)	0.0149 (0.5871)	0.5664 (0.5803)	0.0371 (0.0906)	5.1012 (0.0000)

Source: Authors' own elaboration with data from Bloomberg and MATLAB R2017a.

Moreover, Tables 3a and 3b show the estimators for the different parameters of the probability density functions that have been proposed in this work.

Table 3a. Maximum likelihood estimates of alternative distribution functions

Series	Stable				GLD			
	α	β	γ	δ	λ_1	λ_2	λ_3	λ_4
AC	1.5558	0.0894	0.5367	-0.0242	0.0001	207.9390	-0.2446	-0.2713
ALFAA	1.7832	0.0734	0.6155	-0.0155	0.0009	117.2657	-0.1959	-0.2102
AMXL	1.8293	-0.0764	0.6365	0.0108	0.0021	83.8017	-0.1762	-0.1556
BIMBOA	1.7248	0.1319	0.5994	-0.0354	0.0006	121.0025	-0.1101	-0.1242

Series	Stable				GLD			
	α	β	γ	δ	λ_1	λ_2	λ_3	λ_4
CEMEXCPO	1.8299	0.0996	0.6408	-0.0087	0.0012	103.6839	-0.1143	-0.1132
ELEKTRA	1.6834	0.2317	0.5772	-0.0469	0.0002	112.5773	-0.0897	-0.1185
FEMSAUBD	1.7959	0.1491	0.6240	-0.0198	0.0003	104.8507	-0.0819	-0.1173
GCARSOA1	1.6957	0.0750	0.5872	-0.0076	0.0011	112.9643	-0.2457	-0.2469
GFINBURO	1.8161	0.1063	0.6270	-0.0167	0.0021	91.5443	-0.2468	-0.2281
GFNORTEO	1.7580	0.0701	0.6080	-0.0091	0.0010	115.9371	-0.1862	-0.2240
GMEXICOB	1.8698	-0.0632	0.6584	0.0141	0.0008	134.1758	-0.1751	-0.1846
KIMBERA	1.6513	0.0635	0.5667	-0.0118	0.0003	170.2619	-0.2233	-0.2275
PEÑOLES	1.7087	0.0000	0.5798	0.0066	0.0006	127.1018	-0.2178	-0.2268
TLEVICPO	1.8958	0.3071	0.6639	-0.0242	0.0005	116.2106	-0.2737	-0.2599
WALMEX	1.8694	0.0000	0.6546	-0.0058	0.0004	130.9675	-0.1562	-0.1927
MEXBOL	1.8758	-0.5090	0.6589	0.0515	0.0012	170.7524	-0.1826	-0.1341

Notes: Estimated parameters of the stable densities were approximated using the computer program STABLE described in Nolan (1997).

Table 3b. Maximum likelihood estimates of alternative distribution functions

Series	NIG				GST	
	μ	δ	α	β	η	λ
AC	-0.0001	0.0082	36.2035	1.8173	2.8242	0.0231
ALFAA	0.0005	0.0168	31.6323	1.1695	4.9800	0.0228
AMXL	0.0024	0.0246	27.9481	-0.6657	6.8148	-0.0244
BIMBOA	0.0003	0.0182	52.5900	1.3477	4.2272	0.0288
CEMEXCPO	0.0015	0.0213	45.7561	-0.7221	7.0031	0.0174
ELEKTRA	-0.0003	0.0200	52.7316	2.0769	3.7439	0.0673
FEMSAUBD	-0.0004	0.0214	50.0046	2.7252	5.4071	0.0374
GCARSOA1	0.0008	0.0167	23.8288	0.4351	4.1691	0.0165
GFINBURO	0.0016	0.0200	19.3541	0.0764	5.0617	0.0274
GFNORTEO	0.0001	0.0163	29.2648	2.4850	5.1021	0.0175
GMEXICOB	0.0005	0.0150	41.2739	1.2137	6.9216	-0.0050
KIMBERA	0.0005	0.0108	38.3513	-0.2562	3.4726	-0.0017
PEÑOLES	0.0004	0.0147	29.4514	0.5983	3.8647	0.0191
TLEVICPO	0.0005	0.0167	23.1076	-0.3694	8.8392	0.0404
WALMEX	0.0000	0.0149	39.4820	2.0406	7.2742	-0.0001
MEXBOL	0.0021	0.0122	59.7963	-6.5391	9.7479	-0.1132

Source: Authors' own elaboration with data from Bloomberg and MATLAB R2017a.

4. Empirical results

4.1. GARCH model estimation

Since returns series are not *i.i.d.,* though they show little serial correlation, a GARCH (m,s) model, introduced by Bollerslev (1986) can be used to filter the log returns into an approximately *i.i.d*. series. We take the simplest one m = s = 1 with a constant non-zero mean. Empirical studies support that GARGH (1,1) model works well for financial data see Bali and Theodossiou (2007), Liu and Brorsen (1995) and Panorska *et al.* (1995). Individual stock return is modeled as $R_t = \mu_t + \varepsilon_t$ and $\varepsilon_t = \sigma_t z_t$. Throughout this paper, normal, GST, NIG, GLD and α-stable distributions are imposed for the conditional distribution. Table 4 shows the specification for GARGH models.

Table 4. GARCH models

Model	Specification	
stable-GARCH	$\lvert\sigma_t\rvert = a_0 + a_1\lvert\varepsilon_{t-1}\rvert + b_1\lvert\sigma_{t-1}\rvert$	$z_t \sim S(\alpha,\beta,1,0)$
GST-GARCH	$\sigma_t^2 = a_0 + a_1(\varepsilon_{t-1} - c)^2 + b_1\sigma_{t-1}^2$	$z_t \sim GST(\eta,\lambda)$
NIG-GARCH	$\sigma_t^2 = a_0 + a_1\varepsilon_{t-1}^2 + b_1\sigma_{t-1}^2$	$z_t \sim NIG(\mu,\delta,\alpha,\beta)$
GLD-GARCH	$\sigma_t^2 = a_0 + a_1\varepsilon_{t-1}^2 + b_1\sigma_{t-1}^2$	$z_t \sim GLD(\lambda_1,\lambda_2,\lambda_3,\lambda_4)$
Normal-GARCH	$\sigma_t^2 = a_0 + a_1\varepsilon_{t-1}^2 + b_1\sigma_{t-1}^2$	$z_t \sim N(0,\sigma_t^2)$

Notes: Since stable distributions do not have the second absolute expectation, we use the TS-GARGH specification proposed by Taylor (1986) and Schwert (1989).

Tables 5a and 5b present the maximum likelihood estimation for the GARGH models based on the alternative distribution functions.

Table 5a. Maximum likelihood estimates of the GARCH models with alternative distribution

Series	Stable			GST				NIG		
	a_0	a_1	b_1	a_0	a_1	c	b_1	a_0	a_1	b_1
AC	0.0507	0.0961	0.8964	0.4221	0.3873	0.2028	0.6071	0.0039	0.3093	0.5653
ALFAA	0.1198	0.1409	0.8385	0.0694	0.0805	0.5657	0.9025	0.0017	0.1073	0.8592
AMXL	0.0694	0.0864	0.9011	0.0590	0.0664	1.6673	0.8772	0.0013	0.0836	0.9010
BIMBOA	0.1091	0.1079	0.8625	0.1782	0.1279	0.4890	0.8323	0.0008	0.0805	0.8974
CEMEXCPO	0.0423	0.0855	0.9145	0.0092	0.0771	1.0052	0.9080	0.0020	0.0813	0.8726
ELEKTRA	0.0419	0.0682	0.9318	0.3291	0.2406	0.2398	0.7501	0.0005	0.0572	0.9299
FEMSAUBD	0.0370	0.0827	0.9173	0.0511	0.0781	0.5187	0.9032	0.0017	0.0849	0.8789
GCARSOA1	0.0648	0.1183	0.8817	0.0481	0.1246	0.4424	0.8752	0.0022	0.1322	0.8360
GFINBURO	0.0184	0.0343	0.9656	0.1406	0.0900	0.4201	0.8806	0.0038	0.1374	0.8356
GFNORTEO	0.1033	0.1398	0.8532	0.1753	0.1324	0.7449	0.8336	0.0021	0.1625	0.8179
GMEXICOB	0.0629	0.0990	0.9010	0.1065	0.0856	0.7286	0.8974	0.0005	0.0737	0.9121
KIMBERA	0.0550	0.0940	0.8970	0.0255	0.1042	0.5753	0.8956	0.0007	0.0994	0.8820
PEÑOLES	0.1507	0.1031	0.8743	0.4071	0.1556	0.0497	0.8263	0.0006	0.1155	0.8812
TLEVICPO	0.0258	0.0608	0.9392	0.0007	0.0483	1.0445	0.9363	0.0007	0.0815	0.9059
WALMEX	0.0345	0.0806	0.9194	0.0784	0.0927	0.5729	0.8764	0.0039	0.1607	0.7427
MEXBOL	0.0291	0.0956	0.9044	0.0000	0.0885	0.9695	0.8644	0.0055	0.0987	0.8753

Source: Authors' own elaboration with data from Bloomberg and MATLAB R2017a.

Table 5b. Maximum likelihood estimates of the GARCH models with alternative distribution.

Series	GLD			Normal		
	a_0	a_1	b_1	a_0	a_1	b_1
AC	0.0008	0.1007	0.8506	0.0676	0.8811	0.0877
ALFAA	0.0015	0.0997	0.8618	0.2165	0.8372	0.1188
AMXL	0.0012	0.0799	0.9045	0.1874	0.8820	0.0761
BIMBOA	0.0008	0.0836	0.8911	0.1845	0.8562	0.0929
CEMEXCPO	0.0019	0.0786	0.8729	0.0791	0.9022	0.0830
ELEKTRA	0.0004	0.0602	0.9272	0.0793	0.9197	0.0681
FEMSAUBD	0.0016	0.0760	0.8810	0.0390	0.9181	0.0734
GCARSOA1	0.0020	0.1203	0.8392	0.0825	0.8843	0.1028
GFINBURO	0.0032	0.1133	0.8429	0.0877	0.9340	0.0465
GFNORTEO	0.0025	0.1549	0.7913	0.2282	0.8305	0.1343
GMEXICOB	0.0005	0.0677	0.9140	0.1396	0.8954	0.0883
KIMBERA	0.0006	0.0849	0.8835	0.0743	0.8955	0.0763
PEÑOLES	0.0005	0.0989	0.8875	0.3888	0.8589	0.1003
TLEVICPO	0.0007	0.0829	0.9030	0.0499	0.9315	0.0539
WALMEX	0.0001	0.1073	0.8261	0.0661	0.9098	0.0711
MEXBOL	0.0002	0.0962	0.8774	0.0450	0.8824	0.0940

Source: Authors' own elaboration with data from Bloomberg and MATLAB R2017a.

4.2. VaR estimation

In this section, we consider a heteroskedastic VaR model, which assume that the returns follow: a stable distribution; a GST distribution (Hansen 1994); a NIG distribution; a GLD distribution; a normal distribution.

For the purpose of testing VaR models financial regulators advise to choose a time horizon of one day, so we take $\tau = 1$. In this section VaR is estimated employing the entire sample of observations, *i.e.,* the window length is N, where N is the sample size.

We compute the VaR estimators at the confidence level $1 - q$ using the following algorithm:

Step 1. Use MLE to estimate the parameters for the GARGH models given in Table 4;

Step 2. Use MLE to estimate the parameters for the alternative distribution functions;

Step 3. Forecast σ_{t+1} by the GARGH model;

Step 4. Calculate the observed z_i, $i = 1, \dots, t$ from the GARGH models, using the parameters we get in step 1;

Step 5. Simulate S realizations of z_{t+1} $\left(\hat{z}_{t+1,j}\right)$ $j = 1, \dots, S$, using the parameter we get in step 2;

Step 6. Calculate the simulated returns $\hat{r}_{t+1,j}$ from (4), $j = 1, \dots, S$;

Step 7. VaR is measured as the negative of the $q - th$ quantile of the simulated return's distribution.

VaR measurements were calculated at confidence levels of 95% and 99%. The 99% (95%) VaR was determined as the negative of the 1% (5%) quantile. The 99% and 95% VaR estimates are reported in Table 6.

Table 6. Heteroskedastic Conditional VaR estimates

Series	VaR 95%					VaR 99%				
	Stable	Normal	GST	NIG	GLD	Stable	Normal	GST	NIG	GLD
AC	-0.8919	-0.5532	-0.4593	-0.8267	-0.4623	-2.1390	-0.8263	-0.9649	-2.2962	-1.0095
ALFAA	-0.2562	-0.1746	-0.1718	-0.1217	-0.1882	-0.4387	-0.2481	-0.2734	-0.4155	-0.2837
AMXL	-0.4856	-0.3198	-0.3574	-0.4764	-0.3857	-0.8147	-0.4683	-0.5869	-0.8651	-0.5601
BIMBO A	-0.8713	-0.5507	-0.5686	-0.9573	-0.5405	-1.5568	-0.7886	-0.9576	-1.5475	-0.9504
CEME XCPO	-0.4714	-0.3069	-0.2832	-0.4356	-0.3077	-0.7840	-0.4439	-0.4574	-0.8121	-0.4687
ELEKT RA	-31.4479	-20.1605	-16.9892	-28.8819	-15.0456	-63.7097	-29.2625	-30.4844	-61.2376	-29.5543
FEMS AUBD	-2.1481	-1.3755	-1.2439	-2.1268	-1.2821	-3.6526	-1.9437	-2.0623	-3.6450	-2.1344
GCAR SOA1	-0.8771	-0.5915	-0.5997	-0.6429	-0.5421	-1.8169	-0.8042	-0.9819	-1.7426	-1.0316
GFINB URO	-0.8814	-0.5586	-0.5065	-0.8384	-0.4987	-1.4846	-0.7850	-0.8515	-1.5132	-0.8421
GFNO RTEO	-1.7969	-1.2056	-1.1228	-1.7485	-1.0231	-3.1439	-1.7483	-1.9247	-2.8852	-1.8243
GMEXI COB	-1.2063	-0.7878	-0.8108	-1.2153	-0.7554	-1.9723	-1.1258	-1.3052	-2.1553	-1.3721
KIMBE RA	-0.6537	-0.4333	-0.3874	-0.7555	-0.4093	-1.3189	-0.6308	-0.7473	-1.1957	-0.8061
PEÑO LES	-18.1883	-10.2340	-9.1236	-24.6214	-9.1864	-31.9295	-15.0012	-16.5631	-32.2136	-15.6953
TLEVI CPO	-1.5876	-1.1003	-1.0847	-1.4877	-1.0441	-2.3307	-1.5747	-1.6741	-2.1519	-1.7093
WALM EX	-1.0980	-0.7159	-0.6268	-0.9034	-0.6271	-1.7609	-1.0208	-1.0039	-1.7059	-1.0178
MEXB OL	-665.0058	-419.2780	-470.9195	-545.8527	-498.0830	-1061.6881	-601.2865	-743.3414	-1004.7423	-780.6214

Source: Authors' own elaboration with data from Bloomberg and MATLAB R2017a.

4.3. Evaluation of the Performance of Heteroskedastic VaR Models

In this section, we evaluate and compare the performance of heteroskedastic VaR models based on the unconditional coverage test statistics. In this paper, we use the most recent years historical data (*k=502*) to forecast the current VaR.

The test of unconditional coverage consists of determining if the realized coverage rate equals the theoretical coverage rate. The Kupiec likelihood ratio test (given in Kupiec (1995)) tests whether the expected proportion of violations is equal to α and it follows an asymptotic chi-square distribution with one degree of freedom. The likelihood ratio test statistic is given by:

$$LR_{UC} = -2ln\left[\frac{\alpha^n(1-\alpha)^{T-n}}{p^n(1-p)^{T-n}}\right] \quad (7)$$

where: T is the sample size; n is the number of violations (when the loss exceeds the estimated VaR); $p = n/T$ is the percentage of violations. Kupiec (1995) pointed out that the LR_{UC} statistic is the most powerful statistic for a given sample.

The results of the Kupiec test are represented in Table 7. The symbol "X" point out VaR models which pass the conditional coverage test. Asterisk ("*") and minus ("-") signs denote that the conditional coverage test is rejected due to overestimation and underestimation of the VaR. Models that satisfy the hypothesis of correct conditional coverage are accepted as well-specified VaR models.

Table 7. Kupiec likelihood ratio test at 1% significance level

Series	Kupiec likelihood ratio test 95%					Kupiec likelihood ratio test 99%				
	Stable	Normal	GST	NIG	GLD	Stable	Normal	GST	NIG	GLD
AC	*	X	X	X	X	X	-	X	X	X
ALFAA	*	X	X	X	X	X	X	X	X	X
AMXL	*	X	X	X	X	X	-	X	X	X
BIMBOA	*	X	X	*	-	X	-	X	X	*
CEMEXCPO	X	-	-	X	-	X	-	-	X	*
ELEKTRA	*	X	-	-	-	X	X	X	*	*
FEMSAUBD	*	X	X	X	X	X	X	X	X	X
GCARSOA1	*	X	X	X	X	X	X	X	X	X
GFINBURO	*	X	X	X	*	X	X	X	X	X
GFNORTEO	*	X	-	*	*	X	-	-	X	*
GMEXICOB	*	-	-	*	*	X	-	X	X	X
KIMBERA	*	X	X	X	-	X	X	X	X	*
PEÑOLES	*	X	X	-	*	X	X	X	*	X
TLEVICPO	*	X	X	-	-	X	X	X	X	*
WALMEX	*	X	X	*	X	X	-	X	X	*
MEXBOL	*	X	X	X	X	X	-	X	X	*

Source: Authors' own elaboration with data from Bloomberg and MATLAB R2017a.

As can be seen in Table 7 the α-stable distribution has more robust results than the rest of the distributions for high confidence level; under 99% confidence level, its distribution does not underestimate or overestimate the VaR. The NIG distribution, the generalized t-Student, the GLD function, and finally the normal one are followed in performance. In other words, it can be stated that for a high confidence level the α-stable probability distribution shows a better performance in the VaR estimation.

However, for the 95% VaR estimation the conditional stable model is not satisfactory; measurements over estimates the potential losses.

Conclusion

This paper considered the family of stable distributions in VaR modeling as an alternative in the Mexican financial market and the performance is compared against the normal, NIG, GLD and GST estimations. The statistical results suggest that the conditional α-stable VaR model provides more accurate VaR estimates at 1% level of significance. So, the set of estimates provided evidence that the α-stable model provides superior fit in modeling VaR at high confidence levels. In contrast, stable modeling is not satisfactory at low confidence level.

In addition to this work, we would have as future research the realization of the estimates for different sub periods that show different degrees of volatility. Then we would verify the conclusion in other markets and extend the application of the α-stable distribution.

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The Calculation and Applications Pseudoinverse of Matrix in Managerial Decision Making

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Abstract:

Pseudoinverse of a matrix is a matrix that generalizes inverse of a square invertible matrix. The most commonly encountered pseudoinverse is the Moore-Penrose matrix inverse, which is a special case of a general type of pseudoinverse. The aim of this paper is to provide the basic information about the pseudoinverse of a matrix, to show that basic decomposition product of the matrices is the skeletal decomposition to product and that it can be used in calculating the pseudoinverse of a matrix, present the possibility of calculating the Moore-Penrose pseudoinverse of a matrix using wxMaxima open source computer algebra system, language R and MS Mathematics. The aim is also to highlight the possibility of using the pseudoinverse of a matrix for solving systems of linear equations and outline the possibilities of its application in the economic analysis in the matrix model.

Keywords: Moore-Penrose inverse of a matrix; matrix decomposition; system of linear equations; wxMaxima; R language; matrix models

JEL classification: C63; C67

1. Introduction

Pseudoinverse of a matrix is a generalization of the inverse of matrix. It means that if there an inverse matrix the pseudoinverse matrix is equal to the same inverse matrix. However, if a given matrix inverse matrix does not exist, then a pseudoinverse of a matrix always exists, which has similar properties and in many cases, both in theoretical considerations or applications, replaces it. For any given matrix, it is possible to define many possible pseudoinverses. Moore-Penrose pseudoinverse of a matrix is particularly important for applications. The calculation is more difficult although it can be easily implemented in a number of generally available software, such as in the paper showed. Linear algebra is a part of mathematics, which has extensive application possibilities in economic analysis and other sectors of the economy. Its models are frequently used inverse matrix, which under certain conditions (when there is) could be replaced by pseudoinverse of a matrix. At the end of the paper we shall present samples of one of those possibilities of economic analysis.

In economic analysis, the Moore-Penrose pseudoinverse of a matrix has usage in various applications of matrix calculus in the matrix economic models. Matrix models formally describe a number of structural relations like for example a relationship between economic variables. They appear under certain conditions, the formation of

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branching and the production process in the production, capital reproduction or partial production processes in companies.

The official available data must be the primary data source in economic studies. However, in economic modelling related with supply-use tables this aspect is ignored. In fact, as in this structure the number of products exceeds the number of industries, there is considerable information lost due to aggregations in order to get square matrices. Nevertheless, rectangular matrices can directly be modelled using generalized inverses (Moore - Penrose inverse). Therefore, it is not required to elaborate symmetric input-output tables for modelling. In spite of it, in (Pereira, Fernández, Carrascal 2014) it is reminded how to construct symmetric matrices through the two main traditional hypotheses: product technology and industry technology.

Therefore, they can be used in the macroeconomic (input-output analysis and system of national accounts (Fisher, Marshall 2006) and the microeconomic area (to measure the performance of production systems in portfolio theory, in the methods of a multiple regression, the capital asset pricing, *etc.*). Matrix models allows solving non-standard tasks of operational research and then to represent an economic structure, the description of the possible combinations of input and output indicators of business management. We will show how to use the Moore-Penrose pseudoinverse of a matrix in a simple linear production model.

2. Definition of fundamental terms and relations between them

Let $\mathbf{A}$ is a matrix of the type $m \times n$ (also denoted by $\mathbf{A}_{m\times n}$). The matrix $\mathbf{X}$ for which

$$\mathbf{AXA} = \mathbf{A} \tag{1}$$

is called *pseudoinverse of the matrix* $\mathbf{A}$. The most commonly encountered pseudoinverse is the Moore-Penrose matrix inverse, which is a special case of a general type of pseudoinverse, which in addition to conditions (1) requires the completion of the other three conditions, see (Skula 2013). It has some interesting features, which are used in various applications. Pseudoinverse of a matrix $\mathbf{A}$ we denote by $\mathbf{A}^-$. Obviously, if the matrix $\mathbf{A}$ is regular, then $\mathbf{A}^- = \mathbf{A}^{-1}$. From definition pseudoinverse of a matrix $\mathbf{A}_{m\times n}$ it follows that $\mathbf{A}^-_{n\times m}$.

For example the pseudoinverse matrix of the matrix $\mathbf{A} = \begin{pmatrix} 1 & -1 & 1 \\ -1 & 1 & 1 \end{pmatrix}$ is the matrix $\mathbf{A}^- = \begin{pmatrix} 1/2 + r & s \\ r & 1/2 + s \\ 1/2 & 1/2 \end{pmatrix}$, $r, s \in \mathbf{R}$, which has been received by solution of equation (1).

Remark that if the matrix $\mathbf{A}_{m\times n}$ is null, then pseudoinverse of the matrix $\mathbf{A}$ is also null matrix of the type $n \times m$.

2.1 Algorithm for pseudoinverse of a matrix

In Adetunde, Oladejo and Apio (2009) is described algorithm for compute pseudoinverse of a matrix. We describe it briefly as follows:

1. For an non-null matrix $\mathbf{A}_{m\times n}$ we calculate rank of $\mathbf{A}$. Let $\text{rank}(\mathbf{A}) = r$.
2. We find non-singular minor $\mathbf{M}$ of a matrix $\mathbf{A}$ with $\text{rank}(\mathbf{M}) = r$.
3. Calculate $\mathbf{M}^{-1}$.
4. Let element of minor $\mathbf{M}$ which in the upper left corner lies in the *r*-th row and *s*-th column of matrix $\mathbf{A}$. Then element of $\mathbf{M}^{-1}$ which is in the upper left corner will be lie in the *s*-th row and *r*-th column of a matrix $\mathbf{A}^-$ and other element of matrix $\mathbf{M}^{-1}$ will be added to the matrix $\mathbf{A}^-$ according this element. Other elements of matrix $\mathbf{A}^-_{n\times m}$ will be null.

Example 1. Find pseudoinverse of the matrix

$$\mathbf{A} = \begin{pmatrix} 3 & 2 & 5 \\ 7 & 5 & 12 \\ 4 & 3 & 7 \\ 7 & 5 & 12 \\ 3 & 2 & 5 \end{pmatrix}.$$

Solution. The $\text{rank}(\mathbf{A}) = 2$. Let us take for example the minor

$$\mathbf{A}=\begin{pmatrix}3 & 2 & 5\\ 7 & 5 & 12\\ 4 & 3 & 7\\ 7 & 5 & 12\\ 3 & 2 & 5\end{pmatrix}$$

marked with a rectangular in the matrix $\mathbf{A}$. So $\mathbf{M}=\begin{pmatrix}4 & 3\\ 7 & 5\end{pmatrix}$, $\operatorname{rank}(\mathbf{M})=2$, $\mathbf{M}^{-1}=\begin{pmatrix}-5 & 3\\ 7 & -4\end{pmatrix}$.

According the described algorithm we have $\mathbf{A}^{-}=\begin{pmatrix}0 & 0 & -5 & 3 & 0\\ 0 & 0 & 7 & -4 & 0\\ 0 & 0 & 0 & 0 & 0\end{pmatrix}$.

We check the accuracy of the calculation

$$\mathbf{A}\mathbf{A}^{-}\mathbf{A}=\begin{pmatrix}3 & 2 & 5\\ 7 & 5 & 12\\ 4 & 3 & 7\\ 7 & 5 & 12\\ 3 & 2 & 5\end{pmatrix}\begin{pmatrix}0 & 0 & -5 & 3 & 0\\ 0 & 0 & 7 & -4 & 0\\ 0 & 0 & 0 & 0 & 0\end{pmatrix}\begin{pmatrix}3 & 2 & 5\\ 7 & 5 & 12\\ 4 & 3 & 7\\ 7 & 5 & 12\\ 3 & 2 & 5\end{pmatrix}=\begin{pmatrix}3 & 2 & 5\\ 7 & 5 & 12\\ 4 & 3 & 7\\ 7 & 5 & 12\\ 3 & 2 & 5\end{pmatrix}.$$

Note that there is a lot of methods to determine the pseudoinverse of a matrix. For example: calculate pseudoinverse of a matrix with a maximum rank using decomposition into blocks, using Gauss elimination, decomposition into blocks using modified Hermit form, calculation of the reflex matrix using decomposition into blocks and using Gauss elimination, see Sojka, Ivaničová, Trnovský (1986), or other methods like, Hausholder transformation, permutation method, modified orthogonalization of Gramma-Smith, iterative method of Ben-Israela and Cohena, method using singular decomposition, and so on.

2.2. Several fundamental definitions and properties

Next, we introduce several definitions and properties we shall use of them later:

a) If $\operatorname{rank}(\mathbf{A}_{m\times n})=m$, then the matrix $\mathbf{A}\mathbf{A}'$ (where $\mathbf{A}'$ is denoted a transposed matrix of $\mathbf{A}$) is regular matrix of the type $m\times m$. Similarly, if $\operatorname{rank}(\mathbf{A}_{m\times n})=n$, then the matrix $\mathbf{A}'\mathbf{A}$ is regular matrix of the type $n\times n$.

b) If for the matrix $\mathbf{A}$ a matrix $\mathbf{X}$ exists which satisfies the condition

$$\mathbf{A}\mathbf{X}=\mathbf{I},\quad [\mathbf{X}\mathbf{A}=\mathbf{I}]$$

where: $\mathbf{I}$ is the identity matrix), then the matrix $\mathbf{X}$ is called the *right inverse matrix to matrix* $\mathbf{A}$ (denoted $\mathbf{A}_R^{-1}$), similarly *left inverse matrix to matrix* $\mathbf{A}$ (denoted $\mathbf{A}_L^{-1}$).

If $\mathbf{A}$ is a regular matrix then $\mathbf{A}_R^{-1}=\mathbf{A}_L^{-1}=\mathbf{A}^{-1}$.

c) *Existence of right and left inverse matrix*.

- if $\operatorname{rank}(\mathbf{A}_{m\times n})=m$ then

$$\mathbf{A}\mathbf{A}'(\mathbf{A}\mathbf{A}')^{-1}=\mathbf{I}\ \Rightarrow\ \mathbf{A}_R^{-1}=\mathbf{A}'(\mathbf{A}\mathbf{A}')^{-1}.$$

- if $\operatorname{rank}(\mathbf{A}_{m\times n})=n$ then

$$(\mathbf{A}'\mathbf{A})^{-1}\mathbf{A}'\mathbf{A}=\mathbf{I}\ \Rightarrow\ \mathbf{A}_L^{-1}=(\mathbf{A}'\mathbf{A})^{-1}\mathbf{A}'.$$

d) *Skeletal decomposition of a matrix.* If $\operatorname{rank}(\mathbf{A}_{m\times n})=r$, then exists matrices $\mathbf{B}_{m\times r}$, $\mathbf{C}_{r\times n}$ so that:

$$\mathbf{A}=\mathbf{B}\,\mathbf{C} \tag{2}$$

where: $\operatorname{rank}(\mathbf{B})=\operatorname{rank}(\mathbf{C})=r$.

e) The base decomposition of a matrix is a skeletal decomposition of the matrix. The statement follows from the comparison of the definitions mentioned decomposition, see (Fecenko, Sakálová 2004).

f) *Existence of the pseudoinverse of a matrix.*
In the introduction, we mentioned about existence pseudoinverse of null matrix and presented an algorithm for calculate pseudoinverse of a matrix. Now show another proof about existence pseudoinverse of a matrix.
If a matrix $\mathbf{A}_{m\times n}$ is non-null and $\operatorname{rank}\left(\mathbf{A}_{m\times n}\right)=r.$ Then, with according of skeletal decomposition, there exist the matrices $\mathbf{B}_{m\times r}$, $\mathbf{C}_{r\times n}$, such that $\mathbf{A}=\mathbf{B}\cdot\mathbf{C}$, where $\operatorname{rank}\left(\mathbf{B}\right)=\operatorname{rank}\left(\mathbf{C}\right)=r.$ Then, according to the property of two mutually transposed matrix, it follows that matrices $\mathbf{B}'\mathbf{B}$ and also $\mathbf{C}\mathbf{C}'$ are regular matrices of the type $r\times r$. Let us denote:

$$\mathbf{X}=\mathbf{C}_R^{-1}\mathbf{B}_L^{-1}=\mathbf{C}'\left(\mathbf{C}\mathbf{C}'\right)^{-1}\left(\mathbf{B}'\mathbf{B}\right)^{-1}\mathbf{B}', \tag{3}$$

where: $\mathbf{C}_R^{-1}$, $\mathbf{B}_L^{-1}$ are defined according c).

Calculate:

$$\mathbf{A}\mathbf{X}\mathbf{A}=\mathbf{B}\mathbf{C}\mathbf{X}\mathbf{B}\mathbf{C}=\mathbf{B}\mathbf{C}\mathbf{C}'\left(\mathbf{C}\mathbf{C}'\right)^{-1}\left(\mathbf{B}'\mathrm{B}\right)^{-1}\mathbf{B}'\mathbf{B}\mathbf{C}=$$
$$=\mathbf{B}\mathbf{C}\mathbf{C}_R^{-1}\mathbf{B}_L^{-1}\mathbf{B}\mathbf{C}=\mathbf{B}\mathbf{I}\mathbf{I}\mathbf{C}=\mathbf{B}\mathbf{C}=\mathbf{A}.$$

We proved that $\mathbf{X}=\mathbf{A}^{-}$.

g) If $\mathbf{A}=\mathbf{P}\begin{pmatrix}\mathbf{I}_r & \mathbf{0}\\ \mathbf{0} & \mathbf{0}\end{pmatrix}\mathbf{Q}$ for any non-singular matrices $\mathbf{P}$ and $\mathbf{Q}$, then $\mathbf{A}^{-}=\mathbf{P}^{-1}\begin{pmatrix}\mathbf{I}_r & \mathbf{U}\\ \mathbf{V} & \mathbf{W}\end{pmatrix}\mathbf{Q}^{-1}$ for any matrices $\mathbf{U},\mathbf{V},\mathbf{W}$.

h) The entire class of pseudoinverse of matrix is generated from any given inverse $\mathbf{A}^{-}$ by the formula of Rao and Mitra (1972).

$$\mathbf{A}^{-}+\mathbf{U}-\mathbf{A}^{-}\mathbf{A}\mathbf{U}\mathbf{A}\mathbf{A}^{-} \tag{4}$$

where: $\mathbf{U}$ is arbitrary, or by the formula:

$$\mathbf{A}^{-}+\mathbf{V}(\mathbf{I}-\mathbf{A}^{-}\mathbf{A})+(\mathbf{I}-\mathbf{A}\mathbf{A}^{-})\mathbf{W} \tag{5}$$

The formulas (4), (5) are possible generalized (authors).
Pseudoinverse of a matrix $\mathbf{A}$ determined by the relationship (3) is called the Moore-Penrose pseudoinverse of a matrix and usually is denotes $\mathbf{A}^{+}$ and the calculation itself of pseudoinverse matrix according to equation (3) is called the Moore-Penrose pseudoinversion. Note that the Moore-Penrose pseudoinverse of a matrix is uniquely determined. The Moore-Penrose pseudoinverse of a matrix $\mathbf{A}$ satisfies of conditions

$$\mathbf{A}\mathbf{A}^{+}\mathbf{A}=\mathbf{A}$$

$$\mathbf{A}^{+}\mathbf{A}\mathbf{A}^{+}=\mathbf{A}^{+}$$

$$\left(\mathbf{A}\mathbf{A}^{+}\right)'=\mathbf{A}\mathbf{A}^{+}$$

$$\left(\mathbf{A}^{+}\mathbf{A}\right)'=\mathbf{A}^{+}\mathbf{A}$$

Theorem 1. Let $\mathbf{A}_{m\times n}$ be a non-zero matrix and let $\operatorname{rank}(\mathbf{A})=h.$ Then matrices $\mathbf{B}$, $\mathbf{C}$ exist so that $\mathbf{A}=\mathbf{B}\mathbf{C},$ where matrix $\mathbf{B}_{m\times h}$ is created from any h linear independent column vectors of matrix $\mathbf{A}$ arranged in any order and the matrix $\mathbf{C}_{h\times n}$ is created from h column vectors, whose elements are coordinates of column vectors of matrix $\mathbf{A}$ in the base of space generated by column vectors of $\mathbf{A}$, which created of column vectors matrix $\mathbf{B}$ in given order. *Proof.* See (Fecenko and Sakálová 2004,166). For the technique of calculation of the decomposition of a matrix with elemental change of base, see for example (Fecenko, Sakálová 2004, Sakálová 2010, Klůfa 1997) or see also part 2.3.

Example 2. In mentioned book (Fecenko and Sakálová 2004), four bases decomposition of the matrix

$$\mathbf{A}=\begin{pmatrix}1 & 2 & -1 & 0\\ 3 & 5 & 2 & -1\\ 1 & 1 & 4 & -1\end{pmatrix}. \tag{6}$$

were calculated:

$$\mathbf{A}=\begin{pmatrix}1 & 2\\ 3 & 5\\ 1 & 1\end{pmatrix}\begin{pmatrix}1 & 0 & 9 & -2\\ 0 & 1 & -5 & 1\end{pmatrix}=\mathbf{BC},\quad \mathbf{A}=\begin{pmatrix}2 & 1\\ 5 & 3\\ 1 & 1\end{pmatrix}\begin{pmatrix}0 & 1 & -5 & 1\\ 1 & 0 & 9 & -2\end{pmatrix}=\mathbf{BC}$$

$$\mathbf{A}=\begin{pmatrix}1 & 0\\ 3 & -1\\ 1 & -1\end{pmatrix}\begin{pmatrix}1 & 2 & -1 & 0\\ 0 & 1 & -5 & 1\end{pmatrix}=\mathbf{BC},\quad \mathbf{A}=\begin{pmatrix}-1 & 0\\ 2 & -1\\ 4 & -1\end{pmatrix}\begin{pmatrix}-1 & -2 & 1 & 0\\ -5 & -9 & 0 & 1\end{pmatrix}=\mathbf{BC},$$

these are the skeletal decomposition of the matrix $\mathbf{A}$, too.

Now we will present the calculation of the Moore-Penrose pseudoinverse of a matrix $\mathbf{A}$ step by step using the equation (3). Note that if we started from any basic decomposition of a matrix $\mathbf{A}$, then the Moore-Penrose pseudoinverse of a matrix $\mathbf{A}$ is uniquely given. For Moore-Penrose pseudoinverse of a matrix $\mathbf{A}$ are usually used a mark $\mathbf{A}^{+}$.

Let us consider, for example, the first decomposition, where we have matrixes $\mathbf{B}=\begin{pmatrix}1 & 2\\ 3 & 5\\ 1 & 1\end{pmatrix}$ and $\mathbf{C}=\begin{pmatrix}1 & 0 & 9 & -2\\ 0 & 1 & -5 & 1\end{pmatrix}$.

Then:

$$\mathbf{B}'=\begin{pmatrix}1 & 3 & 1\\ 2 & 5 & 1\end{pmatrix},\ \mathbf{C}'=\begin{pmatrix}1 & 0\\ 0 & 1\\ 9 & -5\\ -2 & 1\end{pmatrix},\ \mathbf{CC}'=\begin{pmatrix}1 & 0 & 9 & -2\\ 0 & 1 & -5 & 1\end{pmatrix}\begin{pmatrix}1 & 0\\ 0 & 1\\ 9 & -5\\ -2 & 1\end{pmatrix}=\begin{pmatrix}86 & -47\\ -47 & 27\end{pmatrix},$$

$$\left(\mathbf{C}\cdot\mathbf{C}'\right)^{-1}=\frac{1}{113}\begin{pmatrix}27 & 47\\ 47 & 86\end{pmatrix},\ \mathbf{B}'\mathbf{B}=\begin{pmatrix}1 & 3 & 1\\ 2 & 5 & 1\end{pmatrix}\begin{pmatrix}1 & 2\\ 3 & 5\\ 1 & 1\end{pmatrix}=\begin{pmatrix}11 & 18\\ 18 & 30\end{pmatrix},\ \left(\mathbf{B}'\mathbf{B}\right)^{-1}=\frac{1}{6}\begin{pmatrix}30 & -18\\ -18 & 11\end{pmatrix}.$$

It is easy to see that:

$$\mathbf{A}^{+}=\mathbf{C}'\left(\mathbf{CC}'\right)^{-1}\left(\mathbf{B}'\mathbf{B}\right)^{-1}\mathbf{B}'=\begin{pmatrix}1 & 0\\ 0 & 1\\ 9 & -5\\ -2 & 1\end{pmatrix}\frac{1}{113}\begin{pmatrix}27 & 47\\ 47 & 86\end{pmatrix}\frac{1}{6}\begin{pmatrix}30 & -18\\ -18 & 11\end{pmatrix}\begin{pmatrix}1 & 3 & 1\\ 1 & 5 & 1\end{pmatrix}=$$

$$=\frac{1}{678}\begin{pmatrix}26 & 47 & -5\\ 62 & 86 & -38\\ -76 & -7 & 145\\ 10 & -8 & -28\end{pmatrix}.$$

Note that if $\mathbf{A}=\mathbf{BC}$ is skeletal decomposition of the matrix $\mathbf{A}$, then $\mathbf{A}^{+}=\mathbf{C}^{+}\mathbf{B}^{+}$.

3. Moore-Penrose pseudoinverse of a matrix and open source systems

As it can be seen from the presented calculation of Moore-Penrose pseudoinverse of a matrix, itself a direct calculation without the use of available software tools such as MS Excel, wxMaxima, R language and MS Mathematics, is a bit difficult calculation. The above-mentioned software, two of which are open source systems and last freely downloadable, provides an easy way of calculating mentioned the Moore-Penrose pseudoinverse of a matrix.

3.1. wxMaxima

After the startup of wxMaxima, we have to first activate *Linear Algebra Package* using command load(linearalgebra)$. Enter the matrix (denote for example **A**) to which we want to determine the Moore-Penroseovu pseudoinverse of a matrix by the command A: matrix([1,2,-1,0],[3,5,2,-1],[1,1,4,-1]). Command X: moore_penrose_pseudoinverse(A) calculate the Moore-Penrose pseudoinverse $\mathbf{A}^{-}$ of a matrix $\mathbf{A}$, which will be stored in the object X. We receive output:

$$\mathbf{X}: \begin{pmatrix} \frac{13}{339} & \frac{47}{678} & -\frac{5}{678} \\ \frac{31}{339} & \frac{43}{339} & -\frac{19}{339} \\ -\frac{38}{339} & -\frac{7}{678} & \frac{145}{678} \\ \frac{5}{339} & -\frac{4}{339} & -\frac{14}{339} \end{pmatrix}$$

3.2. R language

For the calculation of Moore-Penrose pseudoinverse of a matrix in R language we need to install and activate the package *MASS*. Then source code (according *Example 2*) is:

```
library(MASS)
a <- c(1,2,-1,0);b <- c(3,5,2,-1);c <- c(1,1,4,-1)
A<-rbind(a,b,c)
ginv(A, tol = sqrt(.Machine$double.eps))
```

It provides the following output, for R language information see also *e. g.* Páleš (2017):

```
             [,1]        [,2]         [,3]
[1,]  0.03834808  0.06932153 -0.007374631
[2,]  0.09144543  0.12684366 -0.056047198
[3,] -0.11209440 -0.01032448  0.213864307
[4,]  0.01474926 -0.01179941 -0.041297935
```

3.3. Microsoft Mathematics

This method of calculation, from a methodological point of view, has the advantage that the reader has the opportunity to follow the logic of the whole procedure of calculating pseudoinverse of a matrix according to the relationship (3). We enter the matrix, for which we want to determine pseudoinverse of a matrix (do not be surprised if the system writes our matrix into two brackets). We receive the following output:

$$\mathbf{A} := \begin{pmatrix} 1 & 2 & -1 & 0 \\ 3 & 5 & 2 & -1 \\ 1 & 1 & 4 & -1 \end{pmatrix}$$

Subsequently, the following sequence of commands associated input from and output to calculate the pseudoinverse of a matrix. The reader can understand the meaning of the command in the Help menu of MS Mathematics.

$$\mathbf{A_1} := \text{reduce}(A) = \begin{pmatrix} 1 & 0 & 9 & -2 \\ 0 & 1 & -5 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix};$$

$$\mathbf{B} := \text{subBlockMatrix}(\text{A}, 1, 1, 3, 2) = \begin{pmatrix} 1 & 2 \\ 3 & 5 \\ 1 & 1 \end{pmatrix};$$

$$\mathbf{C} := \text{subBlockMatrix}(A_1, 1, 1, 2, 4) = \begin{pmatrix} 1 & 0 & 9 & -2 \\ 0 & 1 & -5 & 1 \end{pmatrix};$$

$$\mathbf{X} := \text{transpose}(\mathbf{C}) * \text{inverse}(\mathbf{C} * \text{transpose}(\mathbf{C})) * \text{inverse}(\text{transpose}(\mathbf{B}) * \mathbf{B}) * \text{transpose}(\mathbf{B}) =$$

$$= \begin{pmatrix} \frac{13}{339} & \frac{47}{678} & -\frac{5}{678} \\ \frac{31}{339} & \frac{43}{339} & -\frac{19}{339} \\ -\frac{38}{339} & -\frac{7}{678} & \frac{145}{678} \\ \frac{5}{339} & -\frac{4}{339} & -\frac{14}{339} \end{pmatrix} = \begin{pmatrix} 0.0383480825959 & 0.0693215339233 & -0.0073746312684 \\ 0.0914454277286 & 0.1268436578171 & -0.0560471976401 \\ -0.1120943952802 & -0.0103244837758 & 0.2138643067847 \\ 0.0147492625369 & -0.0117994100295 & -0.0412979351032 \end{pmatrix}.$$

We note that the sign * of matrix multiplication is not necessary to use in MS Mathematics.

4. Application of pseudoinverse matrix for solving systems of linear equations and matrix equations

Let: $\mathbf{A}\mathbf{x} = \mathbf{b}$ (7)

be a consistent system of linear equations and $\mathbf{A}^-$ be a pseudoinverse of a matrix $\mathbf{A}$, then:

$$\mathbf{x} = \mathbf{A}^-\mathbf{b} \tag{8}$$

is a solution of (7). This statement can be easily proved. Assuming that the system of linear equations (7) is consistent; then a vector $\mathbf{y}$ exists, such that $\mathbf{A}\mathbf{y} = \mathbf{b}$. We show that the vector $\mathbf{x}$ in (8) is solution of system of linear equations (7). It is valid that:

$$\mathbf{A}\mathbf{x} = \mathbf{A}\left(\mathbf{A}^-\mathbf{b}\right) = \left(\mathbf{A}\mathbf{A}^-\mathbf{A}\right)\mathbf{y} = \mathbf{A}\mathbf{y} = \mathbf{b}.$$

q.e.d.

If the solution of the system of linear equations $\mathbf{A}\mathbf{x} = \mathbf{b}$ is expressed in the form $\mathbf{x} = \mathbf{A}^-\mathbf{b}$ and $\mathbf{A}^-$ is Moore-Penrose pseudoinverse of the matrix $\mathbf{A}$, then this solution minimizes the norm $\|\mathbf{A}\mathbf{x} - \mathbf{b}\|$ and of all *n*-dimensional vectors $\mathbf{x}$ that minimize this norm has the lowest norm. Such a vector solution of the system linear equations is called a *solution of system linear equations with the least squares solution of minimum norm* or *the best approximate solution of the system*. Norm of the vector $\mathbf{x}$ is defined as the square root of the scalar product of vectors $\mathbf{x}$ and $\mathbf{x}$.

4.1. The theorem *of solving the system of linear equations using pseudoinverse of a matrix.*

Let (7) be a consistent system of linear equations and $\mathbf{A}^-$ be a pseudoinverse of a matrix $\mathbf{A}$, where $\mathbf{A}_{m\times n}$ then general solution of the system of linear equations can be expressed in the form:

$$\mathbf{x} = \mathbf{A}^-\mathbf{b} + (\mathbf{A}^-\mathbf{A} - \mathbf{I})\mathbf{t} \tag{9}$$

where: $\mathbf{t}$ is a *n*-components vector and $\mathbf{I}$ is a unit matrix of the type $n \times n$.

Similarly as above we show that vector (9) is a solution of system linear equations (7) for any $\mathbf{t}$. Let at least one solution $\mathbf{y}$ exists that $\mathbf{A}\mathbf{y} = \mathbf{b}$, then

$$\mathbf{A}\mathbf{x} = \mathbf{A}(\mathbf{A}^-\mathbf{b} + (\mathbf{A}^-\mathbf{A} - \mathbf{I})\mathbf{t}) = \mathbf{A}\mathbf{A}^-\mathbf{A}\mathbf{y} + (\mathbf{A}\mathbf{A}^-\mathbf{A} - \mathbf{A}\mathbf{I})\mathbf{t} = \mathbf{A}\mathbf{y} + (\mathbf{A} - \mathbf{A})\mathbf{t} = \mathbf{b}.$$

Now let: $\mathbf{X}\mathbf{A} = \mathbf{B}$ (10)

be a consistent of matrix equation. Then $\mathbf{X} = \mathbf{B}\mathbf{A}^-$ is a solution of a matrix equation (10). A proof is simple. Let $\mathbf{Y}$ is the solution of (10). Let us compute $\mathbf{X}\mathbf{A} = \mathbf{B}\mathbf{A}^-\mathbf{A} = \mathbf{Y}\mathbf{A}\mathbf{A}^-\mathbf{A} = \mathbf{Y}\mathbf{A} = \mathbf{B}$. General solution of matrix equation (10) is $\mathbf{X} = \mathbf{B}\mathbf{A}^- + \mathbf{t}(\mathbf{A}\mathbf{A}^- - \mathbf{I})$, where $\mathbf{t}$ has similarly sense as in the previous case.

Remark 1. Similarly it can be proved (as above) that if the matrix equation $\mathbf{A}\mathbf{X} = \mathbf{B}$ be a consistent, then $\mathbf{X} = \mathbf{A}^-\mathbf{B}$ is a solution of the matrix equation $\mathbf{A}\mathbf{X} = \mathbf{B}$ and the $\mathbf{X} = \mathbf{A}^-\mathbf{B} + (\mathbf{A}^-\mathbf{A} - \mathbf{I})\mathbf{t}$ is general solution of matrix equation $\mathbf{A}\mathbf{X} = \mathbf{B}$.

Continue of example 2. Let us consider the system of linear equations $\mathbf{A}\mathbf{x} = \mathbf{b}$, where the matrix system of linear equations $\mathbf{A}$ is the matrix from Example 2 and let the vector of right sides of the linear equations be:

$$\mathbf{b} = \begin{pmatrix} 1356 \\ 2034 \\ 5424 \end{pmatrix}.$$

The rank of matrix $\mathbf{A}$ is 2, which follows e.g. from the basic decomposition of the matrix $\mathbf{A}$. It is easily also verified by calculation or by command rank(A) in wxMaxima; qr(A)$rank in R language; reduce(A)in MS Mathematics, so that $\text{rank}(\mathbf{A}) = 2$ and the rank of extended matrix is $\text{rank}(\mathbf{A}|\mathbf{b}) = 3$.

From the application of Frobenius theorem in the corresponding system of linear equations follows that the system of linear equations has no solution, because $\text{rank}(\mathbf{A}) = 2 \neq 3 = \text{rank}(\mathbf{A}|\mathbf{b})$.

Let us determine a vector $\mathbf{x}_0 = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix}$, which will be the best approximate solution of linear equations $\mathbf{A}\mathbf{x} = \mathbf{b}$, according to Section 4 $\mathbf{x}_0 = \mathbf{A}^{-}\mathbf{b}$. We receive a solution:

$$\mathbf{x}_0 = \mathbf{A}^{-}\mathbf{b} = \frac{1}{678}\begin{pmatrix} 26 & 47 & -5 \\ 62 & 86 & -38 \\ -76 & -7 & 145 \\ 10 & -8 & -28 \end{pmatrix}\begin{pmatrix} 1356 \\ 2034 \\ 5424 \end{pmatrix} = \begin{pmatrix} 153 \\ 78 \\ 987 \\ -228 \end{pmatrix},$$

where: $\mathbf{A}^{-}$ is the Moore-Penrose pseudoinverse of a matrix $\mathbf{A}$. Then for minimum norm applicable.

$$\|\mathbf{A}\mathbf{x}_0 - \mathbf{b}\| = 1017\sqrt{6} = 2491{,}13107 \tag{11}$$

and $\|\mathbf{x}_0\| = 1027{,}45.$

For *the best approximate solution* $\mathbf{x}_0$ of linear equations, the norm $\|\mathbf{A}\mathbf{x} - \mathbf{b}\|$ is minimal, but vector $\mathbf{x}_0$ may not be the only one vector with the minimum norm (11), but only one with $\|\mathbf{x}_0\| < \|\mathbf{x}\|$.

5. Some application of pseudoinverse of a matrix in the economic analysis

5.1. Simple linear production model

For the production of three products V_1, V_2, V_3 in unknown amounts v_1, v_2, v_3 expressed by the output matrix called production matrix $\mathbf{V} = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \end{pmatrix}$ the company to require three types of raw materials S_1, S_2, S_3 in the specified amounts S_1, S_2, S_3 expressed by the consumption matrix $\mathbf{S} = \begin{pmatrix} s_1 \\ s_2 \\ s_3 \end{pmatrix}$.

The relationship between the consumption of raw materials and produced products gives the matrix equation $\mathbf{A}\mathbf{V} = \mathbf{S}$, where $\mathbf{A}$ is a technological coefficient matrix (Fecenko, Sakálová, 2004). If $\mathbf{V}$ is unknown and $\mathbf{A}$ is regular then $\mathbf{V} = \mathbf{A}^{-1}\mathbf{S}$.

Let $\mathbf{A} = \begin{pmatrix} 1 & 2 & 1 \\ 3 & 4 & 1 \\ 2 & 3 & 4 \end{pmatrix}$, $\mathbf{S} = \begin{pmatrix} 11 \\ 21 \\ 28 \end{pmatrix}$. Then $\hat{\mathbf{V}} = \mathbf{A}^{-1}\mathbf{S} = \begin{pmatrix} 1 & 2 & 1 \\ 3 & 4 & 1 \\ 2 & 3 & 4 \end{pmatrix}^{-1}\begin{pmatrix} 11 \\ 21 \\ 28 \end{pmatrix} = \begin{pmatrix} 3 \\ 2 \\ 4 \end{pmatrix}$, which can be interpreted as: if, with according technological matrix $\mathbf{A}$, 11 raw materials S_1, 21 raw materials S_2 a 28 raw materials S_3 are used for the production, then 3 products V_1, 2 products V_2 and 4 products V_3 are produced. If the matrix $\mathbf{A}$ is singular we can use for calculations Moore-Penrose pseudoinverse $\mathbf{A}^{+}$ of a matrix $\mathbf{A}$.

Now, let us consider $\mathbf{A}=\begin{pmatrix}2 & 2 & 1\\ 1 & 1 & 1\\ 4 & 4 & 5\end{pmatrix}$, $\mathbf{S}=\begin{pmatrix}80\\ 52\\ 232\end{pmatrix}$. It is obvious that $\mathrm{rank}(\mathbf{A})=\mathrm{rank}(\mathbf{A}\,|\,\mathbf{S})=2$. So equation $\mathbf{AV}=\mathbf{S}$ has infinitely many solutions. One of it we can determine using by Moore-Penrose pseudoinverse of a matrix $\mathbf{A}$.

$$\mathbf{A}^{+}=\begin{pmatrix}\frac{31}{76} & \frac{1}{19} & -\frac{7}{76}\\ \frac{31}{76} & \frac{1}{19} & -\frac{7}{76}\\ -\frac{25}{38} & -\frac{1}{19} & \frac{13}{38}\end{pmatrix}=\begin{pmatrix}0,4078947368421053 & 0,05263157894736842 & -0,09210526315789473\\ 0,4078947368421053 & 0,05263157894736842 & -0,09210526315789473\\ -0,6578947368421053 & -0,05263157894736842 & 0,3421052631578947\end{pmatrix}$$

Then production of matrices $\widehat{\mathbf{V}}=\mathbf{A}^{+}\mathbf{S}=\begin{pmatrix}14\\ 14\\ 24\end{pmatrix}$ gives a solution of an equation $\mathbf{AV}=\mathbf{S}$ with feature $\left\|\widehat{\mathbf{V}}\right\|\le\left\|\mathbf{V}\right\|$ for all solution. Put now, $\mathbf{S}=\begin{pmatrix}76\\ 76\\ 228\end{pmatrix}$. Matrix equation $\mathbf{AV}=\mathbf{S}$ has no solution because $\mathrm{rank}(\mathbf{A})=2\neq\mathrm{rank}(\mathbf{A}|\mathbf{V})=3$. No such number of products V_1,V_2,V_3 with consumption $\mathbb{S}$ exists (even if we accepted that number of products may not only be integers, such as if it were material expressed in volume or weight). Then production matrix:

$$\widehat{\mathbf{V}}=\mathbf{A}^{+}\mathbf{S}=\begin{pmatrix}14\\ 14\\ 24\end{pmatrix}. \tag{12}$$

We obtained *the best approximate solution* (of the considered system) – production of products at a given consumption of raw materials. Let us interpret the result of calculation. To produce of 14 products V_1, 14 products V_2 and 24 products V_3 we would need:

$$\hat{\mathbf{S}}=\mathbf{AV}=\begin{pmatrix}2 & 2 & 1\\ 1 & 1 & 1\\ 4 & 4 & 5\end{pmatrix}\begin{pmatrix}14\\ 14\\ 24\end{pmatrix}=\begin{pmatrix}80\\ 52\\ 232\end{pmatrix},$$

80 raw materials S_1, 52 raw materials S_2 and 232 raw materials S_3. We see that the consumption matrix $\widehat{\mathbf{S}}$ is different from the desired (required) matrix consumption $\mathbf{S}=\begin{pmatrix}76\\ 76\\ 228\end{pmatrix}$ (because the corresponding system of linear equations has no solution). But this approximate solution is the best in deviation from the target in the sense that the norm of the difference vector and the approximate solution required is minimal. In our case:

$$\left\|\widehat{\mathbf{S}}-\mathbf{S}\right\|=\sqrt{(80-76)^2+(52-76)^2+(232-228)^2}=24,6576560118759.$$

As mentioned earlier the production matrix, we received in (12), may not be the only one with the above mentioned properties. By using analytical methods it can be proved that such production matrices there are infinitely many and can be expressed in the form

$$\mathbf{V}^* = \begin{pmatrix} 28-t \\ t \\ 24 \end{pmatrix}, 0 \le t \le 28 . \qquad (13)$$

Indeed $\hat{\mathbf{S}}^* = \mathbf{A} \cdot \mathbf{V}^* = \begin{pmatrix} 2 & 2 & 1 \\ 1 & 1 & 1 \\ 4 & 4 & 5 \end{pmatrix} \cdot \begin{pmatrix} 28-t \\ t \\ 24 \end{pmatrix} = \begin{pmatrix} 80 \\ 52 \\ 232 \end{pmatrix}$, so $\left\| \hat{\mathbf{S}}^* - \mathbf{S} \right\| = 24{,}6576560118759$.

Is the same as above $\left\| \hat{\mathbf{S}} - \mathbf{S} \right\|$. But of all production matrix, expressed by the (13) there is only one production matrix (production vector), which the Euclid's norm is minimum.

$$\min_{0 \le t \le 28} \sqrt{(28-t)^2 + t^2 + 24^2} = 11\sqrt{8} = 31{,}1126983722081, \text{ for } t = 14 .$$

This is just the solution expressed in (12). Somewhat simplified, in practical terms, we can say: the production matrix *V*, we received in (12) is such a solution that specifies the minimal required correction of the entered matrix consumption in order to minimize the sum of quadrates of deviations of the required raw materials (to be completed or discarded) from the presumed number in a given manufacturing process. Moreover, this solution is such that has the smallest Euclidean norm of all the solution, in our case equal to 31,113. This can be simplistically interpreted in economic terms that this solution distributes the individual components of the output matrix as evenly as possible.

5.2. Aggregation in linear economic models

Understanding the complex structure, relationships, and contexts of economic systems are limited and therefore we are forced to aggregate them. Generally, an aggregate is defined as a set or group of elements that has other new properties compared to individual elements. In relation to the environment, the aggregate forms a relatively closed unit that is capable of interacting with other elements, or with the environment. It is necessary to recognize the difference between aggregation and abstraction. Abstraction is primarily about neglecting (non-essential random) components from a set of elements. In aggregation, the unit acquires new features of individual elements. The aggregate acquires system properties.

Aggregation in economic modeling will primarily consist of a quantitative aspect of the characteristics of the objects and the whole of them created in such a way that the whole expresses objects exactly in terms of their size and does not distort them. This has, of course, a retrospective impact on the assessment of the quantitative aspect of the whole.

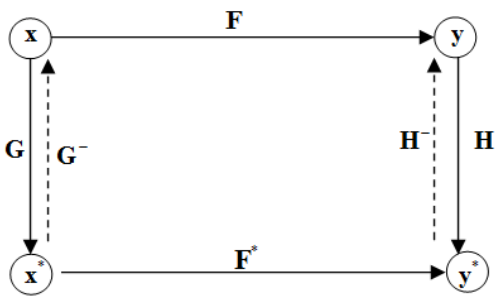
Let $\mathbf{x} \in \mathbf{R}^n$, $\mathbf{y} \in \mathbf{R}^m$, $\mathbf{x}^* \in \mathbf{R}^{n^*}$, $\mathbf{y}^* \in \mathbf{R}^{m^*}$, that $n^* < n$, $m^* < m$. Let us consider the transformation matrices:

$$\mathbf{F}_{m \times n} : \mathbf{x} \to \mathbf{y}, \quad \mathbf{y} = \mathbf{F}\mathbf{x} \qquad \mathbf{G}_{n^* \times n} : \mathbf{x} \to \mathbf{x}^*, \quad \mathbf{x}^* = \mathbf{G}\mathbf{x}$$

$$\mathbf{H}_{m^* \times m} : \mathbf{y} \to \mathbf{y}^*, \quad \mathbf{y}^* = \mathbf{H}\mathbf{y} \qquad \mathbf{F}^*_{m^* \times n^*} : \mathbf{x}^* \to \mathbf{y}^*, \quad \mathbf{y}^* = \mathbf{F}^*\mathbf{x}^* .$$

We can illustrate the aggregation and disaggregation by diagram as the Figure 1.

Figure 1. Diagram of aggregation a disaggregation



Source: own

Matrix $\mathbf{G}$ (similar to matrix $\mathbf{H}$) has a structure $\mathbf{G} = \begin{pmatrix} \mathbf{g}_1 & \dots & \dots & 0 \\ \dots & \mathbf{g}_2 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & \dots & \dots & \mathbf{g}_{n^*} \end{pmatrix}$, when $\mathbf{g}_i$ are vector vectors with r_i non-negative components and $\sum_i r_i = n.$

Economically $\mathbf{g}_i$ can be a weight for aggregating components into individual products. Vector $\mathbf{x}$ can be interpreted as a vector of the intensity of use of individual technologies in the production of products. Vector $\mathbf{y}$ can be explained as a vector of capacities that are aggregated into the higher capacities. In case that $\text{rank}(\mathbf{G}_{n^* \times n}) = n^*$ then inverse matrix $\mathbf{G}_R$ exists to matrix $\mathbf{G}$, and $\mathbf{G}_R$ is equal to the Moore-Penrose pseudoinverse matrix $\mathbf{G}^+$ with the property $\mathbf{G}\mathbf{G}_R = \mathbf{G}\mathbf{G}^+ = \mathbf{I}$. That aggregation is consistent (perfect) is sufficient to satisfy the requirement

$$\mathbf{F}^*\mathbf{G} = \mathbf{H}\mathbf{F}. \tag{14}$$

Example 3. Let $\mathbf{F} = \begin{pmatrix} 2 & 1 & 1 & 1 \\ 1 & 2 & 1 & 1 \\ 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 2 \end{pmatrix}$, $\mathbf{x} = \begin{pmatrix} 2 \\ 2 \\ 1 \\ 1 \end{pmatrix}$. Then $\mathbf{y} = \mathbf{F}\mathbf{x} = \begin{pmatrix} 8 \\ 8 \\ 7 \\ 7 \end{pmatrix}$. In the appropriate matrix $\mathbf{F}$, we will aggregate the first two rows and the first two columns, so that matrix $\mathbf{F}^*$ has a dimension $\mathbf{F}^*_{3\times3}$. Let the aggregation matrices have a form $\mathbf{G} = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$, $\mathbf{H} = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$. To the matrix $\mathbf{G}$ we find a Moore-Penrose pseudoinverse of a matrix $\mathbf{G}^+$ using the software mentioned above. We get $\mathbf{G}^+ = \begin{pmatrix} \frac{1}{2} & 0 & 0 \\ \frac{1}{2} & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \mathbf{H}^+$. From the remark 1 implies a solution of the equation (14) for the unknown matrix $\mathbf{F}^*$, that is $\mathbf{F}^* = \mathbf{H}\mathbf{F}\mathbf{G}^+$.

We get $\mathbf{F}^* = \mathbf{H}\mathbf{F}\mathbf{G}^+ = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 2 & 1 & 1 & 1 \\ 1 & 2 & 1 & 1 \\ 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 2 \end{pmatrix} \begin{pmatrix} \frac{1}{2} & 0 & 0 \\ \frac{1}{2} & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 3 & 2 & 2 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{pmatrix}.$

Then,

$$\mathbf{x}^* = \mathbf{G}\mathbf{x} = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 2 \\ 2 \\ 1 \\ 1 \end{pmatrix} = \begin{pmatrix} 4 \\ 1 \\ 1 \end{pmatrix}, \quad \mathbf{y}^* = \mathbf{H}\mathbf{y} = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 8 \\ 8 \\ 7 \\ 7 \end{pmatrix} = \begin{pmatrix} 16 \\ 7 \\ 7 \end{pmatrix},$$

$$\mathbf{y}^* = \mathbf{F}^*\mathbf{x}^* = \begin{pmatrix} 3 & 2 & 2 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{pmatrix} \begin{pmatrix} 4 \\ 1 \\ 1 \end{pmatrix} = \begin{pmatrix} 16 \\ 7 \\ 7 \end{pmatrix}.$$

We verify the consistency of aggregation (14)

$$\mathbf{F}^{*}\mathbf{G}=\begin{pmatrix}3&2&2\\1&2&1\\1&1&2\end{pmatrix}\begin{pmatrix}1&1&0&0\\0&0&1&0\\0&0&0&1\end{pmatrix}=\begin{pmatrix}3&3&2&2\\1&1&2&1\\1&1&1&2\end{pmatrix},$$

$$\mathbf{H}\mathbf{F}=\begin{pmatrix}1&1&0&0\\0&0&1&0\\0&0&0&1\end{pmatrix}\begin{pmatrix}2&1&1&1\\1&2&1&1\\1&1&2&1\\1&1&1&2\end{pmatrix}=\begin{pmatrix}3&3&2&2\\1&1&2&1\\1&1&1&2\end{pmatrix}.\ \mathbf{x}=\mathbf{G}^{+}\mathbf{x}^{*}=\begin{pmatrix}\frac{1}{2}&0&0\\\frac{1}{2}&0&0\\0&1&0\\0&0&1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix}=\begin{pmatrix}2\\2\\1\\1\end{pmatrix}.$$

$$\mathbf{x}=(\mathbf{F}^{*}\mathbf{G})^{+}\mathbf{y}^{*}=(\mathbf{H}\mathbf{F})^{+}\mathbf{y}^{*}=\frac{1}{10}\begin{pmatrix}3&-2&-2\\3&-2&-2\\-2&8&-2\\-2&-2&8\end{pmatrix}\begin{pmatrix}16\\7\\7\end{pmatrix}=\begin{pmatrix}2\\2\\1\\1\end{pmatrix}.$$

The last two disaggregations are accurate because the vector $\mathbf{x}$ is the eigenvector of the matrix $\mathbf{G}^{+}\mathbf{G}$, which corresponds to the eigenvalue of matrix $\mathbf{G}^{+}\mathbf{G}$ equal to 1. It is possible to prove that the set of all vectors $\mathbf{x}$, which after the aggregation give the vectors $\mathbf{x}^{*}$ and $\mathbf{y}^{*}$ and after the disaggregation of the vectors $\mathbf{x}=\mathbf{G}^{+}\mathbf{x}^{*}$ and $\mathbf{x}=(\mathbf{F}^{*}\mathbf{G})^{+}\mathbf{y}^{*}=(\mathbf{H}\mathbf{F})^{+}\mathbf{y}^{*}$, satisfies the condition in our case.

$$\hat{\mathbf{x}}=\begin{pmatrix}c_1\\c_1\\c_2\\c_3\end{pmatrix},\ c_i\in\mathbf{R},\ i=1,2,3. \tag{15}$$

Obviously $\mathbf{x}=\mathbf{G}^{+}\mathbf{x}^{*}=\mathbf{G}^{+}(\mathbf{G}\mathbf{x})=(\mathbf{G}^{+}\mathbf{G})\mathbf{x}=\begin{pmatrix}\frac{1}{2}&\frac{1}{2}&0&0\\\frac{1}{2}&\frac{1}{2}&0&0\\0&0&1&0\\0&0&0&1\end{pmatrix}\begin{pmatrix}c_1\\c_1\\c_2\\c_3\end{pmatrix}=\begin{pmatrix}c_1\\c_1\\c_2\\c_3\end{pmatrix}=\hat{\mathbf{x}}.$

Note that, for selected vector $\mathbf{x}$, relation (15) also applies to other precise disaggregations $\mathbf{x}=\mathbf{G}^{-}(\mathbf{F}^{*})^{-1}\mathbf{y}^{*}$, $\mathbf{x}=\mathbf{F}^{-1}\mathbf{H}^{-}\mathbf{y}^{*}$. If we select a vector outside of this class (15), disaggregations do not give exactly the same vector, which we can easily verify.

5.3 Aggregation in optimization models

In terms of transparency and understanding the complex structure of relations in economic models of optimization functions and variables are aggregated. Moreover, models often have a hierarchical structure and in these models is necessary aggregation (Sojka, Walter *et al.* (1986).

The problem of linear programming will be written in the form $\max \mathbf{cx}\{\mathbf{x}\,|\,\mathbf{Ax}\le\mathbf{b};\ \mathbf{x}\ge\mathbf{0}\}$, where a vector $\mathbf{c}=(c_1,c_2,\ldots,c_n)$ is the vector of the coefficient of the objective function with the set of indices $\mathbf{K}=\{1,2,\ldots,n\}$, $\mathbf{x}=(x_1,x_2,\ldots,x_n)'$ is a vector of variables with a defined set of indices $\mathbf{K}$, $\mathbf{b}=(b_1,b_2,\ldots,b_m)'$ is a vector constraint conditions with a set of indices $\mathbf{L}=\{1,2,\ldots,m\}$.

Dividing the set of indices $\mathbf{K}=\{1,2,\ldots,n\}$ into subsets K_r is defined as follows: $\mathbf{K}=\{K_r;r\in\mathbf{N}\}$,

$K_r\neq\varnothing,\ r\in\mathbf{N},$

where: $K_r\cap K_s=\varnothing,\ r\neq s,\ r,s\in\mathrm{N},$

$\bigcup_{r\in} K_r=\mathbf{K}$

Aggregate variables are marked with an asterisk. If we want to reduce the size of vector bounding conditions, we use a map matrix $\mathbf{H}$ from $\mathbf{b}$ to $\mathbf{b}^{*}$, $\mathbf{H}:\mathbf{b}\to\mathbf{b}^{*}$, $\mathbf{b}^{*}=\mathbf{H}\mathbf{b}$. The operator of aggregation has the form:

$$\mathbf{H} = \begin{pmatrix} \mathbf{h}_1 & \dots & \dots & 0 \\ \dots & \mathbf{h}_1 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & \dots & \dots & \mathbf{h}_{m^*} \end{pmatrix},$$

where: $\mathbf{h}_k$, $k = 1,2,\dots,m^*$ are row vectors whose number corresponds to the size of the vector $\mathbf{b}^*$, all of which $\mathbf{h}_k \geq \mathbf{0}$.

If we interpret the subvectors $\mathbf{h}_k$ such as the prices of individual sources and the vector $\mathbf{b}$ such as a system source, then the vector components $\mathbf{b}^*$ are aggregated resource groups expressed in prices (Sojka, Walter *et al.* (1986).

Matrix $\mathbf{H}$ is also called the left aggregator operator. The sum of the components of the individual rows $\mathbf{h}_k$ is equal to one. Note that weights h_{k_i} in vector $\mathbf{h}_k$ would be theoretically best obtained from dual variables. If we aggregate the vector $\mathbf{b}$, we have to aggregate the matrix $\mathbf{A}$ as well.

So the optimization problem acquired by the left aggregator operator is $\max \mathbf{cx}\{\mathbf{x} \mid \mathbf{HAx} \leq \mathbf{b}^*; \mathbf{x} \geq \mathbf{0}\}$. If we want to aggregate the initial matrix according to the columns (multiple activities aggregate into one activity) and, based on this aggregation, to get an aggregated vector of solution $\mathbf{x}^*$, we must use matrix $\mathbf{Q}$ as a right aggregating operator in terms of relation $\max \mathbf{cQx}^*\{\mathbf{x}^* \mid \mathbf{AQx}^* \leq \mathbf{b}; \mathbf{x}^* \geq \mathbf{0}\}$,

where: $\mathbf{Q} = \begin{pmatrix} \mathbf{q}^{(1)} & \dots & \dots & 0 \\ \dots & \mathbf{q}^{(2)} & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & \dots & \dots & \mathbf{q}^{n^*} \end{pmatrix}$, if $\mathbf{q}^{(k)}$, $k = 1,2,\dots,n^*$ are column vectors.

Using the operator $\mathbf{Q}$, we decrease the number of columns of the initial matrix $\mathbf{A}$ from n to n^*. All $\mathbf{q}^{(k)} \geq \mathbf{0}$. The sum of the components of each column $\mathbf{q}^{(k)}$ is equal to 1. Note, that weights $q^{(k_i)}$ in vector $\mathbf{q}^{(k)}$ would be theoretically best obtained from dual variables. If we aggregate the optimization task on both rows and columns, we get $\max \mathbf{c}^*\mathbf{x}^*\{\mathbf{x}^* \mid \mathbf{A}^*\mathbf{x}^* \leq \mathbf{b}^*; \mathbf{x}^* \geq \mathbf{0}\}$, where $\mathbf{c}^* = \mathbf{cQ}$, $\mathbf{A}^* = \mathbf{HAQ}$.

Example 4. Let us solve the problem of linear programming $\max \mathbf{cx}\{\mathbf{x} \mid \mathbf{A}\,\mathbf{x} \leq \mathbf{b}, \mathbf{x} \geq \mathbf{0}\}$, where:

$$\mathbf{c} = (4,4,4,4), \quad \mathbf{A} = \begin{pmatrix} 2 & 1 & 1 & 1 \\ 1 & 2 & 1 & 1 \\ 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 2 \end{pmatrix}, \quad \mathbf{b} = \begin{pmatrix} 130 \\ 130 \\ 140 \\ 150 \end{pmatrix}.$$

We will aggregate this problem with matrix $\mathbf{A}_{4\times4}$ to problem with matrix $\overline{\mathbf{A}}^*_{3\times3}$ so that we aggregate the first and second column and the first and second row of matrix $\mathbf{A}$. The solution of this optimization problem is the vector $\mathbf{x} = (20,20,30,40)'$, then $\mathbf{cx} = 440$. Solving the corresponding dual problem is a vector $\mathbf{u} = (0{,}8, 0{,}8, 0{,}8, 0{,}8)'$. Note, that we have formulated this problem in such a way that the vector $\mathbf{x}$ belongs to the class of solution given by the relationship (15). Since the first and second coordinates of the vector $\overline{\mathbf{x}}$ and the like $\overline{\mathbf{u}}$ have the equal value, we use due to the requirement of standardization of weights for the first and second row and the first and second column, therefore $(\frac{1}{2}, \frac{1}{2})$.

Matrix $\mathbf{H}$ and matrix $\mathbf{Q}$ will then $\mathbf{H} = \begin{pmatrix} \frac{1}{2} & \frac{1}{2} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$, $\mathbf{Q} = \begin{pmatrix} \frac{1}{2} & 0 & 0 \\ \frac{1}{2} & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$.

We receive $\mathbf{cQ} = (4,4,4,4)\begin{pmatrix} \frac{1}{2} & 0 & 0 \\ \frac{1}{2} & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = (4,4,4) = \mathbf{c}^*$, $\mathbf{Hb} = \begin{pmatrix} \frac{1}{2} & \frac{1}{2} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} 8 \\ 8 \\ 7 \\ 7 \end{pmatrix} = \begin{pmatrix} 130 \\ 140 \\ 150 \end{pmatrix} = \mathbf{b}^*$,

$$\mathbf{HAQ} = \begin{pmatrix} \frac{1}{2} & \frac{1}{2} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} 2 & 1 & 1 & 1 \\ 1 & 2 & 1 & 1 \\ 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 2 \end{pmatrix}\begin{pmatrix} \frac{1}{2} & 0 & 0 \\ \frac{1}{2} & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} \frac{3}{2} & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{pmatrix} = \bar{\mathbf{A}}^*.$$

The solution of optimization problem $\max(\mathbf{cQ})\mathbf{x}^*\{\mathbf{x}^* \mid \bar{\mathbf{A}}^*\mathbf{x}^* \le \mathbf{b}^*, \mathbf{x}^* \ge 0\}$ is vector $\bar{\mathbf{x}}^* = (40,30,40)$ and the corresponding dual problem is the vector $\bar{\mathbf{u}}^* = (1,6,\ 0,8,\ 0,8)$. After disaggregation of $\bar{\mathbf{x}}^*$ and $\bar{\mathbf{u}}^*$ we get a solution to the initial optimization problem and a their corresponding dual problem.

$$\mathbf{Q}\bar{\mathbf{x}}^* = \begin{pmatrix} \frac{1}{2} & 0 & 0 \\ \frac{1}{2} & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} 40 \\ 30 \\ 40 \end{pmatrix} = \begin{pmatrix} 20 \\ 20 \\ 30 \\ 40 \end{pmatrix} = \mathbf{x},\ \bar{\mathbf{u}}^*\mathbf{H} = (1,6,\ 0,8,\ 0,8)\begin{pmatrix} \frac{1}{2} & \frac{1}{2} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} = (0,8,\ 0,8,\ 0,8,\ 0,8) = \bar{\mathbf{u}}.$$

Aggregation of vector solution $\mathbf{x} = (x_1, x_2, \ldots, x_n)'$ can be easily realized using a projection matrix $\mathbf{P} = (p_{ij})$, when $p_{ij} = \begin{cases} 1, & \text{if } q_{ji} \ne 0 \\ 0 & \text{in other case} \end{cases}$. It can be proved that matrix $\mathbf{P}$ satisfies the relations $\mathbf{PQ} = \mathbf{I}$ and $(\mathbf{QP})\mathbf{Q} = \mathbf{Q}$. It means, $\mathbf{P}$ is a left inverse matrix to matrix $\mathbf{Q}$, therefore $\mathbf{P} = \mathbf{Q}_L^{-1}$, which is not generally uniquely determined. The second relation, states that $\mathbf{P} = \mathbf{Q}^-$, therefore $\mathbf{P}$ is pseudoinverse matrix of a matrix $\mathbf{Q}$, which is not generally uniquely determined too. In our case $\mathbf{P} = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$. Matrix $\mathbf{P}$ in generally has properties

$\mathbf{PQ} = \mathbf{I}$, as we mentioned above, $\mathbf{P} = \mathbf{Q}_L^{-1}$

$\mathbf{QPQ} = \mathbf{Q}$, therefore $\mathbf{P} = \mathbf{Q}^-$

$\mathbf{PQP} = \mathbf{P}$, i. e. $\mathbf{Q} = \mathbf{P}^-$

$$(\mathbf{PQ})' = \mathbf{PQ}$$

$(\mathbf{QP})' = \mathbf{QP}$, in our case it is $\mathbf{Q}' = \mathbf{Q}^+$, but in general this relation may not apply. Let's return to our example

$$\mathbf{x}^* = \mathbf{P}\mathbf{x}. \tag{16}$$

Then $\mathbf{x}^* = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} 20 \\ 20 \\ 30 \\ 40 \end{pmatrix} = \begin{pmatrix} 40 \\ 30 \\ 40 \end{pmatrix}$.

Or

$$\mathbf{x} = \mathbf{P}^-\mathbf{x}^* = \mathbf{Q}\mathbf{x}^*. \tag{17}$$

Then $\mathbf{x} = \begin{pmatrix} \frac{1}{2} & 0 & 0 \\ \frac{1}{2} & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 40 \\ 30 \\ 40 \end{pmatrix} = \begin{pmatrix} 20 \\ 20 \\ 30 \\ 40 \end{pmatrix}$.

For correctness, let us note that relations (16) and (17) are precisely because the vector $\mathbf{x} = (20,20,30,40)'$ is the eigenvector of the matrix $\mathbf{P}^{-}\mathbf{P}$, corresponding to the eigenvalue 1. Generally, to the calculated $\mathbf{x}^{*}$ disaggregation $\hat{\mathbf{x}} = \mathbf{P}^{-}\mathbf{x}^{*}$ would be "closest" to solving the non-aggregated optimization problem, in the sense that norm $\|\mathbf{A}\mathbf{x} - \mathbf{A}\hat{\mathbf{x}}\|$ would be minimal approximation of all solutions, provided that $\mathbf{P}^{-}$ would be a Moore-Penrose pseudoinverse matrix of a matrix $\mathbf{P}$, which as in our case.

Relationships (16), (17) in economic applications are valid only for models with a special structure (*e.g.* transport problem, allocation problem, *etc.*).

Conclusion

In this paper, we presented some properties of pseudoinverse of a matrix, the technique of its calculation using the open-source systems and sample application of pseudoinverse of a matrix in the economic analysis too. In conclusion, let us note that problem presented in the part 4.1 may be solving as a problem of linear programming: $\min \|\mathbf{A}\cdot\mathbf{V} - \mathbf{S}\|$, $\min \|\mathbf{V}\|$ subject to: $v_i \geq 0$, $i = 1,2,\ldots$

The input-output framework offers numerous analytical possibilities because it is possible to work directly through supply-use tables or through the traditional symmetric table. For example in (Pereira, Fernández and Carrascal 2014) are going to focus on the general case. In fact, several models of demand and supply are developed within the supply-use tables structure. Generally, intermediate consumption matrices related with supply-use tables framework are rectangular. Therefore, to obtain the production vector (by products or by industries) in the construction of models from the supply-use tables, it is necessary to work with the "inverses" of rectangular matrices. In order to avoid an assumed problem, there is a simple and quite employed procedure, which consists on aggregating products to achieve a square matrix. But undoubtedly, this implies a significant loss of information available on the supply-use tables. They want to highlight that, in economic research, input-output framework inverses must be considered as a working tool and not as the final product. In this paper are showed how this problem can be avoided using generalized inverses, providing the advantage that they are perfectly calibrated and, consequently, they can be used as an analytical tool. Recently, a previous study developed a demand model within the supply-use tables framework through the use of the Moore-Penrose inverse.

In generally, the pseudoinversion of a matrix can almost always be used where it is not possible to use a standard matrix inversion.

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In-Depth Analysis of ASEAN Stock Markets' Diversification Benefit under Vector Autoregressive Model

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Abstract:

After the ASEAN Trading Link was established in 2011 in order to connect the ASEAN stock markets together, more developed information technology permits the more market integration of this region through the network of brokerage firms in the member countries. However, the integration of ASEAN countries is not limited to only the stock markets but also other economic fundamentals. As a result, ASEAN members could become more similar which, in turn, may affect those investing in ASEAN stock market. To prove that the stock market integration may not support the sustainable returns for investors, this research examines the reduction in the diversification benefit of the portfolio which includes the stocks from different ASEAN markets. The finding from VAR model shows that the more combined ASEAN countries' economies could negatively affect investors who focus on lowering their risk by spreading their investment in different ASEAN's stock markets.

Keywords: ASEAN; brokerage; integration; risk diversification; VAR model

JEL classification: G1; F36

1. Introduction

The recent development of global and regional stock market integration is an attempt to comfort investors to invest in overseas stock markets rather than the domestic markets. The attempt includes the combination of regional stock markets into a single stock market and the development of technology to provide trading link among regional stock markets. For the development of trading link, a good example is the Association of Southeast Asian Nations (ASEAN) Trading Link which was started in 2011 but has been terminated in 2017. However, the ASEAN trading link has later been reconsidered to be reactivated with more countries in ASEAN in order to promote the economic collaboration among the ASEAN countries in the ASEAN Economic Community (AEC). Therefore, this paper tries to exhibit the pros and cons of the stock market integration in this region whether it really benefits investors in the AEC and brings sustainable returns to them.

Since the establishment of the AEC in 2015 is intended to bring about the collaboration among the ASEAN countries in different aspects, especially trade and investment, the AEC should be able to promote economic, political, social and cultural cooperation across the region. The AEC is expected to help both ASEAN and non-ASEAN firms to expand their business across this region. As a result, the funds to support the growth in economic activities of this region are in great demand, and the integration of capital markets to pool the funds becomes the tool to achieve this purpose. Apparently, the integration of regional stock markets is expected to attract investors in this region and from other regions since the combination of capital markets would provide the more accessibility to invest in stocks of other ASEAN markets and would generate the higher liquidity for stock trading in stock markets of ASEAN countries. In additions, investors would be able to diversify their risk by investing in stocks of companies from various ASEAN countries at lower transaction cost.

In terms of capital market integration in the AEC, the vivid evidence is the attempt to launch the ASEAN Linkage as a part of collaboration between seven stock exchanges in six countries in ASEAN comprising Indonesia,

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Malaysia, the Philippines, Singapore, Thailand, and Vietnam (both exchanges in Hanoi and Ho Chi Minh City). With advanced internet and computer technology, the cross-border network could be created at lower cost but with high operating efficiency. At beginning, the Singapore Stock Exchange and Bursa Malaysia were incorporated through the network called ASEAN Trading Link in 2011, and the Stock Exchange of Thailand then later joined as the third exchange in this platform. The ASEAN Linkage was aimed to promote the growth of ASEAN capital markets by exhibiting ASEAN investment opportunities to a wider range of investors. In other words, the system was expected to be the tool to link ASEAN countries' stock exchanges together so that investors could easily trade stocks of the member countries as if they are registered in the same exchange.

The Linkage was, however, terminated in the last quarter of 2017 due to the negligence of regional securities firms in joining the trading system structured by the exchanges. The securities firms prefer their developed computer technology and their internet networks to place their clients' orders for trading the stocks in the stock markets all over the world. Since the ASEAN Trading Link is no longer to continue, the growth of the capital market integration in the AEC is expected to carry on under brokerage firms' networks.

Nevertheless, the reconsideration of the ASEAN Linkage reveals the attempt in supporting the integration development and brings up a research question whether the combined stock markets would create the value under the context of co-integration and risk diversification. The pros and cons of the integration of ASEAN stock markets becomes key success factors for the development of the ASEAN capital markets. The integration also leads to the sharing of economic fundamentals and regional responsiveness on economic threats and opportunities. Thus, the big issue is whether the integration of ASEAN countries through the trading link or any processes may lower the degree of the geographic segmentation and create the hindrance of the risk diversification.

The first attempt for this research focuses on the capital market integration of the economic-leading countries of the AEC or ASEAN-5 countries including Indonesia, Malaysia, the Philippines, Singapore, and Thailand where the development of capital markets is relatively high and where the economic integration is noticeably advantageous for both regional and international investors. If the markets are real integrated, good events from one country might positively affect the other countries in the same way and vice versa. Therefore, this study examines the co-integration of the combined stock markets including Singapore Stock Exchange, Bursa Malaysia, the Stock Exchange of Thailand, Indonesia Stock Exchange, and the Philippine Stock Exchange. The investigation is done under a passive investment strategy, so called indexing. Investors are assumed to invest in portfolios imitating each country's stock index. The indices include the FTSE Straits Times Index (STI) of Singapore Exchange, the FTSE Kuala Lumpur Composite Index (FTSE KLCI) of Bursa Malaysia, the Stock Exchange of Thailand (SET) Index, the Indonesia Stock Exchange (IDX) Index, and the Philippine Stock Exchange Index (PSEI). For examining the co-integration of these markets, the unit root test with error correction model and granger causality test will be employed. In order to promote the in-depth understanding on the diversification benefit of this regional market integration, this study goes beyond the traditional correlation and co-integration analysis. The research investigates the linear interdependencies among the ASEAN stock markets' returns under the Vector Autoregressive (VAR) Model to observe the diversification benefit from these markets' integration.

The data used for this investigation is limited to the stock markets of ASEAN-5 countries during ASEAN Trading Link's activated time. The stock markets of other countries in this region are discarded because these markets are newly established and have small market capitalization. The structure of these markets could easily change when new stocks are listed. Moreover, these markets' liquidity is low. The returns might not reflect the real demand and supply of these markets. Accordingly, counting these markets into the analysis could affect the reliability of the research results.

The research results of this paper are expected to help the stock market investors in ASEAN to build portfolios with more appropriate strategies for the investment in the ASEAN stock markets. Also, since the AEC policy makers are reconsidering to relaunch the ASEAN Trading Link, the research results are expected to help them make better policy on capital market in order to support the economic growth for this region. For academics, the findings of this research extend the study of market efficiency and the advantages of regional diversification.

The structure of this paper after this introduction section is arranged by adding the literature review which describes the general grounded concepts of the study. Then, the data and methodology, the report of the findings, and concluding remark are included thereafter.

2. Literature review

In modern portfolio theory, Markowitz (1952, 77-91) shows that the risk reduction occurs when stocks which are not perfectly correlated are put together in the portfolio. The further studies suggest for adding international stocks into investors' portfolio to further lowering risk through diversification model. For instance, Heston, Rouwenhorst,

and Wessels (1995,173-197), claim for the existence of advantage from diversification in economically integrated region, Levy and Sarnat (1970, 668-675) recommend the inclusion of stocks of the countries with low economy's correlation to gain risk diversification benefit, Griffin and Karolyi (1998, 351-373) exhibit the results of international diversification in the study concerning the country-specific risk, and Brooks and Del Negro (2004, 659-680) provide evidences which support the risk reduction from international diversification.

However, there are also several researches which find the evidences against the benefit of cross-country diversification, especially, for regional diversification. The issue of economic sharing among country members is discussed as the reason to fade the benefit of cross-country diversification. For example, Hung and Cheung (1995, 281-288) reveal that the existence of co-integration of Asian stock markets reduces the advantage of international diversification. The change in one market responded to the change of another market is continuously found Berben and Jansen (2005, 832-857) apply the GARCH model to investigate shifts in correlation patterns among international equity returns and find that in the period 1980-2000, correlations among the German, UK and US stock markets have doubled, whereas Japanese correlations have remained the same. Marimuthu (2010, 61-80) discovers the influence of U.S. market on Asian markets and finds the influence of Asian markets on the other Asian markets. Patel (2013) discloses that Sri Lanka, Japan, Singapore, and China markets could affect the Indian market.

The studies on the integration of ASEAN capital markets come up with the similar results. Click and Plummer (2005, 5-28) investigate whether the ASEAN-5 stock markets are integrated or segmented using the time series technique of co-integration and confirm that those markets are co-integrated. Nittayagasetwat and Buranasiri (2017, 562-567) use the stochastic dominance technique to investigate the diversification benefit on the integration of five AEC countries' capital markets during 1999 and 2016. They find that the value of equally weighted portfolio built from combining five AEC countries' stock markets is not significantly high, compared to the value of each AEC country's portfolio. The follow-up study of Nittayagasetwat and Buranasiri (2018, 543-548) apply co-integration analysis on the South-East Asian stock markets and suggests that international investment might not be good enough to bring risk diversification to the portfolio if the added foreign markets are quite economically integrated with the existing one.

For the investigation method, beside the studies on correlation and co-integration for the proof of the risk reduction from market integration, Vector Autoregressive (VAR) model is an interesting tool which could help researchers to gain profound understanding on the diversification. The model could prove the impact of the shocks of the events in other markets on the studied markets and control the influence of the lag of the studied markets at the meantime. The findings under VAR report the size of the impacts from the lagged return variables and the number of statistically significant lagged returns. As a result, the researchers could point out how fast the information flow from one market to another related market or how long a market needs to reflect a piece of relevant information. Accordingly, the level of pricing efficiency of a market could be measured. Recently, Mohanasundaram and Karthikeyan (2015, 475-485) apply the VAR model to find the short-run relationship among different stock markets and they find that U.S. and South Africa markets are independent from other markets. In order to gain thorough understanding on the risk diversification of investing in ASEAN markets in new aspects, this study employs VAR model as the main research methodology.

3. Methodology

This paper applies the Vector Autoregressive (VAR) model to explore the co-integration possibility of ASEAN-5 stock markets since the VAR model can exhibit the interrelation of endogenous variables in the model. This study focuses on the stock markets' returns, so the stock indices include the STI, the FTSE KLCI, the SET Index, the IDX Index, and PSEI. The data are collected from January 2012, one year after the ASEAN Trading Link was established, to December 2017, when the link was terminated. The daily return could be calculated from the natural logarithm in total return index of each market from Reuter Database as follows:

$$R_{i,t} = ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right) \quad (1)$$

where: $R_{i,t}$ is the daily return of stock market *i* at day *t*; $P_{i,t}$ is the index of stock market *i* at day t; $P_{i,t-1}$ is the index of stock market *i* at day *t-1.*

In addition to the descriptive statistics analysis for disclosing the distribution of each stock market's return, correlation coefficient of each pair of markets is calculated to find out the relation of ASEAN markets' returns. The lower the coefficient, the higher the possibility for risk reduction from holding stocks of these different markets.

Next, Vector Autoregressive (VAR) model is applied to find the impact of each market's returns on another markets. The testing step starts from applying Augmented Unit Root Test (1984) to check the stationary of the data to avoid the spurious results. Then, VAR model is employed to test the effect from lag return of the investigated market and the lag returns of another markets. The equation of VAR analysis for the test is as follows:

$$R_{i,t} = a_i' + b_i' R_{i,t-m} + \sum_{m=1}^{n} \gamma_j' R_{j,t-m} + e_{i,t}' \quad (2)$$

where: $R_{i,t}$ is the daily return of stock market *i* at day *t*; a_i' is the intercept of the equation; b_i' is the beta coefficient of lagged return of the stock market *i*; γ_j' is the beta coefficient of lagged return of the stock market *j*; $R_{i,t-m}$ is the lagged return of stock market *i* at day *t-m.*

Five lagged returns are examined for one-week information spill-over from a market to another markets. The lagged returns are presumed to have power over the tested stock market's return if their beta coefficients are statistically significant continuously from the first lagged variable.

4. Result

For descriptive statistics, Table 1 shows that, during testing period, Thailand's stock market has the highest average daily return at 0.05% following by the Philippines at 0.04%, Indonesia at 0.03%, Singapore at 0.03% and Malaysia at 0.01%. The ranking of the fluctuation in the returns, using standard deviation, from the highest to the lowest markets are the Philippines at 1.00%, Indonesia at 0.93%, Thailand at 0.86%, Singapore at 0.68% and Malaysia at 0.51%. Kurtosis and skewness show that all markets are not normally distributed. All markets are skewed to the left and most have kurtosis higher than the normal level of 3.00.

Table 1. Descriptive Statistics for daily returns of stock markets in Indonesia, Malaysia, the Philippines, Singapore, and Thailand from 2012 to 2017

	Indonesia	Malaysia	The Philippines	Singapore	Thailand
Mean	0.03%	0.01%	0.04%	0.03%	0.05%
Standard Deviation	0.93%	0.51%	1.00%	0.68%	0.86%
Kurtosis	4.05	3.73	5.86	2.45	4.63
Skewness	-0.41	-0.19	-0.73	-0.23	-0.42
Minimum	-5.75%	-2.74%	-6.99%	-4.39%	-5.37%
Maximum	4.54%	3.32%	5.54%	2.66%	4.48%
Count	1565	1565	1565	1565	1565

The fluctuations of the stock returns in each ASEAN market are calculated in relation to the stock returns by using the ratio of standard deviation to average return and compared to the old study by Nittayagasetwat and Buranasiri (2017, 562-567). The higher ratios in Table 2 clearly indicate that all ASEAN stock markets become more volatile. The Malaysia market has the highest ratio (51 times), followed by Indonesia (31 times), the Philippines (25 times), Singapore (23 times), and Thailand (17 times). The highest increase is in Malaysia market by 46 times, followed by Indonesia (28 times), the Philippines (15 times), Singapore (12 times) and Thailand (times). Obviously, investors should be more careful about market risk of all ASEAN markets and risk reduction strategies become more important nowadays.

Table 2. The ratios of standard deviation to the average return of Stock Markets in Indonesia, Malaysia, the Philippines, Singapore, and Thailand*

	Indonesia	Malaysia	The Philippines	Singapore	Thailand
Standard Deviation to Mean from 2012 to 2017 (times)	31	51	25	23	17
Standard Deviation to Mean before Subprime Crisis* (times)	3	5	10	11	5
Differences (times)	28	46	15	12	12

Note: *Based on the study of Nittayagasetwat and Buranasiri (2017, 562-567)

For correlation analysis, Table 3 shows that ASEAN markets' returns are not highly correlated. The maximum correlation coefficient is between the pair of Indonesia and Singapore at 0.57 while the lowest correlation coefficient is between the pair of the Philippines and Singapore at 0.39. The correlation coefficient of other pairs includes the pair of Singapore and Thailand at 0.56, the pair of Singapore and Malaysia at 0.55, the pair of Indonesia and Thailand at 0.51, the pair of Indonesia and the Philippines of 0.46, the pair of Malaysia and the Philippines of

0.45, and the pair of the Philippines and Thailand at 0.40. Thus, holding stocks from different market generates significant risk diversification and benefits investors. When compared with the old correlation coefficients in the report of Nittayagasetwat and Buranasiri (2017, 562-567) before the Subprime Crisis in 2008, seven out of ten pairs of coefficients including the pairs of Indonesia and Malaysia, Indonesia and Singapore, Indonesia and Thailand, the Philippines and Malaysia, Singapore and Malaysia, Thailand and Malaysia, and Thailand and Singapore becomes higher. Overall, ASEAN stock markets, but the Philippines, become more economically integrated. In conclusion, adding stocks of these ASEAN members together generates less risk diversification benefit these days.

Table 3. Correlation coefficient between each pair of ASEAN Markets during 2012 to 2017, compared with the correlation before the subprime crisis ( )*

	Indonesia	Malaysia	The Philippines	Singapore	Thailand
Indonesia	1.00				
Malaysia	0.51 (0.35)	1.00			
Philippine	0.46 (0.55)	0.45 (0.25)	1.00		
Singapore	0.57 (0.53)	0.55 (0.43)	0.39 (0.54)	1.00	
Thailand	0.51 (0.48)	0.45 (0.29)	0.40 (0.53)	0.56 (0.54)	1.00

Note: *Based on the study of Nittayagasetwat and Buranasiri (2017, 562-567)

The test of Augmented Unit Root Test (1984) to avoid spurious problem shows that all null hypotheses of a unit root of all time-series daily returns are rejected at 1% level. The time-series analyses of ASEAN-5 countries' daily market returns are stationary as shown in Table 4 and, accordingly, can provide statistically significant evidence in the further Vector Autoregressive (VAR) analysis.

Table 4. Unit Root Test for the Time-Series of ASEAN-5 countries' Daily Market Returns during 2012 to 2017

Augmented Dickey-Fuller Test Statistics			
		T-statistics	Prob.*
Indonesia	None	-25.48905	0.0000
	Constant	-25.53799	0.0000
	Constant and Linear Trend	-25.53128	0.0000
Malaysia	None	-35.95508	0.0000
	Constant	-35.95681	0.0000
	Constant and Linear Trend	-35.95239	0.0000
The Philippines	None	-37.84079	0.0000
	Constant	-37.89499	0.0000
	Constant and Linear Trend	-37.90002	0.0000
Singapore	None	-38.51695	0.0000
	Constant	-38.61495	0.0000
	Constant and Linear Trend	-38.61443	0.0000
Thailand	None	-38.43665	0.0000
	Constant	-38.49072	0.0000
	Constant and Linear Trend	-38.48221	0.0000

Note: *MacKinnon (1996, 601-618) one-sided p-values

The Vector Autoregressive (VAR) results in Table 5 disclose that the influences of ASEAN members' stock markets' return to each other are divided. The first group includes Indonesia and Singapore. Indonesia and Singapore markets' lagged returns could affect all of other 4 stock markets' returns in the next day, but their own next day returns. Most of the impact occurs only one day. Next group is the Philippines market. Interestingly, its lagged returns impact not only to other members, except Thailand, but also to its own returns up to 5 days. For Thailand, its lagged returns could influence only the Philippines' returns and the effect longs for one day. Last, the lagged returns of Malaysia market could affect only its own market. Overall, impact from the one market to the other markets could last to the next day or longer. Especially the Philippines, the impact of its lagged returns to its own next day returns lasts many days. Theoretically, if a market is priced efficiently, the price would reflect all relevant information immediately. In weak-form efficiency, the past prices or returns should have been reflected into the current price. Thus, this long duration of the influence may imply that the market's pricing efficiency is low. In addition, if ASEAN markets becomes more efficient or the information is reflected in shorter time, the correlation coefficients of ASEAN markets might be higher. In other words, the diversification benefit tends to be lower than the benefits shown from correlation coefficients in Table 2. Moreover, if investors face a market's liquidity problem and need to hold their stocks for the next day, their returns would be further affected by other ASEAN market.

Table 5. Vector Autoregressive (VAR) Model of ASEAN-5 Countries' Daily Market Returns during 2012 to 2017.

Lagged Return	Indonesia	Malaysia	The Philippines	Singapore	Thailand
Indonesia (-1)	0.045842	0.033508*	0.071895**	0.128693***	0.039861*
Indonesia (-2)	-0.065155**	-0.009161	0.031286	0.017006	0.009026
Indonesia (-3)	-0.127131***	-0.006148	0.090134***	-0.009481	-0.012422
Indonesia (-4)	0.014035	0.012280	0.032530	0.037714	0.014010
Indonesia (-5)	-0.050794	-0.029599*	-0.028096	-0.043210	-0.040797*
Malaysia (-1)	-0.053972	0.057765*	-0.064859	-0.018133	0.016504
Malaysia (-2)	0.057680	0.029520	0.051920	0.010647	0.049456
Malaysia (-3)	-0.034455	-0.036047	-0.074136	-0.066790	-0.020440
Malaysia (-4)	-0.075990	-0.005770	-0.058054	-0.080163	-0.073020*
Malaysia (-5)	0.129346**	0.012819	0.092414	0.036541	0.070451*
The Philippines (-1)	-0.066295**	-0.030282*	-0.088860***	-0.046631*	-0.021389
The Philippines (-2)	-0.016345	0.005995	-0.076665***	0.010769	0.030554
The Philippines (-3)	-0.041649	-0.035415	-0.123539***	0.015417	-0.018611
The Philippines (-4)	-0.032437	-0.024687	-0.089000***	-0.018241	0.035524*
The Philippines (-5)	-0.035634	-0.002939	-0.063552**	0.017754	0.011928
Singapore (-1)	0.106953***	0.030942*	0.157827***	0.000635	0.049875**
Singapore (-2)	0.075505***	0.011370	0.091476***	-0.010307	0.027531
Singapore (-3)	0.048966	0.019042	0.002458	-0.039690	0.025365
Singapore (-4)	0.024774	0.013474	0.047205	0.042857	0.008036
Singapore (-5)	0.029708	0.025452	0.054644	0.012296	0.007280
Thailand (-1)	0.029191	0.015769	0.144641***	-0.035548	-0.020509
Thailand (-2)	0.010764	0.001001	-0.025772	-0.024877	-0.061889**
Thailand (-3)	0.040482	0.026388	0.082903*	0.071111*	0.023389
Thailand (-4)	-0.072916*	-0.005718	-0.021674	-0.020839	-0.003777
Thailand (-5)	-0.026129	-0.000160	0.017252	0.032622	0.041350
C	0.000326	8.27E-05	0.000325	0.000432*	0.000199
Adjusted R-Square	0.031643	0.011348	0.060350	0.006434	0.008467

Note: * Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01.

Conclusion

To The examination focuses on the diversification benefit of the investment in 5-ASEAN stock markets in Indonesia, Malaysia, the Philippines, Singapore, and Thailand during the period of the ASEAN Trading Link among the stock markets in Malaysia, Singapore and Thailand. Overall, the returns of all markets are skewed to the left and highly swing. At first, the regional investment seems to help creating risk diversification and promote sustainable returns for investors. The correlation coefficients among each pair of ASEAN stock markets are rather low. However, the comparison reveals that most recent coefficients become higher than the past coefficients. Moreover, Vector Autoregressive (VAR) analysis shows the existence of the influence from most members' market return on other members' market returns for the short-run.

The evidence supports that ASEAN markets may share some economic fundamentals. This inter-dependence may lower the diversification benefit for investors when these markets could faster reflect the relevant information. In other words, those who perform risk reduction through the international diversification should carefully monitor the change in correlation among different markets, especially in the highly economic-integrated region. The study also suggests that markets' liquidity in ASEAN markets should be considered when investors develop their investment strategies. If investors could not close their positions in different markets at the same time, they would gain less diversification benefit. In other words, to gain more benefit through diversification, investors should try to invest in the countries which are economically independent from each other.

The research provides important contributions to both academics and investors. For academics, the findings provide the evidence of the diversification benefit in relation to the economic integration. For investors, the results let them know whether their investment in the combined markets of these five main countries is worth. The question is whether investors still gain diversification benefit from the investment in across the countries in the AEC region. There are not many studies done on this issue and the answer is unclear for investors. Hence, the study concerning the reward of diversification benefit for this region is necessary. Finally, for policy makers, the findings of this study might reveal whether the combined stock markets should be continued or terminated as it would happen in the last quarter of 2017.

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Why is Administrative Corruption Pervasive? A Mediation Approach

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Abstract:

Despite the existence of valuable literature on political and corporate corruption, there have been only a limited number of papers examining the determinants of administrative corruption. A thorough search of the relevant literature shows there has been no examination of the multivariate impact of corrupt culture, the weakness of organizational culture, the political instability, and the institutional weakness on administrative corruption and the interplay among these constructs has yet to be studied. By testing a sample of 677 responses that reflect the perspective of the general public in Basra, Iraq, this current study attempts to fill these gaps by proposing and testing a model using the partial least squares structural equation modeling method. Overall, weak organizational culture mediates the effect of corrupt culture on corruption; institutional weakness mediates the effect of political instability on corruption; and institutional weakness mediates the effect of weak organizational culture on corruption. Finally, through theoretical contributions, managerial implications, limitations, and recommendations for further research, this study brings presents insights on how weak organizational culture and institutional weakness mediate the effect of corrupt culture on corruption.

Keywords: administrative corruption; culture; organizational culture; political instability; institutional weakness; mediation; PLS-SEM

JEL classification: C300; H110; O170

1. Introduction

Corruption has become a global phenomenon. A report published by Transparency International (2018) indicated that more than two-thirds of all countries experience high corruption. Corruption Perceptions Index ranks public sector corruption, using a scale from 0 (highly corrupt) to 100 (very clean); according to their measure for 2017, New Zealand scored 89 and ranked first in the world, whereas Iraq scored only 18 and ranked 169th out of 180 countries. Iraq scored slightly better than North Korea and Libya, but worse than Angola and Chad. A notable

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finding is that many countries were rated as more corrupt in 2017 than previously (Transparency International, 2018). Therefore, the problem should be investigated using a new approach.

This paper will provide insights into administrative corruption, which has prominently taken the form of petty corruption. This corruption primarily stems from personal benefits becoming the main motivation of low- and mid-level public employees. They tend to misuse their power in public organizations through various interactions with people who attempt to access basic public goods or services (Darsareh and Bastanipour 2016, Hacek *et al*. 2013, Transparency International 2018, Treisman 2000). If business managers have social ties with public officials, their firms will mostly engage in corruption (Collins, Uhlenbruck, and Rodriguez 2009). Administrative corruption potentially undermines the effectiveness of any organization. This is evident through several corrupt activities, such as bribery, embezzlement, collusion with the private sector, and nepotism, whereby corrupt public employees breach governmental rules and laws (Arshad *et al.* 2015, Chan and Owusu 2017, Yahya and Gomaa 2016, Zhang 2015).

Administrative corruption has destructive effects in less developed and developing countries, particularly when it is accompanied by political instability. Corruption affects military expenditure and government financial investment. The interaction between corruption and both military and government investment expenditure has strong effects on economic growth (D'Agostino *et al.* 2016). It weakens economic development and increases inflation and public expenditure (Haider *et al.* 2011, Sironi and Tornari 2013). Deteriorating popular trust in public organizations encourages citizens to disobey the rules and laws (Villoria *et al.* 2013). Corruption is a by-product of war, terrorism and internal conflicts (Transparency International 2018). It is a major factor in increasing the cost of new projects in both public and private sectors. This leads to market inefficiencies, poor infrastructure, and increases in poverty and income disparity (Agbiboa 2012, Tebaldi and Mohan 2010). Corruption, together with bureaucracy, makes business endeavors more expensive and depresses the entrepreneurial enthusiasm (Nan 2009). Factors such as inflation and weak or deficient legal codes lead to inefficient businesses; however, corruption has been shown to play a separate and stronger role (Bo' and Rossi 2007). Corruption painfully reduces the truthfulness of financial institutions and markets (Venard and Hanafi 2008).

Previous research has made important contributions to reviewing the corruption index and its indicators, such as the extent of press freedom, access to information about public expenditure, autonomous judicial systems, and the effectiveness of the government (Mousakhani *et al.* 2013, Transparency International 2018, Treisman 2000, Wilhelm 2002, Yun 2004). Moreover, some research papers have evaluated efforts to combat corruption in the public sector (Cleveland, Favo, Frecka, and Owens 2009). Electronic government (e-government) has been considered one of the vital techniques for fighting corruption (Marquez 2015, Mohammed *et al.* 2015). Furthermore, as information technology progresses, so too does the accountability of government and the participation of citizens. Information and communication technology can enhance transparency and assist anti-corruption efforts (Koekpoe 2011, Sharifi-Renani *et al.* 2013). In addition, other research has addressed the factors affecting administrative corruption, which is the main concern of the current paper. Although covering various factors, their contributions have tended to be disconnected and incoherent; the deficiencies in existing research have prompted us to write this paper.

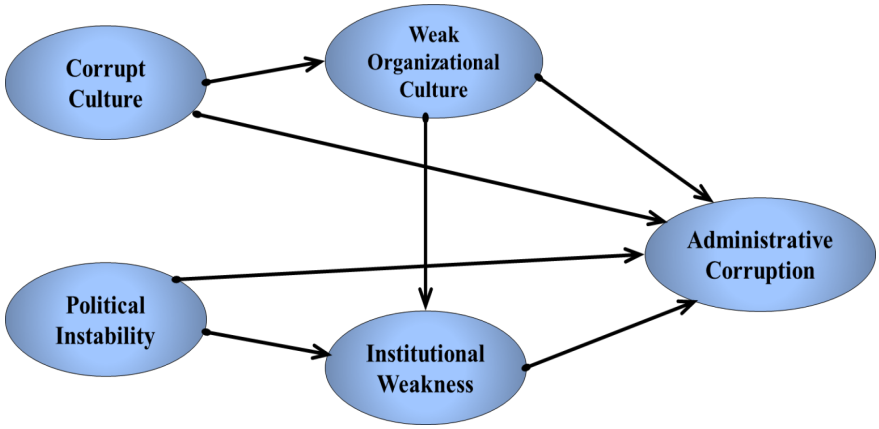
Administrative corruption is influenced by four main constructs: culture, organizational culture, political instability, and institutional weakness. Corrupt culture is the firmest and deepest determination of administrative corruption (Dincer and Johnstony 2017, Rajaei and Arghavani 2016). Public tolerance and a lack of concern about corruption boost administrative corruption (Ambali 2008). Organizational culture is the overall sum of the shared values, beliefs and norms of an organization's employees (Darsareh and Bastanipour 2016, Liu 2016). The absence of clarity, transparency and accountability contributes to weak organizational culture. In addition, the lack of a code of conduct in an organization leads to corruption (Ambali 2008, Voliotis 2017). Political instability erodes the ability of government and public organizations to combat corruption (Bohn 2006). Conflict between parties and sects weakens the policies designed to lessen administrative corruption (Yahya and Gomaa 2016). A deficiency of technological applications in administrative work can lead to a low satisfaction rate among public employees, and the bureaucratic systems may cause institutional weakness that can trigger corruption (Bin-Ismail and Abbas 2015, Darsareh and Bastanipour 2016, Yahya and Gomaa 2016).

There is extensive literature on corruption related to political and corporate aspects (Aguilera and Vadera 2008, Shakantu 2006, Sharifi-Renani *et al.* 2013), whereas only a few studies have examined factors influencing administrative corruption. However, after reviewing various scholarly studies on corruption studies, it is evident that the multivariate influences of culture, organizational culture, political instability, and institutional weakness on administrative corruption have not yet been tested using the partial least squares structural equation modeling (PLS-SEM) method. This method allows for testing the interplay between stated constructs. Previous research has

explored the perceptions of public employees (Darsareh and Bastanipour 2016, Rajaei and Arghavani 2016). However, an analysis of the general public's perspective is yet to be produced. Furthermore, some studies have used international data (Abu and Karim 2015, Koekpoe 2011, Treisman 2000), although we suggest there is a significant need to collect data directly from participants. Some research has examined corruption in a narrow context, such as in a taxation office or firm tax compliance (Ahmadi *et al.* 2010, Alon and Hageman 2013, Darvish and Pakdel 2016, Hindriks *et al.* 1999, Kumar and Bhasker 2015); however, there is a pressing need to understand corruption on a national scale.

The aim of this paper is to fill these gaps by building and testing a comprehensive model to explain administrative corruption (see Figure 1. The paper proposes a model that is intended to make a significant impact on research into administrative corruption due to its key focus on two key areas: first, the direct effects of culture, organizational culture, political instability, and institutional weakness on administrative corruption; and second, the mediating role of organizational culture and institutional weakness on the relationship between culture and corruption and on the relationship between political instability and corruption.

Figure 1. Proposed model



The next section builds the conceptual framework and hypotheses based on previous literature. Section 3 demonstrates that measured items are derived from each construct. Then data is collected and presented to show public attitudes in Iraq, a country that experiences a high degree of corruption. Section 4 examines the measurement model, structural model and hypotheses testing using PLS-SEM. Section 5 discusses the theoretical contributions, managerial implications, limitations, and future research directions.

2. Conceptual framework and hypotheses development

2.1. Administrative corruption, culture, and political instability

Culture is defined as the shared values, beliefs, attitudes, norms, and practices among the general public within a society (Hira 2016). Corruption may be, in part, a cultural phenomenon (Barr and Serra 2010, Lee and Guven 2013). For an experiment on corruption, Berninghaus *et al*. (2013) find that beliefs consider as a good predictor for corruption. Research has shown that when corruption is universal, people tend to learn negative values and accept corrupt practices, and that administrative corruption will have no strong religious or national restrictions among people (Darsareh and Bastanipour 2016). Studies have shown that people justify breaking some rules, such as pretending to be sick at work when they are healthy or using another sick person's prescriptions to get free medicine (Villoria *et al.* 2013). In addition, international aid programs may create corruption because the administrators focus more on formal issues rather than on the culture of the local society that the program intends to assist (Hira 2016). The cultural norm of particularism has a positive effect of demanding a bribe, even asking for a bribe violates the commonly social norm (Rotondi Stanca 2015). Therefore, the following hypothesis is proposed:

- *H1: Corrupt culture positively impacts administrative corruption*

Over time, a positive unidirectional causality runs from political instability to corruption (Abu and Karim 2015). Political instability leads to governments becoming shortsighted, and hence foregoing a long-term view. This, in turn, leads to the undervaluing of infrastructure development and anti-corruption programs (Bohn 2006). Corruption adversely affects the foreign direct investment in countries with a high level of political uncertainty (Touny 2016). Political instability is associated with the inadequacy of legislative bodies in inspecting administrative corruption, as well as with the immobilization of political determination to fight corruption. Disputes between parties and groups

constantly weaken policies against corruption (Yahya and Gomaa 2016). Political instability has an association with corruption as a result of judicial inefficiency (Ismail and Rashid 2014). Hence, the following hypothesis is proposed:

- *H2: Political instability positively impacts administrative corruption*

2.2. Administrative corruption, organizational culture, and institutional weakness

Organizational culture can be defined as the shared values and beliefs of an organization's employees. The leaders and key decision-makers are responsible for framing the culture, and they recruit or attract employees with similar values. Consequently, the key people are accountable for the bad conduct of lower-level management employees (Liu 2016, Pelletier and Bligh 2008). Corruption is the deficiency of shared standards among public employees, regarding to the anti-corruption practices (Darsareh and Bastanipour 2016, Voliotis 2017). If the leaders do not set recognized customs and norms against corruption, these misdemeanors could be prevalent among all departments. Research has shown that taxation departments experience comparatively higher corruption than do educational entities because of the differences in the moral costs of corruption (Ahmadi *et al.* 2010, Schneider and Bose 2017, Soehari and Budiningsih 2017). Firms with a significantly corrupt culture are more likely to engage in accounting fraud and option backdating (Liu 2016). The connection between government and business contributes to corruption, particularly when there is minimal e-government and citizen participation (Choi 2007). The weak business culture and collusion between politics and business lead to unethical decisions (Vaiman, Sigurjonsson, and Davídsson 2011). When an employee has the experience in corruption, he/she will justify bribery and ask for a bribe (Lee and Guven 2013). Hence, the following hypothesis is proposed:

- *H3. Weak organizational culture positively impacts administrative corruption*

In developing countries, the weaknesses of bureaucratic administrative systems are an important cause of corruption (Darsareh and Bastanipour 2016). Lack of accountability is the main reason for misusing public funds for personal benefit (Kpundeh 1994). Poor salaries and lack of job satisfaction among public employees increase the chances of corruption (Bin-Ismail and Abbas 2015). High-ranking criminals react by bribing officials in public organizations, so as to avoid being sanctioned, especially when the cost of bribery is low (Gamba *et al.* 2018, Kugler *et al.* 2005). Public sector hiring depends mainly on relations, nepotism and bribery rather than on qualifications and fair process (Kpundeh 1994). Law enforcement agencies exhibit tenacious misbehavior because of lack of control mechanisms, including judicial oversight, codes of conduct, and the absence of proper strategies (Aguilera and Vadera 2008, Costa 2011, Lee *et al.* 2013). The willingness to engage in corrupt practices is affected by the perceived practices of peer in the same organization (Dong, Dulleck, and Torgler 2012). Therefore, we hypothesize:

- *H4. Institutional weakness positively impacts administrative corruption*

2.3. Culture and organizational culture

Jamil *et al.* (2015) have shown that organizational culture echoes the broader societal culture. Zhang (2015) has argued that people become more honest and less corrupt when they trust that others, such as public employees, have similar values. Other research has explored how educational institutions, including both schools and universities, that do not include anti-corruption practices in their teaching leave students unprepared about suitable codes of conduct in their future workplaces (Dorozhkin *et al.* 2016). Society is the main source of greed among its population, and people probably become corrupt when they obtain power in public organizations (Ambali 2008). Clients and administrators share some common values when the client sometimes pays bribes and the administrator occasionally receives commissions on providing access to public services (Fazekas 2017). Thus, we hypothesize:

- *H5. Corrupt culture positively impacts weak organizational culture*

2.4. Political instability and institutional weakness

Political uncertainty adversely affects the public sector because job appointments depend on nepotism and political and ethnic bonds (Bin-Ismail and Abbas 2015, Kpundeh 1994). Lack of political stability degrades economic development, depreciates currency value, and reduces opportunities for foreign investment and tourism inflows (Bouraoui and Hammami 2017, Okafor 2017, Touny 2016). Governments are unable to spend sufficient money to develop public organizations and services. At the same time, institutional leaders are more concerned with expanding their political power and capitalizing on their personal advantages than with building suitable organizational structures and enhancing satisfaction levels among their subordinates and clients (Ambali 2008).

The transition period from an autocratic regime to democratic government is related to feeble governance and an increase in profiteering from public funds (Haider *et al.* 2011). Hence, the following hypothesis is proposed:

- *H6. Political instability positively impacts institutional weakness*

2.5. Organizational culture and institutional weakness

Lack of satisfaction among public employees pushes them to become corrupt (Bin-Ismail and Abbas 2015). An increase in public dissatisfaction is an indicator of an increase in the degree of corruption (Villoria *et al.* 2013). Flatters and Macleod (1995) stated that acceptance of corruption to some extent could be part of an efficient tax collection system if wages are low and individual tax payers' liabilities cannot easily be established. Inspectors may be paid commission on high income reports (Hindriks *et al.* 1999). Corruption is caused by greediness of public employees and their hunger for wealth, in addition to societal tolerance and institutional weakness (Ambali 2008). Thus, we hypothesize:

- *H7. Weak organizational culture positively impacts institutional weakness*

2.6. The mediating role of organizational culture and institutional weakness

Darsareh and Bastanipour (2016) stated that the expansion of administrative corruption is caused by weak organizational culture and the undermining of national identity among public employees. The negative values are often brought by people when they join public organizations. This will intensify when a job appointment in the public sector is based on nepotism or the membership of a social group or association rather than on competence (Kpundeh 1994). Lack of concern and ignorance about corruption can encourage public employees to exploit public resources for their personal gain. The wider culture of society shapes the culture of administrators; subsequently, weak organizational culture impacts corruption (Ambali 2008). Hence, the following hypothesis is proposed:

- *H8. Weak organizational culture mediates the effect of corrupt culture on administrative corruption*

Researchers have noticed that administrative corruption in autocratic regimes is much lower because of stronger governance. The government becomes weaker during the transition period from an autocratic regime to democratic rule. Public organizations lose their control, which results in the profiteering of public funds (Haider *et al.* 2011). Moreover, key public officials enter into secret agreements with the private sector to exploit public funds (Chan and Owusu 2017). Corruption has had a severe impact on all public institutions due to the defects of local and federal governments; the absence of political stability and security experienced by countries with high level of corruption contributes to this corruption (Mohammed *et al.* 2015). Hence, the following hypothesis is proposed:

- *H9. Institutional weakness mediates the effect of political instability on administrative corruption*

Weak organizational culture helps public employees achieve economic power. The bureaucratic structure is transformed into a device for personal gain which gives unnecessary power to key public employees (Kpundeh 1994). When leaders disregard establishing an anti-corruption culture in their organizations, the ravenous low-level managers enjoy utilizing their positions and power for personal advantage. Institutional weakness can be considered as lack of transparency and accountability, in addition to the absence of civil service work ethics (Ambali 2008). In developing countries, policy-makers spend a significant amount of time on planning rather than implementation. Unsuccessful attempts to improve public management are caused by the ignorance of organizational culture (Rahman *et al.* 2013). Therefore, it can be hypothesized that:

- *H10. Institutional weakness mediates the effect of weak organizational culture on administrative corruption*
- *H11. Weak organizational culture and institutional weakness mediate the effect of corrupt culture on administrative corruption.*

3. Methodology

3.1. Measurement variables

To test the proposed model (Figure 1) using the PLS-SEM approach, we established measurable indicator variables for all constructs that are based on previous research. All observed items were considered as reflective indicators. Each construct had four variables. All items were measured using a seven-point Likert scale and semantic differential scale types, as shown in Table 1.

Table 1. Measurement properties of constructs

Codes	Items	Scale
Corrupt culture (Ambali 2008, Darsareh and Bastanipour 2016, Dincer and Johnstony 2017, Villoria *et al.* 2013)		
C1	People's reactions to corruption are weak.	from 1: strongly disagree to 7: strongly agree
C2	Many people break laws; for instance, traffic and municipal laws.	from 1: strongly disagree to 7: strongly agree
C3	Religious deterrence is no longer an effective factor in preventing state officials from practicing administrative corruption.	from 1: strongly disagree to 7: strongly agree
C4	Corrupt people are characterized by greed.	from 1: strongly disagree to 7: strongly agree
Weak organizational culture (Ahmadi *et al.* 2010, Darsareh and Bastanipour 2016, Liu 2016, Schneider and Bose 2017, Soehari and Budiningsih 2017)		
A1	The culture of public organizations has become corrupt.	from 1: very clean to 7: very corrupt
A2	The failure of public employees to comply with a code of conduct is a cause of administrative corruption.	from 1: strongly disagree to 7: strongly agree
A3	The feeling of dissatisfaction among public employees makes them accept administrative corruption.	from 1: strongly disagree to 7: strongly agree
A4	How satisfied are you with the services of public organizations?	from 1: very satisfied to 7: not at all satisfied
Political instability (Bin-Ismail and Abbas 2015, Bohn 2006, Haider *et al.* 2011, Tebaldi and Mohan 2010, Yahya and Gomaa 2016)		
P1	Parliament is weak at investigating the problems of administrative corruption.	from 1: very strong to 7: very weak
P2	There is no real political will to fight administrative corruption.	from 1: strongly disagree to 7: strongly agree
P3	Conflict between parties and sectarian groups has weakened the campaign against administrative corruption.	from 1: strongly disagree to 7: strongly agree
P4	The performance of the local and federal governments is acceptable.	from 1: very acceptable to 7: not at all acceptable
Institutional weakness (Bin-Ismail and Abbas 2015, Costa 2011, Darsareh and Bastanipour 2016, Kpundeh 1994, Lee *et al.* 2013)		
W1	The administrative work of public organizations is characterized by bureaucracy and complexity of procedures.	from 1: very flexible to 7: very bureaucratic
W2	Appointments in public organizations depend more on nepotism than on qualifications.	from 1: strongly disagree to 7: strongly agree
W3	There is no accountability of employees for misuse of state funds.	from 1: strongly disagree to 7: strongly agree
W4	The use of computers and the Internet in the administrative work of state departments reduces administrative corruption.	from 1: strongly disagree to 7: strongly agree
Administrative corruption (Chan and Owusu 2017, Choi 2007, Hindriks *et al.*1999, Tebaldi and Mohan 2010, Vaiman *et al.* 2011, Yahya and Gomaa 2016, Zhang 2015)		
CO1	Bribery has become one of the manifestations of everyday work in public organizations.	from 1: strongly disagree to 7: strongly agree
CO2	Embezzlement is a widespread phenomenon among public employees.	from 1: strongly disagree to 7: strongly agree
CO3	There is collusion between the government departments and the construction companies executing government projects.	from 1: strongly disagree to 7: strongly agree
CO4	There is a widespread phenomenon of nepotism in the administrative work of public organizations.	from 1: strongly disagree to 7: strongly agree

3.2. Sampling and data collection

The sampling frame used for data collection comprised students and employees from the University of Basra, Iraq, and Basra citizens who were digitally savvy. The sampling technique and procedure used to select the participants for the study was purposive sampling, which is also known as judgmental sampling (Saunders *et al.* 2016). The rationale for using purposive sampling stemmed from the characteristics of the population and the objective of the study (Saunders *et al.* 2016). We decided that, based on the objectives of the research, a sampling frame comprising the students and employees of University of Basra, Iraq, as well as interested digitally savvy citizens in Basra was the most suitable and appropriate.

The measured items under consideration were translated into Arabic and inserted into Google Forms as an electronic survey. We invited 20 friends and relatives, using the purposive sampling procedure to fill in the form. The items themselves and the results were discussed with five academics from the College of Administration and Economics, University of Basra, for pre-testing purposes (Saunders *et al.* 2016). Accordingly, we made slight changes to the first version to ensure reliability and validity (Sekaran and Bougie 2013). The questionnaire (see Table 2) thus became much more understandable for all educational levels.

We communicated first with students, employees and academics from the University of Basra. We then used social media to reach digitally friendly and savvy members of the general public in Basra, Iraq. The main goal is to analyze administrative corruption and its causes from the perspective of the general public. We aimed to reach 1,000 people from different social classes; however, we collected responses from only 715 participants. Of these, 38 were deleted because the respondents had not taken the survey seriously (*e.g.*, they selected 1 in the seven-point scale for all questions). The final sample thus comprised 677 responses. The process of collecting the data took three months, from the beginning of August to the end of October 2017. Appendix A contains the data set of 677 responses. The supplementary data to this article can be found online at Al-Jundi (2018).

The sampling frame was quite diverse. Participants who held secondary school certificates represented 27% of the total sample size, 14% had a diploma, 33% had achieved a bachelor's degree, 9% a master's and 13% a PhD. Only 3% had elementary school certificates or less. As for monthly household income, 16% earned less than $400, 16% $400–600, 17% $601–800, 16% $801–1000, 10% $1001–1200, 8% $1201–1400 and 17% earned more than $1400.

3.3. Partial least squares - structural equation modeling (PLS-SEM)

Structural equation modeling (SEM) has been applied in this research. SEM is a second-generation comprehensive multivariate data analysis approach. It consists of a set of statistical models that explain the relationships among multiple variables (Hair *et al.* 2016). SEM has several advantages over first-generation approaches that cannot measure multiple relationships simultaneously (Hair *et al.* 2016). Among these advantages are:

- SEM can integrate unobservable constructs measured indirectly by indicator problem (Hair *et al*. 2016);
- SEM enables complex construct relationships to be graphically modeled and statistically examined, and it provides a holistic view of the entire model (Gefen and Straub 2005);
- SEM is popular in behavioral science research (Hair *et al.* 2016) and in technology and systems research (Gefen and Straub 2005).

SEM is most commonly identified with partial least squares (PLS) (Fornell and Bookstein 1982, Gefen and Straub 2005, Hair *et al.* 2016), which is preferable for the following reasons:

- Causality investigation when no theory-based evidence is necessary;
- Appropriateness for exploratory theory rather than for confirmatory theory testing (Urbach and Ahlemann 2010);
- Suitability for estimating and testing small samples (Chin 1998);
- Applicability to complex models with a large number of variables (Urbach and Ahlemann 2010).

PLS is a set of processes that "provides successive approximations for the estimates, subset by subset, of loadings and structural parameters" (Fornell and Bookstein 1982, 441). PLS analysis is usually conducted in two stages: the measurement (outer) model testing; the structural (inner) model testing (Hair *et al.* 2016). The next sections discuss the two phases in detail.

4. Data analysis and results

4.1. Partial least squares (PLS) measurement (outer) model results

First, the item loadings were assessed in order to view the correlations between the variable and its measuring items. Following Hair *et al.* (2016), items loading above 0.6 were retained, whereas item loadings between 0.4 and 0.6 were directly examined against construct validity and reliability. Low items loadings (below 0.4) were eliminated from the analysis. As a result, nearly all items were found above the acceptable level of 0.6, thus demonstrating reliable items (as shown in Table 2).

Table 2. Items' loadings and cross-loadings

Codes	Weak Organizational Culture	Corrupt Culture	Administrative Corruption	Political Instability	Institutional Weakness
A1	**0.658**	0.29	0.359	0.404	0.321
A2	**0.792**	0.52	0.458	0.551	0.462
A3	**0.623**	0.242	0.296	0.294	0.304
A4	**0.564**	0.176	0.255	0.359	0.308
C1	0.272	**0.706**	0.27	0.358	0.317
C2	0.403	**0.811**	0.344	0.421	0.358
C3	0.388	**0.819**	0.423	0.49	0.432
C4	0.475	**0.807**	0.45	0.595	0.5
CO1	0.474	0.395	**0.829**	0.417	0.533
CO2	0.494	0.327	**0.827**	0.409	0.513
CO3	0.418	0.444	**0.84**	0.486	0.609
CO4	0.348	0.417	**0.773**	0.43	0.492
P1	0.425	0.365	0.278	**0.627**	0.312
P2	0.481	0.522	0.433	**0.795**	0.569
P3	0.433	0.541	0.476	**0.812**	0.536
P4	0.466	0.238	0.283	**0.582**	0.39
W1	0.425	0.303	0.348	0.512	**0.654**
W2	0.425	0.496	0.586	0.559	**0.831**
W3	0.414	0.408	0.573	0.489	**0.808**
W4	0.259	0.248	0.334	0.282	**0.543**

To examine the discriminant validity across the items, the items' cross-loadings among constructs were examined. Specifically, the cross-loading should be less than the item loading on its associated construct (Hair *et al.* 2016). In this research, the discriminant validity of nearly all items was demonstrated, since cross-loadings among all constructs were greater than the determined cut-off point (as shown in Table 3).

Another measurement involved in the measurement model testing is construct validity. Construct validity assesses whether the chosen measures actually measure what they are supposed to measure (Gefen and Straub 2005). Convergent validity, one type of validity, refers to the extent to which a measure correlates, or converges, with other measures of the same construct (Hair *et al*. 2016). Convergent validity is achieved when the average variance extracted (AVE) value between the constructs is equal to, or exceeds, 0.5 (Hair *et al.* 2016). As presented in Table 3 the AVE scores for all constructs in the model were higher than 0.5, thus demonstrating convergent validity. An alternative approach to evaluate convergent validity is to inspect the constructs' composite reliability (Fornell and Larcker 1981). Table 3 shows that all constructs demonstrated acceptable composite reliability scores by exceeding the 0.7 cut-off point (Hair *et al*. 2016).

Table 3. Validity and reliability estimates of the constructs

	Cronbach's alpha	rho_A	Composite reliability	Average variance extracted (AVE)
Administrative Corruption	0.835	0.839	0.89	0.669
Corrupt Culture	0.798	0.817	0.866	0.619
Institutional Weakness	0.781	0.723	0.806	0.516
Weak Organizational Culture	0.788	0.717	0.859	0.669
Political Instability	0.774	0.787	0.803	0.508

To examine constructs' reliability, Cronbach's alpha measures were assessed. Constructs' reliability is achieved when alpha scores are greater than 0.7 (Hair *et al.* 2016). Those with scores of lower value should not be further assessed. As presented in Table 4, all scores exhibited acceptably high reliability (after conducting the second-round testing), with alpha scores exceeding the 0.7 threshold. Thus, all constructs demonstrated reliability.

Discriminant validity examines the extent to which a variable is truly different from other variables in predicting the dependent variable (Hair *et al.* 2016). One popular approach is to examine the correlation matrix among constructs. Specifically, the square root of the AVE score of each construct should be higher than the correlations with this construct (Hair *et al.* 2016). The results in Table 4 indicate that all constructs in the research

model achieved discriminant validity, as none of the off-diagonal elements exceeded the correlation coefficients underneath that were calculated through the square root of the AVE scores.

Table 4. Discriminant validity (correlation matrix among construct scores)

	Administrative Corruption	Corrupt Culture	Institutional Weakness	Weak Organizational Culture	Political Instability
Administrative Corruption	**0.818**				
Corrupt Culture	0.485	**0.787**			
Institutional Weakness	0.659	0.522	**0.719**		
Weak Organizational Culture	0.531	0.501	0.537	**0.665**	
Political Instability	0.534	0.507	0.555	0.524	**0.711**

4.2. Partial least squares (PLS) structural (inner) model results

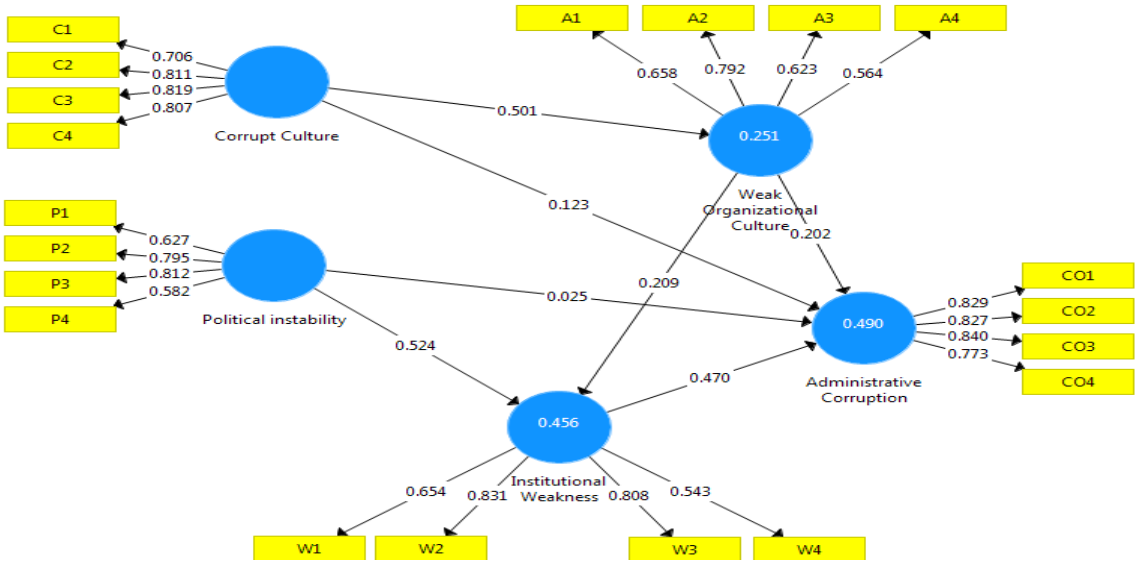
An assessment of the structural model included determining the significance of the paths, the predictive power of the model, and bootstrapping random samples from the original data set (Hair *et al*. 2016). This is achieved by examining the standard error, T-statistics, and significant level (Chin 1998). Table 5 highlights the hypotheses of the study, and shows the path coefficients, T-statistic values, and the results of the hypotheses (*i.e*. either supported or not). The bootstrap T-statistics determine the stability of the estimates; they are considered acceptable with a value above 1.96 at 95% confidence interval (Chin 1998). As a result, ten hypotheses were supported, whereas only one hypothesis was not supported (H2). The results of each path are interpreted in the next section.

Table 5. Influence paths and hypotheses results

Hypotheses	Original sample (O)	T-statistics (|O/STDEV|)	P values	Hypothesis result
H1	0.123	2.624	0.009	Supported
H2	0.025	0.46	0.646	Not supported
H3	0.300	6.076	0	Supported
H4	0.470	7.502	0	Supported
H5	0.501	14.515	0	Supported
H6	0.524	11.376	0	Supported
H7	0.209	4.683	0	Supported
H8	0.101	3.871	0	Supported
H9	0.105	4.255	0	Supported
H10	0.210	6.856	0	Supported
H11	0.049	3.448	0.001	Supported

The model fit is assessed by examining the amount of variance explained by R squared (Hair *et al*. 2016) as well as the predictive ability of the dependent variables (Chin 1998). Hair *et al.* (2016) indicate that the minimum level for a construct's R squared should be greater than 0.10. For instance, the R squared value of Administrative Corruption was found moderate and equal to 49%. In addition, the R squared value of Institutional Weakness and Weak Organizational Culture were also found moderate and equal, at 45.6% and 25.1% respectively (as shown in Figure 2).

Figure 2. Research model (tested and validated)



Therefore, it was appropriate to examine the significance of the paths associated with these variables. Figure 2 shows the tested and validated conceptual model. All path coefficients, item loadings and R squared are also presented on the model, as calculated by SmartPLS3.2.7 software.

5. Discussion

5.1. Theoretical contributions

In discussing and analyzing the current paper, it must be emphasized that it primarily contributes to the existing literature by simultaneously testing the effects of corrupt culture, weak organizational culture, political instability, and institutional weakness on administrative corruption in governmental establishments. Additionally, it provides empirical evidence to support the multivariate influences of these four constructs on corruption, and the interplay between them. We tested a sample of 677 responses that reflects the perspective of the public in Basra. PLS-SEM was employed to examine the overall structure of the research model. Iraq has an extremely high rate of corruption (Transparency International 2018), and the researchers, who live in Iraq, benefit from the respondents' experience and observations.

Arguably, as depicted in Figure 2, corrupt culture in the whole society positively impacts administrative corruption (H1). The finding here is consistently found and established by Barr and Serra (2010), Darsareh and Bastanipour (2016), and Dincer and Johnstony (2017). Weak organizational culture in the public sector leads to the pervasiveness of administrative corruption, (H3) as explained by Liu (2016) and Ahmadi *et al.* (2010). In addition, it is established that institutional weakness also influences corruption (H4), as supported by Kpundeh (1994) and Darsareh and Bastanipour (2016). In this study, the direct relationship between political instability and corruption is not supported (H2); nevertheless, Abu and Karim (2015) maintained that there is a positive unidirectional causality that is embedded and runs from political instability to corruption. Ismail and Rashid (2014) found that political instability is associated with corruption. A high rate of corruption has been established and found in more than two-thirds of all countries (Transparency International 2018), in some of which it is well entrenched and has the backing of the governance structure and system, thereby giving it some credence of political stability. We still have a doubt about the result due to the inherent issues exposed. People who are partisan or affiliated to a specific political view tend to display more biased responses on factual questions than do those who must answer as sharp individuals (Robbett and Matthews 2018). Political instability is still an important factor since it affects corruption via institutional weakness (H9) and it weakens governmental organizations and structures (H6).

In addition, the findings show that corrupt culture positively impacts weak organizational culture (H5) (Jamil *et al.* 2015, Zhang 2015). People learn negative values from their society and become corrupt when they acquire power in public organizations (Ambali 2008). Political instability influences institutional weakness (H6). Political uncertainty and instability adversely affect the public sector because job appointments depend on nepotism, and on political and ethnic bonds (Bin-Ismail and Abbas 2015, Kpundeh 1994). Weak organizational culture boosts institutional weakness (H7). The result here is quite consistent and echoes the findings of Ambali (2008) and Bin-Ismail and Abbas (2015).

To the best of our knowledge, we have established that previous research has not examined the mediating role of weak organizational culture and institutional weakness on the relationship between other constructs and corruption. The results of the current study demonstrate that weak organizational culture mediates and facilitates the effect of corrupt culture on administrative corruption (H8). This result is to some extent consistent with the study by Ambali (2008). Institutional weakness mediates the effect of political instability on corruption (H9). The government becomes weaker during the transition period from an autocratic regime to democratic one rule. Public organizations lose their control, resulting in profiteering from public funds (Haider *et al.* 2011). Institutional weakness mediates the effect of weak organizational culture on corruption (H10). Institutional weakness can be considered as lack of transparency and accountability, as well as the absence of civil service work ethics (Ambali 2008).

The most important finding in the current paper is that weak organizational culture and institutional weakness facilitate and mediate the effect of corrupt culture on administrative corruption (H11). Thus, we can conclude that societal corrupt culture is the crucial and key reason for administrative corruption, since corrupt culture has direct and indirect effects (via weak organizational culture and institutional weakness) on administrative corruption. Corrupt culture, simply and clearly, destroys the culture of governmental organizations, and the latter participate to weaken the structure and policies of the public entities. Institutional weakness allows pervasiveness of administrative corruption in the public sector. While Barr and Serra (2010) argued that corruption may partially be a cultural phenomenon, the current paper proves that corrupt culture is the focal reason for the pervasiveness and prevalence of administrative corruption worldwide. We have to pay a close attention to culture, political environment, and the interaction between politics and business, prior to making any effort to combat corruption (Vaiman *et al.* 2011).

5.2. Managerial implications

The current paper will serve as a useful guide for stakeholders in public governance. Politicians, key decision-makers in the public sector, mass media, and educational institutions will find it informative, and hence beneficial. Since the paper proves that administrative corruption is caused by corrupt culture via weak organizational culture and institutional weakness, and political instability affects corruption via institutional weakness, we can check the measured items of these constructs in order to establish practical implications.

First, anti-corruption endeavors must focus on societal culture. Educational institutes should enrich their programs with anti-corruption values and practices, business ethics and social responsibility. *Second*, key managers in public organizations should be leaders and share anti-corruption practices with their subordinates. *Third*, mass media should participate in anti-corruption endeavors and encourage people not to pay bribes to public employees. *Fourth*, public organizations should set strategic plans and establish visions, missions and values for improving public services and increasing the level of satisfaction among their clients and employees. We can avoid the negative effect of corruption on the whole economy by increasing public officials' wages, thereby reducing their corruptibility (An and Kweon 2017, Van Veldhuizen 2013). *Fifth*, if politicians respect the constitution and solve their conflicts according to the law, the government will be strengthened to fight corruption, accelerate economic development, and attract FDI inflows. The government and parliament should establish standards and codes of conduct for public employees and independent judicial systems. Authorities should encourage self-reporting, which raises distrust between parties attempting to exchange bribes, and this may reduce bribery even where the governmental organizations are ineffective in combating corruption (Abbink and Wu 2017, Ryvkin *et al.* 2017). *Sixth*, the government should allocate resources for the transition from excessive bureaucracy to e-government, and it should widen the use of information technology to improve transparency and citizens' participation (Koekpoe 2011, Marquez 2015, Mohammed *et al.* 2015, Sharifi-Renani *et al.* 2013).

5.3. Limitations and recommendations for further research

The main limitation of this study is related to the small sample size. We collected only 677 responses reflecting the perspective of university students, employees, and the wider public, all of whom were from Basra, Iraq. It is recommended, therefore, that the sample size be increased and that the sampling technique and procedure be reviewed so that the dynamics of the population in general are fully represented. In addition, we reached participants mainly through social media, so we did not get the opportunity to explain the questionnaire; we cannot be sure, therefore, that participants filled in the form with an acceptable level of understanding and seriousness, and without any form of bias (Saunders *et al.* 2016). Olken (2009) found that the public report real information about corruption, while public officials hide corruption so that it is difficult for people to detect. However, political partisans tend to be biased when answering political questions (Robbett and Matthews 2018). The study is also limited in scope because the findings are related to only one country's experiences in a period when there is a high level of

administrative corruption and political instability globally. Perhaps the proposed model could be tested in a developed country with a low level of corruption or even in another country with a similar corruption ranking to that of Iraq, such as Angola or Chad (Transparency International 2018).

Future research should focus on expanding the model by adding constructs such as judicial systems and information technology. The current model should be applied in other cities in Iraq and other countries with different levels of corruption. Because corruption is a complicated phenomenon, a comprehensive model can allow a multivariate analysis that will enable a thorough understanding of the interplay among different constructs. Corruption is pervasive in major sectors of the economy. Thus, it can be analyzed in sectors such as taxation, policing, education, and banking. We strongly recommend that researchers examine the perspective of public employees and compare the results with the perspective of the general public. The study introduced and tested the mediating role of weak organizational culture and institutional weakness. We suggest examining the moderating roles of gender, wealth, and educational level. Finally, the paper used cross-sectional data; however, time series data should be adopted and implemented to build a new corruption model in future research.

Conclusions and recommendations

The PLS-SEM technique was employed to examine the overall structure of a proposed model of administrative corruption in the public sector. A sample of 677 responses, which reflect the perspective of the public in Basra, Iraq, was collected to test the model. We found that:

- corrupt culture positively impacts administrative corruption;
- political instability has no direct effect on corruption;
- weak organizational culture positively influences corruption;
- institutional weakness positively affects corruption;
- corrupt culture impacts weak organizational culture;
- political instability has a direct effect on institutional weakness;
- weak organizational culture has a direct effect on institutional weakness;
- weak organizational culture mediates the effect of corrupt culture on corruption;
- institutional weakness mediates the effect of political instability on corruption;
- institutional weakness mediates the effect of weak organizational culture on corruption;
- weak organizational culture and institutional weakness mediate the effect of corrupt culture on administrative corruption.

Thus, we can conclude that societal corrupt culture is the crucial reason for administrative corruption, since corrupt culture has direct and indirect effects (via weak organizational culture and institutional weakness) on administrative corruption.

In view of the research findings, we strongly recommend the following:

- corporate and governmental organizations must implement structures and cultures that enhance effective institutional practices and procedures to eliminate corrupt practices;
- ethical values and practices must be promoted in all corporate and governmental organizations to instill discipline and self-restraint in employees who may be tempted to involve themselves in corruptible activities;
- anti-corruption policies and charters must be developed, adopted and signed by all employees in corporate and governmental organizations to portray their willingness to be incorruptible in all their activities;
- lawmakers must endeavor to promulgate legislative instruments that will promote acceptable ethical practices and eliminate corruptible practices in both corporate and governmental institutions;
- the mass media must endeavor to use some of their air time to continuously promote good governance, non-biased and fair decisions, the rule of law, and transparent procedures and structures to combat corruption;
- incentives should be offered to whistle-blowers who reveal and report all corrupt practices in their organizations.

Corruption is a global scourge. It has been a social canker and a menace, and it continues unabated despite efforts to combat it. The effects of corruption are numerous, but with a combined effort and will power on the part of all stakeholders, it is our fervent belief that we can make headway in combating this social menace. Declarations of conflicts of interest: none

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The Effect of Railway Transportation on the Aggregate Economic System, Including Separate Sectors in Thailand

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Abstract:

This paper aims to analyze the effect of railway transportation on the aggregate economic system. A Computable General Equilibrium (CGE) model is employed to investigate the economic impacts, comprising: household consumption, gross domestic output, primary factors, government consumption, investment demand, imports, exports, domestic goods, composite goods, value-added, and social welfare. The findings conclude that railway transportation impacts on the manufacturing sector but not necessarily on agriculture, service, and light industry. Since the railway in Thailand is currently used by a limited number of industries, if adopted by a larger number of sectors in the future, it is likely to create a positive impact on all sectors in Thailand.

Keywords: railway; transportation; economic system computable general equilibrium; Thailand

JEL classification: D00; E20; O12; R42

1. Introduction

Transportation in Thailand is one of the most important infrastructure components, and it is necessary to undertake a review of the system in order to thoroughly understand the situation. The World Economic Forum Annual Report 2013–2014 shows the world rankings for transportation quality. Thailand was ranked 61st for overall transportation quality, while Singapore and Malaysia were ranked 5th and 25th, respectively. The quality of transportation in Thailand such as road, rail, water, and air was also ranked lower than Singapore and Malaysia. Roads in Thailand were ranked 42nd while Singapore was ranked 7th and Malaysia 23rd. Rail transportation in Thailand was ranked 72nd with Singapore and Malaysia 7th and 23rd, respectively Marine transportation in Thailand was ranked 56th, and air transportation 34th. In 2012, Thailand's transportation sector reported the deaths of approximately 8,675 people. In 2013 Thailand was ranked 3rd highest in the world for road accidents, less than Niue and the Dominican Republic (Office of Transport and Traffic Policy and Planning Ministry of Transport 2013). Thailand must upgrade the quality of its transportation and reduce costs. Rail transportation development is the most important mode for upgrade because of the low cost involved. Railway system development will help to reduce logistic costs. It can also effectively handle a large volume of transport with lower energy consumption, punctuality, speed, and safety.

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2. Literature review

Previous literature has emphasized the important and effect of transportation on economic system. Jensen *et al.* (1999) found that the transportation infrastructure would create connectivity and economics activity between an urban area and suburban area; the evident of remote sensing of urban/suburban infrastructure show it make the market demand, attracting investment in the industrial sector, better live condition, *etc*.

Moreover, Banerjee *et al*. (2012) showed that the transportation infrastructure is very important in middle-income countries, contributing to rapid economic growth. However, in developed countries, the transportation network contributes to a normal growth rate (slower than that of middle- income countries). The results suggest moderate rates of return at best (slow but long- lived), with little short-run impact but leading to higher growth and output in the long run.

Alternatively, Aschauer (1988) studied the relationship between transportation infrastructure development and economic development in the United States of America during the 1970s explained the drop in productivity caused by decreasing transportation infrastructure investment and concluded that transportation infrastructure was important to economic activity.

In addition, Jaensirisa *et al.* (2010) studied the development of national freight transport model for Thailand. They explain that proper development and management of transportation such as road, rail, and water reduces costs. It also increases effective competition of industrial sector in Thailand. The instrument in a plan to develop transportation is freight model. This paper present ideas for developing a freight model in nationally in a case of Thailand through planning and analyzing future freight policy. The feature of the model includes:

- explaining freight transport in macroeconomic and explain behavior in route selection for freight transportation in the country
- forecasting trend of freight volume and show the volume of product flow in a type of freight transportation in country network.

From the literature review, there is evidence to support the objectives in this research in that railway development is significant to the economic system both regionally and nationally since the rail network is an essential transportation infrastructure, inasmuch as it creates connectivity between regions. The logistic costs are small and a great deal of freight can be transported, helping to reduce costs for firms. From the above, it can be concluded that the railway infrastructure is essential to Thailand's economy. Consequently, the researcher wishes to study the railway network in Thailand and its effect on the country's economy.

3. Methodology

This paper analyzes the effect of investment in railway transportation on the aggregate economic system, including separate sectors by creating a Social Accounting Matrix (SAM). The baseline SAM and input-output table data from the Office of the National Economic and Social Development Board (NESDB) are used to simulate the linkage effect on the Thai economy by applying a CGE model for data analysis. The CGE model is used to analyze the impact on Thailand's economy such as connectivity, logistic costs, accessibility, *etc*.

This paper uses the CGE model to determine the impact of the railway network on Thailand's economy.

Household behavior

Households are assumed to maximize utility subject to income constraints. Household income depends on the endowment of capital and labor. Household utility consists of consumption from each sector. Applying the Cobb-Douglas utility function, the optimization problem can be summarized as follows:

$$maximize_{X_i^p} U = \theta_i X_i^{p^\alpha} \tag{1}$$

Subject to:

$$\sum_i p_i^d X_i^p = \sum_h r_h FA_h. \tag{2}$$

where: i is the commodity; h are primary factors (capital and labor); U is utility; X_i^p is commodity consumption; FA_h is endowment of primary factors; p_i^d is consumer price of the commodity; r_h is factor price; α is share parameter in the utility function $(0 \leq \alpha \leq 1)$.

Applying the Lagrange method to solve the optimization problem.

$$L(X_i^p, \lambda) = \theta_i X_i^{p^\alpha} + \lambda(\sum_h r_h FA_h - \sum_i p_i^d X_i^p) \tag{3}$$

The following first order conditions are held at optimum:

$$\frac{\partial L}{\partial X_i^p} = \frac{\alpha}{X_i^p}\theta_i X_i^{p^\alpha} - \lambda p_i^d = 0, \quad (4)$$

$$\frac{\partial L}{\partial \lambda} = \sum_h r_h FA_h - \sum_i p_i^d X_i^p = 0. \quad (5)$$

From the two equations, the following demand function is obtained

$$X_i^p = \frac{\alpha}{p_i^d}\sum_h r_h FA_h, \quad (6)$$

Firms behavior

The firm is assumed maximize profits by subject to its production technology. It can summarize the optimization problem:

$$maximize_{Z_j, F_{hj}} \pi_j = p_j^s Z_j - \sum_h r_h F_{hj}, \quad (7)$$

Subject to:

$$Z_j = b_j \theta_h F_{hj}^\beta. \quad (8)$$

where: π_j is profit of the firm; Z_j is output of the firm; F_{hj} are input factors of the firm (labor and capital); p_j^s is supply price of the commodity; β is share parameter in the production function $(0 \leq \beta \leq 1)$; b_j is scaling parameter in the production function.

We use Lagrangian and Lagrange multiplier (Λ) to solve the profit maximization problem. As follows:

$$L_j(Z_j, F_{hj}, \eta_j) = \left(p_j^s Z_j - \sum_h r_h F_{hj}\right) + \Lambda(b_j \theta_h F_{hj}^\beta - Z_j) \quad (9)$$

The following first order conditions are held at optimum:

$$\frac{\partial L_j}{\partial Z_j} = p_j^s - \Lambda = 0 \quad (10)$$

$$\frac{\partial L_j}{\partial F_{hj}} = r_h + \Lambda\beta b_j F_{hj}^{\beta-1} = 0 \quad (11)$$

$$\frac{\partial L_j}{\Lambda} = b_j \theta_h F_{hj}^\beta - Z_j \quad (12)$$

From the three equations the factor demand function is obtained:

$$F_{hj} = \frac{\beta}{r_h} p_j^s Z_j \quad (13)$$

3.3. Market equilibrium

$$X_i^p = Z_i \quad (14)$$

$$\sum_j F_{hj} = FA_h \quad (15)$$

$$p_i^s = p_i^d \text{(assume=1)} \quad (16)$$

From equations 1 and 16 the optimum of utility maximization (or social welfare) can be determined, subject to production technology and market equilibrium.

$$maximize_{X_i^p, Z_j, F_{hj}} U = \theta_i X_i^{p^\alpha} \quad (17)$$

Subject to:

$$Z_j = b_j \theta_h F_{hj}^\beta, \qquad X_i^p = Z_i, \qquad \sum_j F_{hj} = FA_h.$$

Government

Government consumption is assumed to depend on tax revenue and public savings:

$$T_j = \tau_j Z_j \quad (18)$$

$$X_i^g = \frac{\mu}{p_i^q}(\sum_j T_j - S^g) \quad (19)$$

where: X_i^g is public consumption, T_j is tax revenue, τ_j is tax rate on production, S^g is public savings *and* μ is share of expenditure $(0 \leq \mu \leq 1)$.

Investment

Investment demand is assumed to depend on savings with the constraints of the share parameter and exchange equal to 1:1.

$$X_i^v = \frac{\eta}{p_i^q}(S + S^g + \varepsilon S^f) \quad (20)$$

where: S is private savings, S^f is foreign savings, X_i^v is investment demand, ε is exchange rate *and* η is share of expenditure $(0 \leq \eta \leq 1)$

International trade

Export and import prices are assumed to be 1. The balance of payments show:

$$\sum_i E_i + S^f = \sum_i M_i \quad (21)$$

where: E_i is amount of exports, M_i is amount of imports.

Open economy

The model is an open economy. Substitutability between the number of imports, exports, and supply of domestic goods is considered using Armington's assumption. The technology is expressed with the production function in CES. The profit maximization of composite exports and domestic goods is:

$$maximize_{Q_i,M_i,D_i}\pi_i^q = p_i^q Q_i - M_i - D_i, \quad (22)$$

$$Q_i = \gamma_i(\delta m_i M_i^{\sigma_i} + \delta d_i D_i^{\sigma_i})^{\frac{1}{\sigma_i}} \quad (23)$$

where: π_i^q is profit from composite goods, p_i^q is price of composite goods (assume = 1), Q_i is output of composite goods, D_i is input of domestic goods, γ_i is production parameter of the composite goods production function, $\delta m_i, \delta d_i$ is the share parameter of the composite goods function $(\delta m_i + \delta d_i = 1)$, σ_i is the parameter related to elasticity of substitution $(\sigma_i = (\phi - 1)/\phi)$, ϕ is the elasticity of substitution $(\phi = \frac{\partial(M_i/D_i)}{(M_i/D_i)})$.

Taking the Lagrangian method and following the first order conditions held at optimum:

$$M_i = (\gamma_i^{\sigma_i}\delta m_i)^{\frac{1}{1-\sigma_i}} Q_i \quad (24)$$

$$D_i = (\gamma_i^{\sigma_i}\delta d_i)^{\frac{1}{1-\sigma_i}} Q_i \quad (25)$$

The optimization problem of firm transformation between imports and domestic goods assume that firms have constant elasticity of transformation (CET) in production technology.

$$maximize_{Z_i,E_i,D_i}\pi_i^z = E_i + D_i - \tau_i Z_i - Z_i, \quad (26)$$

Subject to:

$$Z_i = \mathrm{M}_i(\chi e_i E_i^{\varpi_i} + \chi d_i D_i^{\varpi_i})^{\frac{1}{\varpi_i}} \quad (27)$$

where: π_i^z is profit from transformation, M_i is the productive transformation parameter, $\chi e_i, \chi d_i$ is the share parameter of firm transformation $(\chi e_i + \chi d_i = 1)$, ϖ_i is parameter related to elasticity of transformation $(\varpi_i = (\upsilon - 1)/\upsilon)$, υ is elasticity of transformation $(\upsilon = \frac{\partial(E_i/D_i)}{(E_i/D_i)})$

Taking the Lagrangian method and following the first order conditions held at optimum:

$$E_i = (\mathrm{M}_i^{\varpi_i} \chi e_i \tau_i)^{\frac{1}{1-\varpi_i}} Z_i \quad (28)$$

$$D_i = (\mathrm{M}_i^{\varpi_i} \chi d_i \tau_i)^{\frac{1}{1-\varpi_i}} Z_i \quad (29)$$

Intermediate input

All prices are assumed to be 1. *First* stage:

$$maximize_{y_j, F_{hj}} \pi_j^y = Y_j - \sum_i F_{hj}, \qquad Y_j = b_j \theta_h F_{hj}^{\beta} \quad (30)$$

Second stage: $maximize_{Z_j, Y_j} \pi_j = Z_j - Y_j - \sum_i X_{ij}$, subject to:

$$Z_j = \min\left(\frac{X_{sec1}}{\alpha x_{sec1}}, \ldots, \frac{X_{sec16}}{\alpha x_{sec16}}, \frac{Y_j}{\alpha y_j}\right) \quad (31)$$

Optimal conditions of the maximization problem are shown in equations 30 and 31 and:

$$X_{ij} = \alpha x_j Z_{ij}, \quad (32)$$

$$Y_j = \alpha y_j Z_j \quad (33)$$

$$F_{hj} = \beta Y_j \quad (34)$$

Zero-profit conditions can be determined.

where: X_{ij} is intermediate input; αx is the coefficient for the minimum requirement of intermediate input for one unit of gross output; αy is the coefficient for the minimum requirement of value-added for one unit of gross output; Y_j is value-added

Market-clearing conditions

Market-clearing conditions are applied to obtain general equilibrium in all markets:

$$Q_i = X_i^p + X_i^g + X_i^v + \sum_j X_{ij}, \quad (35)$$

$$\sum_j F_{hj} = FA_h. \quad (36)$$

Simulation of railway transportation sectors

The railway transportation sector for the CGE model is determined by the intermediate input variable (X_{ij}):

$$X_{ij} = \begin{vmatrix} X_{sec1,sec1} & X_{sec1,sec2} & \cdots & X_{sec1,Rail} & \cdots & X_{sec1,sec16} \\ X_{sec2,sec1} & X_{sec2,sec2} & \cdots & X_{sec2,Rail} & \cdots & X_{sec2,sec16} \\ \vdots & \vdots & \ddots & \vdots & & \vdots \\ X_{Rail,sec1} & X_{Rail,sec2} & \cdots & X_{Rail,Rail} & \cdots & X_{Rail,sec16} \\ \vdots & \vdots & & & \ddots & \vdots \\ X_{sec16,sec1} & X_{sec16,sec2} & \cdots & X_{sec16,Rail} & \cdots & X_{sec16,sec16} \end{vmatrix} \quad (37)$$

where: Sec1 is Agriculture; Sec2 is Mining and Quarrying; Sec3 is Food Manufacturing; Sec4 is Textiles; Sec5 is Sawmills and Wood Products; Sec6 is Paper and Printing; Sec7 is Rubber, Chemicals, and Petroleum; Sec8 is Non-metallic Products (Cement, Concrete and Cement Products, Ceramics, Glass, *etc.*); Sec9 is Metal, Metal Products, and Machinery; Sec10 is Other Manufacturing (Leather Products, Watches and Clocks, Jewelry and Related Articles. *etc.*); Sec11 is Public Utilities (Electricity and Gas, Water Works, and Supply); Sec14 is Transportation and Communication (not including the railway); Sec15 Services (Restaurants and Hotels, Banking and Insurance, *etc.*); Sec16 is Unclassified; Rail is Railway Transportation.

In the CGE model scenario, the researcher shocks the railway sector ($X_{Rail,Rail}$). This can affect all sectors through household consumption, gross domestic output, primary factors, government consumption, investment demand, imports, exports, domestic goods, composite goods, value-added, and social welfare. Investment in railway transportation increases the railway sector ($X_{Rail,Rail}$) and intermediate input variable (X_{ij}), affecting this model through transmission of market equilibrium conditions.

4. Empirical results

4.1. The effect of investment in railway transportation on the aggregate economic system including individual sectors

Analyses of the impact of investment in railway transportation upon the Thai economic using standard Computable General Equilibrium model (CGE) provide two scenarios.

Scenario 1: Investment in railway transportation make the railway transportation sector doubles the size of the sector compared to the baseline but it very few values compare with other the transportation sector and the other sectors.

Scenario 2: Investment in railway transportation makes the sector half the size of the other transportation sectors.

Scenario 1	Define Shock in variable $X_{Rail,Rail}$ = 2.$X_{Rail,Rail}$
Scenario 2	Define Shock in variable $X_{Rail,Rail}$ = 1/2.$X_{Sec14,Sec14}$

4.2. Parameters and elasticity

The data set used for model calibration was constructed for the base year of 2010. The latest I/O table for 2010 was obtained from the The National economic and Social Development Board (NESDB). The elasticity of substitution and transformation data was taken from Phuwanich (2008).

Table 1. Classification of sectors and goods

Descriptions	Sectors in the Original I-O table
1. Sec1	1. Agriculture
2. Sec2	2. Mining and Quarrying
3. Sec3	3. Food Manufacturing
4. Sec4	4. Textile Industry
5. Sec5	5. Saw Mills and Wood Products
6. Sec6	6. Paper Industries and Printing
7. Sec7	7. Rubber, Chemical and Petroleum Industries
8. Sec8	8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass, *etc.*)
9. Sec9	9. Metal, Metal Products and Machinery
10. Sec10	10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc.*)
11. Sec11	11. Public Utilities (Electricity and Gas, Water Works and Supply)
12. Sec12	12. Construction
13. Sec13	13. Trade (Wholesale Trade, Retail Trade)
14. Sec14	14. Transportation and Communication (not include railway)
15. Sec15	15. Services (Restaurants and Hotels, Banking and Insurance *etc.*)
16.Sec16	16. Unclassified
17. Railway	17. Railway transportation sector

For the scenario, the CGE simulation as shown in Table 2-12. The results of the impact on household consumption in scenario one show minimal or no effect from shock occurring in the railway transportation sector. However, in scenario two, shock in the railway transportation sector has a substantial effect, with household consumption increasing the service sector decreasing. This is because the railway system in Thailand is not dependent on household consumption in the service sectors, particularly banking and insurance. Investment in the railway sector obstructs household consumption in the service sector. The railways contribute to household consumption in the manufacturing sector rather than the service sector, as indicated by the results in Table 2.

Table 2. Effects on railway transportation shock and household consumption

Sectors	Scenario 1 (%)	Scenario 2 (%)
1. Agriculture	-0.00143	0.519737
2. Mining and Quarrying	0	0
3. Food Manufacturing	0	0.580201
4. Textile Industry	0	0.996232
5. Saw Mills and Wood Products	0	0.379459
6. Paper Industries and Printing	0	0.213144
7. Rubber, Chemical and Petroleum Industries	0	0.619584

Sectors	Scenario 1 (%)	Scenario 2 (%)
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass, *etc*.)	0	0.337734
9. Metal, Metal Products and Machinery	0	0.193208
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc*.)	-0.00191	0.798795
11. Public Utilities (Electricity and Gas, Water Works and Supply)	-0.00526	0.322762
12. Construction	0	0.289519
13. Trade (Wholesale Trade, Retail Trade)	-0.00045	0.661361
14. Transportation and Communication (not include railway)	-0.00193	0.379766
15. Services (Restaurants and Hotels, Banking and Insurance *etc*.)	0.001606	-1.89715
16. Unclassified	0	0.48249

Source: Authors' estimates

The result in the effects on gross domestic output between two scenario shows that. The scenario one has no effect on domestic output. It changes output of only 0.000385, -0.00112, 0.000417%, *etc*. However, scenario 2 shows a greater effect on domestic output than scenario 1, contributing to increases of about 0.92, 0.53, 1.54, 0.19, 2.66, 0.57, 0.01, 1.82, and 2.94%, respectively for mining and quarrying, textiles, rubber, chemicals and petroleum, non-metallic products, metal, metal products and machinery, other manufacturing, trade, services, and unclassified sectors. The negative effect on gross domestic output decreases output by about 0.88, 1.06, 0.02, 1.41, 0.71, 0.30, and 0.65%, respectively for agriculture, food manufacturing, sawmills and wood products, paper and printing, public utilities, construction, transportation, and communication. Since railway transportation in Thailand is used by the primary manufacturing sector, investment in the railway network can induce output. However, the opposite result is true for the secondary manufacturing sector, as indicated by the results in Table 3.

Table 3. Effects on railway transportation shock and domestic gross output

Sectors	Scenario 1 (%)	Scenario 2 (%)
1. Agriculture	0.000385	-0.88634
2. Mining and Quarrying	-0.00112	0.928599
3. Food Manufacturing	0.000417	-1.06394
4. Textile Industry	0.000285	0.537634
5. Saw Mills and Wood Products	-0.00173	-0.02887
6. Paper Industries and Printing	0.000602	-1.41553
7. Rubber, Chemical and Petroleum Industries	-0.00103	1.546002
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass)	-0.00103	0.194105
9. Metal, Metal Products and Machinery	-0.00296	2.667996
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc*.)	-0.00181	0.575493
11. Public Utilities (Electricity and Gas, Water Works and Supply)	6.14E-05	-0.74549
12. Construction	0	-0.30849
13. Trade (Wholesale Trade, Retail Trade)	-7.8E-05	0.015416
14. Transportation and Communication (not include railway)	-8.1E-05	-0.65517
15. Services (Restaurants and Hotels, Banking and Insurance *etc*.)	0.001542	1.82698
16. Unclassified	-0.00408	2.948911

Source: Authors' estimates

The result in the effects on primary factors (labor and capital) between two scenario shows that. The scenario 1 indicate that the primary factors (labor and capital) are not affected at all by transportation shock. However, scenario 2 is shown to have both a negative and positive effect on primary factors. The negative effect indicates a decrease in labor in almost all sectors. Whereas the positive effect increases capital in most sectors. Railway transportation shock contributes to production factors moving from labor to capital, as shown in Table 4.

Table 4. Effects on railway transportation shock and Primary Factors (labor and capital).

Sectors	Scenario 1 (%)	Scenario 2 (%)
Labor		
1. Agriculture	0.001755	-2.62306
2. Mining and Quarrying	0	-0.80411
3. Food Manufacturing	0	-2.75347
4. Textile Industry	0	-1.05059
5. Saw Mills and Wood Products	0	-1.56417
6. Paper Industries and Printing	0	-3.0913
7. Rubber, Chemical and Petroleum Industries	0	-0.16999
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass)	0	-1.52078
9. Metal, Metal Products and Machinery	-0.00255	0.870564
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc*.)	0	-0.89524
11. Public Utilities (Electricity and Gas, Water Works and Supply)	0.001409	-2.3208
12. Construction	0	-1.92417
13. Trade (Wholesale Trade, Retail Trade)	0.001304	-1.88566
14. Transportation and Communication (not include railway)	0.001636	-2.20731
15. Services (Restaurants and Hotels, Banking and Insurance *etc*.)	0.002416	-2.97659
16. Unclassified	0	0.843882
Capital		
1. Agriculture	0	-0.20617
2. Mining and Quarrying	-0.00165	1.655782
3. Food Manufacturing	0	-0.33841
4. Textile Industry	0	1.406589
5. Saw Mills and Wood Products	-0.0128	0.857326
6. Paper Industries and Printing	0	-0.68406
7. Rubber, Chemical and Petroleum Industries	-0.00182	2.30672
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass)	0	0.926338
9. Metal, Metal Products and Machinery	-0.00316	3.375695
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc*.)	-0.00262	1.566148
11. Public Utilities (Electricity and Gas, Water Works and Supply)	-0.00048	0.103615
12. Construction	0	0.532163
13. Trade (Wholesale Trade, Retail Trade)	-0.00046	0.549342
14. Transportation and Communication (not include railway)	-0.00116	0.219881
15. Services (Restaurants and Hotels, Banking and Insurance *etc*.)	0.000603	-0.56846
16. Unclassified	-0.01019	3.271504

Source: Authors' estimates

The result in the effects on government consumption between *scenario 1* and *scenario 2*. It shows the effect in *scenario 1*; it's no effect on the sectors, shock in railway transportation sector cannot contribute government consumption. However, *scenario 2* the shock in railway transportation is more massive. The government consumption also increases but in the services sector consumption is decreased. The result is show in Table 5.

Table 5. Effects on railway transportation shock and government consumption

Sectors	Scenario 1 (%)	Scenario 2 (%)
1. Agriculture	0	0.542005
2. Mining and Quarrying	0	0
3. Food Manufacturing	0	0.961538
4. Textile Industry	0	0.96463
5. Saw Mills and Wood Products	0	0.515464
6. Paper Industries and Printing	0	0.20562
7. Rubber, Chemical and Petroleum Industries	0	0.626305
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass)	0	0
9. Metal, Metal Products and Machinery	0	0.192169
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc*.)	0	0.829876

Sectors	Scenario 1 (%)	Scenario 2 (%)
11. Public Utilities (Electricity and Gas, Water Works and Supply)	0	0.327571
12. Construction	0	0.393701
13. Trade (Wholesale Trade, Retail Trade)	0	0.648855
14. Transportation and Communication (not include railway)	0	0.332226
15. Services (Restaurants and Hotels, Banking and Insurance *etc.*)	0.001614	-1.89718
16. Unclassified	0	0.463822

Source: Authors' estimates

The result in the effects on investment demand between two scenario shows that. The results from *scenario 1* indicate that transportation shock has no effects on investment demand. However, in *scenario 2* transportation shock is shown to have a positive effect on investment demand. It contributes to an increase in investment demand of about 2.83, 2.28, 0.241, 0.596, and 0.358%, respectively for metal, metal products and machinery, other manufacturing, public utilities, construction and trade, as shown by the results in Table 6.

Table 6. Effects on railway transportation shock and investment demand

Sectors	Scenario 1 (%)	Scenario 2 (%)
1. Agriculture	0	0
2. Mining and Quarrying	0	0
3. Food Manufacturing	0	0
4. Textile Industry	0	0
5. Saw Mills and Wood Products	0	0
6. Paper Industries and Printing	0	0
7. Rubber, Chemical and Petroleum Industries	0	0
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass)	0	0
9. Metal, Metal Products and Machinery	0.00270	2.83
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc.*)	0	2.28
11. Public Utilities (Electricity and Gas, Water Works and Supply)	-0.00262	0.241
12. Construction	0.00455	0.596
13. Trade (Wholesale Trade, Retail Trade)	0.00109	0.358
14. Transportation and Communication (not include railway)	0	0
15. Services (Restaurants and Hotels, Banking and Insurance *etc.*)	0	0
16. Unclassified	0	0

Source: Authors' estimates

The result in the effects on import and export between two scenario shows that. The results from scenario 1 show that transportation shock has hardly any effect on imports and exports. It creates a change in imports and exports of only 0-0.03% for all sectors. However, scenario 2 has a greater effect on imports and exports. It contributes to an increase in imports for eight sectors and a decrease in six sectors (mining and quarrying, food manufacturing, textiles, metal, metal products and machinery, other manufacturing, and services). Exports show an increase in 11 sectors and a decrease in only four sectors (agriculture, food manufacturing, textiles, and services). However, the shock form railway transportation creates economic activity with international trade, as shown by the results in Tables 7 and 8.

Table 7. Effects on railway transportation shock and import

Sectors	Scenario 1 (%)	Scenario 2 (%)
1. Agriculture	0.00188	-1.09059
2. Mining and Quarrying	-0.00048	0.621823
3. Food Manufacturing	0.001537	-2.41044
4. Textile Industry	0.002003	-0.92351
5. Saw Mills and Wood Products	0.01564	1.063497
6. Paper Industries and Printing	0.00219	0.609313
7. Rubber, Chemical and Petroleum Industries	-0.00107	4.351573
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass)	0	1.258775
9. Metal, Metal Products and Machinery	-0.00207	-0.12295
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc.*)	0.001037	-0.28116

Sectors	Scenario 1 (%)	Scenario 2 (%)
11. Public Utilities (Electricity and Gas, Water Works and Supply)	0.030941	0.959158
12. Construction	0	0
13. Trade (Wholesale Trade, Retail Trade)	0	0
14. Transportation and Communication (not include railway)	0.002806	1.315248
15. Services (Restaurants and Hotels, Banking and Insurance *etc.*)	0	-0.0616
16. Unclassified	0.006749	0.317225

Source: Authors' estimates

Table 8. Effects on railway transportation shock and export

Sectors	Scenario 1 (%)	Scenario 2 (%)
1. Agriculture	0.002673	-1.39821
2. Mining and Quarrying	-0.00343	0.435319
3. Food Manufacturing	-0.00023	-0.74937
4. Textile Industry	0	-0.00442
5. Saw Mills and Wood Products	0	0.790155
6. Paper Industries and Printing	0.002258	0.411025
7. Rubber, Chemical and Petroleum Industries	-0.00104	0.800918
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass)	0	0.955141
9. Metal, Metal Products and Machinery	-0.00225	0.649066
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc.*)	0	0.193781
11. Public Utilities (Electricity and Gas, Water Works and Supply)	0	0.743149
12. Construction	0	0
13. Trade (Wholesale Trade, Retail Trade)	0	0.60778
14. Transportation and Communication (not include railway)	0.002034	0.933711
15. Services (Restaurants and Hotels, Banking and Insurance *etc.*)	0	-0.01105
16. Unclassified	0	0.169725

Source: Authors' estimates

The result in the effects on domestic goods between two scenario shows that. The result from *scenario 1* shows that railway transportation shock has no effect on domestic output. However, in *scenario 2* railway transportation is shown to have a positive effect on domestic goods, contributing to an increase of about 0.92, 0.54, 1.57, 0.19, 3.26, 1.79, 0.08, 0.15, 0.06, and 0.16%, respectively for mining and quarrying, textiles, rubber, chemical and petroleum, non-metallic products, metal, metal products and machinery, other manufacturing, public utilities, construction, trade, and services. Conversely, railway transportation shock also has a negative effect on gross domestic goods in some sectors, resulting in a decrease of about 0.88, 1.15, 0.02, 1.41, 0.32, and 0.30% for agriculture, food manufacturing, sawmills and wood products, paper and printing, transportation and communication, and unclassified. Since railway transportation in Thailand is used by the manufacturing sector, gross domestic goods can induce output. However, the opposite result is true for the other sectors, as shown in Table 9.

Table 9. Effects on railway transportation shock and Domestic goods

Sectors	Scenario 1 (%)	Scenario 2 (%)
1. Agriculture	0.000402	-0.88628
2. Mining and Quarrying	-0.0012	0.928541
3. Food Manufacturing	0.000637	-1.15471
4. Textile Industry	0.000354	0.547388
5. Saw Mills and Wood Products	-0.00197	-0.02563
6. Paper Industries and Printing	0.000674	-1.41559
7. Rubber, Chemical and Petroleum Industries	-0.00104	1.575679
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass)	-0.00112	0.197492
9. Metal, Metal Products and Machinery	-0.00298	3.265786
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc.*)	-0.00188	1.793873
11. Public Utilities (Electricity and Gas, Water Works and Supply)	6.15E-05	0.087538
12. Construction	0	0.152202
13. Trade (Wholesale Trade, Retail Trade)	-8.4E-05	0.063101

Sectors	Scenario 1 (%)	Scenario 2 (%)
14. Transportation and Communication (not include railway)	-9.4E-05	-0.32719
15. Services (Restaurants and Hotels, Banking and Insurance *etc.*)	0.001539	0.167886
16. Unclassified	-0.00343	-0.30838

Source: Authors' estimates

The result in the effects on composite goods between two scenario shows that. The results from scenario 1 show that railway transportation shock has almost no effect on composite goods. However, scenario 2 has a greater effect than scenario 1. Railway transportation shock is shown to have a positive effect on composite goods, contributing to an increase in mining and quarrying, textiles, rubber, chemical and petroleum, non-metallic products, metal, metal products and machinery, other manufacturing, construction trade, and unclassified. Conversely, other sectors are negatively affected by composite goods, as indicated by the results in Table 10.

Table 10. Effects on railway transportation shock and composite goods

Sectors	Scenario 1 (%)	Scenario 2 (%)
1. Agriculture	0.000446	-0.90753
2. Mining and Quarrying	-0.00083	0.791105
3. Food Manufacturing	0.000752	-1.22964
4. Textile Industry	0.000321	0.407039
5. Saw Mills and Wood Products	0	-0.05305
6. Paper Industries and Printing	0.000906	-1.49603
7. Rubber, Chemical and Petroleum Industries	-0.00107	1.380258
8. Non-metallic Products (Cement, Concrete and Cement Products, Ceramic, Glass)	0	0.165135
9. Metal, Metal Products and Machinery	-0.00273	2.585786
10. Other Manufacturing (Leather Products, Watches and Clocks, Jewelry & Related Articles *etc.*)	-0.00151	0.422512
11. Public Utilities (Electricity and Gas, Water Works and Supply)	0.000122	-0.74684
12. Construction	0	-0.30506
13. Trade (Wholesale Trade, Retail Trade)	-8.3E-05	0.015498
14. Transportation and Communication (not include railway)	0.00016	-0.69284
15. Services (Restaurants and Hotels, Banking and Insurance *etc.*)	0.001513	-1.79351
16. Unclassified	-0.00305	2.891847

Source: Authors' estimates

The effect on value-added between *scenario 1* and *scenario 2* shows that. The results from *scenario 1* show that railway transportation shock has almost no effect on the value-added for all sectors. Whereas, *scenario 2* shows a substantially greater effect from railway transportation shock on value-added than scenario 1. Railway transportation shock results in an increase in the value-added for mining and quarrying, rubber, chemicals and petroleum, non-metallic products, metal, metal products and machinery, and other manufacturing. On the other hand, agriculture, food manufacturing, sawmills and wood products, paper and printing, public utilities, construction, transportation and communication, and services show a decrease in the value-added, as shown by the results in Table 11.

Table 11. Effects on railway transportation shock and value added

Sectors	Scenario 1 (%)	Scenario 2 (%)
1. Agriculture	0.000353	-0.88634
2. Mining and Quarrying	-0.00066	0.928599
3. Food Manufacturing	0.000489	-1.06394
4. Textile Industry	0.001036	0.537634
5. Saw Mills and Wood Products	0	-0.02887
6. Paper Industries and Printing	0.001437	-1.41553
7. Rubber, Chemical and Petroleum Industries	-0.00097	1.546002
8. Non-metallic Products(Cement, Concrete and Cement Products, Ceramic, Glass)	0	0.194105
9. Metal, Metal Products and Machinery	-0.0031	2.667996
10. Other Manufacturing (Leather Products ,Watches and Clocks, Jewelry & Related Articles *etc.*)	-0.00189	0.575493
11. Public Utilities (Electricity and Gas, Water Works and Supply)	0	-0.74549
12. Construction	0	-0.30849
13. Trade (Wholesale Trade, Retail Trade)	-9.9E-05	0.015416

Sectors	Scenario 1 (%)	Scenario 2 (%)
14. Transportation and Communication (not include railway)	-0.00044	-0.65517
15. Services(Restaurants and Hotels, Banking and Insurance *etc.*)	0.001552	-1.82698
16. Unclassified	0	2.948911

Source: Authors' estimates

The comparative results between *scenarios 1* and *2* (Table 12) show the impact on household utility. In *scenario 1*, the shock from railway transportation decreases household utility by 0.00203%. However, such a small shock cannot contribute to social welfare. In *scenario 2*, the shock from railway transportation is greater than for *scenario 1,* contributing positively to social welfare, with household utility increasing by 0.079256%.

Table 12. Effects on railway transportation shock and welfare

Welfare	Scenario 1 (%)	Scenario 2 (%)
Household utility	-0.00203	0.079256

Source: Authors' estimates

The results of the paper indicate that railway development is important to the Thai economy, contributing to growth at both the macroeconomic and microeconomic level. Investment in the railway has an effect on all economic sectors such as household consumption, gross domestic productivity, imports, exports, *etc.*, as summarized in the next chapter.

Conclusion

This study aims to analyze the effect of investment in railways transportation on the aggregate economic system including individual sectors by employing the standard CGE model. The findings reveal two scenarios, the first of which defines twice as much stock in the railway transportation than the baseline. The impact of scenario 1 on household consumption, gross domestic output, primary factors, government consumption, investment demand, imports, exports, domestic goods, composite goods, value-added, and social welfare are approaching zero since railway transportation system in Thailand is large. Investment in the rail network for development and maintenance requires a substantial amount of money.

In *scenario 1* there is little money invested in the railway systems and change cannot be affected. Although the second scenario involves a great deal of money being spent on the railway network, it contributes positively to household consumption, gross domestic output, primary factors, government consumption, investment demand, imports, exports, domestic goods, composite goods, value-added, and social welfare. Before putting the railway transportation shock into the CGE model, it was assumed that the shock from railway investment in the development and maintenance of the railway system in Thailand would have a positive effect on all sectors of the economy, but this is not the case. The railway can contribute positively to household consumption and government consumption in almost all sectors except service, and creates a positive effect on gross domestic output, domestic goods, composite goods, and value-added in heavy industries such as mining and quarrying, rubber, chemicals and petroleum, non-metallic products (cement, concrete and cement products, ceramics, glass, *etc.*), metal, metal products and machinery, and other manufacturing (leather products, watches and clocks, jewelry and related articles, *etc.*). On the other hand, in agriculture, food manufacturing, public utility, services, and non-manufacturing sectors it has a negative impact on gross domestic output, domestic goods, composite goods, and value-added. The results from the impact on exports and imports show that railway transportation increases activity from international trade. The primary factors become more capital-intensive when the railway transportation sector increases.

Moreover, it can be summarized that railway transportation contributes to the manufacturing sector but not necessarily to agriculture, services, and non-heavy manufacturing. This is because the railway in Thailand is used by a limited number of sectors. In the future, when the rail network in Thailand is used by a greater number of sectors, it can make a positive contribution to Thailand's economy, according to the researcher's original assumption.

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Earnings Quality on Pre vs Post Audit Report: Evidence from Banking Industry in Indonesia

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Abstract:

The aim of this research is to examine and analyze the association betwen audit adjustment and earnings quality. Samples used in this research are banking companies listed on the Indonesia Stock Exchange during the period 2012-2016, a total of 358 samples from 42 companies. This research examined the effect of audit adjustment on earnings quality with a focus on banking companies in Indonesia and measurements that were adjusted to the nature of banking companies.The analysis of this research employs Ordinary Least Square Regression, and T-test processed with STATA 14 software. This study finds that audit adjustment helps to reduce earnings management. The result indicates that audit adjustment has an impact on earnings quality in highly regulated industry, especially in the banking industry.

Keywords: audit adjustment; earnings quality; accrual quality; earnings distribution around zero

JEL classification: M41; M42

1. Introduction

Earnings quality is a topic used in many previous studies (Altamuro *et al.* 2010, Kanagaretnam *et al.* 2011, Zhu *et al.* 2012, Kanagaretnam *et al.* 2014, Grougiou *et al.* 2014, Acar *et al.* 2015, Lennox *et al*. 2016, Gideon *et al.* 2018, Maso *et al.* 2018). Earnings quality is an interesting topic because companies often do manipulation related to earnings. One reason for this is that investor valuation is usually based on the company's ability to produce earnings. Some research evidence shows limitation on the benefits of using earnings as a basis for valuations by investors. This is supported by research conducted by Lev (1989). His research focuses on the low quality of information on reported earnings. This may occur because of the biases caused by accounting measurements, the principle of assessment, and manipulation by management.

The controversy about the use of income smoothing as an indicator of low earnings quality is an ongoing debate. Income smoothing can be a sign of both low earnings quality (Leuz *et al.* 2003, Lennox *et al.* 2016), or high level of earnings quality (Tucker and Zarowin 2006). The existence of the discontinuity in earning distribution around zero is also still questionable. Discontinuity in earnings distribution around zero was declared to have disappeared starting in 2002 (Gilliam *et al.* 2015, Makarem *et al.* 2018), but was also still found in some previous studies (Leuz *et al.* 2003, Shen and Chih 2005, Lennox *et al.* 2016). This research contributes to knowing the use of income smoothing and earning distribution around zero in banking companies.

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The banking industry has several specific reasons for doing earnings management that are different than other industries. First, banks often face illiquidity problems which are a risk for the continuity of the company (Shen and Chih 2005). Second, banks have high uncertainty over leverage. Third, capital adequacy ratio, liquidity ratio, and other ratios in banking companies are regulated by special arrangements. Fourth, Banking System are complex (Hassan *et al.* 2008). Earnings management is a management skill to deal with changes in regulations.

In Indonesia, banking companies are required to submit monthly and quarterly financial reports to the Indonesian Financial Service Authority. In addition, financial statements are also audited by a public accounting firm that has been registered in the Financial Service Authority. Based on the Financial Services Authority Regulation Number 13/PJOK.03/2017, not all public accounting offices are allowed to audit banking companies. The public accounting firm must register with certain requirements. Based on the explanation above, it shows that the financial statements of banking companies have a high supervision of financial statements in both pre- and post-audit.

Based on the policeman theory, the auditor is responsible for finding, disclosing and preventing fraud committed by the company (Hayes *et al.* 2005). If a banking company conducts earnings management then an audit adjustment should reduce or even eliminate the earnings management. To examine this problem, this research uses banking companies listed on the Indonesia Stock Exchange. This study used a sample of 358 observations from 43 banking companies listed on the Indonesia Stock Exchange from 2012-2016. This study was conducted by comparing between pre- and post-audit earnings in the same year.

Earnings quality is measured based on several measurements, income smoothing, earnings persistence, accrual quality, signed and absolute accrual, and discontinuity in earnings distribution around zero, by comparing the differences in pre audit and post audit. The existence of an audit is expected to produce higher earnings quality in post-audit than in the pre-audit. However, with all the limitations in audits, there is no guarantee that post-audit earnings quality will be higher than the pre-audit. Audits without adjustments may have lower earnings quality if the auditor should need to propose an audit adjustment, but it is not done (Lennox *et al*. 2016), or, conversely, financial statements without adjustments may have higher quality because financial statements have been fairly presented so that audit adjustments are not needed.

This study found that earnings management in the form of income smoothing diminished after the audit adjustments, which meant increasing the level of earning quality. Pre-audit earnings show a persistence coefficient, but there is no significant effect in the post-audit. This means that earnings have good quality even before an audit adjustment is performed. The next finding is that the absolute discretionary value between pre-audit and post-audit does not show a significant difference, in other words, the audit adjustment does not improve the accrual quality. The audit adjustment also does not affect the magnitude of signed and absolute accrual. Finally, discontinuity in earnings distribution around zero is still found in Indonesia.

This study provides additional evidence related to research on earnings quality, especially banking companies, which have different characteristics than other industries. Loan loss provision is a tool used by banking companies in conducting earnings management. This study explains how audit adjustments affect the level of earnings management, especially income smoothing by banking companies. The remainder of this paper is structured as follows. Section 2 develops the research hypothesis. Section 3 describes the sample and variables. Section 4 specifies the empirical models and presents the result. Section 5 summarizes the paper and presents concluding remarks.

2. Literature review and hypotheses

2.1. Income smoothing and earnings persistence

Current earnings can be a way to predict the picture of future earnings (Subramanyam 1996). Earnings ability to predict future earnings is related to earnings persistence. If the audit adjustment is able to reduce the overstatement of company earnings, the audit adjustment also should produce persistence earnings.

Based on several studies related to income smoothing in banking companies, loan loss provisions are used by banking companies to conduct earnings management (Kanagaretnam *et al*. 2004, 2011, 2014; Fonseca *et al.* 2008, Altamuro *et al*. 2010, Acar *et al*. 2015, Serdaneh 2018). Income smoothing can affect the actual performance of the company, thus indicating low earnings quality (Leuz *et al.* 2003). This statement may apply when there is management intervention in making income smoothing so the earnings reported are not according to reality. Lennox *et al.* (2016) assume that earnings smoothness indicates high earnings quality. This is because audit adjustments help improve earnings volatility by reducing reporting errors that cause earnings volatility.

There are two possibilities related to income smoothing done by a company. First, when management does income smoothing, the auditor should carry out his role as a policeman to reduce the level of earnings management.

This makes the pre-audit earnings smoother than post-audit earnings. Second, when a company makes income smoothing by raising earnings in the current period, it will produce understatement earnings in the next period. This will cause pre-audit earnings to have higher volatility than post-audit earnings, so that the earnings have less persistence. Income smoothing also causes earnings to have more persistence because companies tend to maintain the same earnings level as in previous years. Based on this explanation, the hypotheses are as follows:

H1a : Income smoothing in pre-audit earnings is higher than income smoothing in post-audit earnings

The next hypothesis is written in the null form:

H1b : There is no difference between pre- and post-audit earnings in terms of earnings persistence.

2.2. Accrual quality

Accrual plays an important role in earnings quality assessment. It is important to know whether accruals are supported by past, present and future cash flow (Dechow *et al*. 2002). Aspects of accruals in earnings quality valuation are expected to increase measurement of company performance (Dechow *et al.* 2010). This statement relates to the possibility that the company increases the number of accruals without being followed by cash flow. For example, the company increases the amount of accounts receivable without the possibility of cash receipt. This is where the auditor plays a role. When accrual is not supported by cash flow, the auditor can make adjustments. The accrual quality in the post-audit should be higher than the accrual quality at the pre-audit. Based on this explanation, the next hypothesis is as follows:

H2 : Accrual quality in post-audit earnings is higher than accrual quality in pre-audit earnings.

2.3. Signed and absolute accrual

Signed accrual and absolute accrual are proxies often used in audit quality assessment (Francis and Yu 2009, Leuz *et al.* 2013, Yuan *et al.* 2016). Signed accruals have advantages over absolute accruals (Lennox *et al.* 2016). Audit adjustment can change the direction of signed accruals that may not be captured by absolute accrual. For example, pre-audit accruals that were originally positive can turn negative after being audited. Such changes may not be caught by absolute accrual. For example, if the pre-accrual value is 0.01 and the post-accrual value is -0.01, then the decrease in signed accrual is 0.02 while the absolute accrual is not changed.

On the other hand, the audit adjustment might reduce and increase absolute negative accrual. Lennox *et al.* (2016) state that the audit leads more to absolute than signed accrual The greater value of negative accrual indicates the existence of earnings management to reduce profits earnings. This may not apply if the higher negative accruals are caused by the conservatism of the auditor. Research conducted by Kinney and Martin (1994) found that downward adjustments were found more frequently than upward adjustments. The first hypothesis related to sign accrual is as follows:

H3a: The frequency of having a positive pre-audit accrual with negative post-audit accrual is higher than the frequency of having a negative pre-audit accrual with positive post-audit accrual

Next, we examine how audit adjustments influence the negative and positive accruals. The possibility of negative accrual is that the auditor performs an upward adjustment to reduce earnings management related to the decrease in earnings or downward adjustments that are caused by auditor conservatism (Lennox *et al.* 2016). In positive accrual, auditors have a tendency to prevent earnings management from increasing profits and the tendency to be conservative. Based on the explanation above, the following hypotheses are:

H3b: There is no difference value between negative pre-accrual and negative post-accrual

H3c : The value of positive pre-accrual is higher than the value of positive post-accrual.

2.4. Discontinuity in earnings distribution around zero

The existence of earnings distribution around zero is still a debate among several researchers. Prior studies (Burgstahler and Dichev 1997) found that 8% to 12% of companies with small profit declines use discretion to report increased profits. On the other hand, zero earnings discontinuity has disappeared since 2002 (Gilliam *et al.* 2015). Some research discusses the causes of banking companies in conducting earnings management based on prospect theory (Kahneman and Tversky 1979, Burgstahler and Dichev 1997, Degeorge *et al.* 1999, Shen and Chich 2005). Prospect theory explains that individuals interpret the value of gain and loss based on their reference points. If shareholder preferences are consistent with prospect theory, the manager will have the urge to report earnings above the threshold or reference point, such as zero earnings level or zero earnings (Shen and Chich 2005).

If discontinuity is not caused by earnings management, the audit process cannot reduce it through an audit adjustment. Conversely, if discontinuity is caused by earnings management, then the auditor should be able to make adjustments to earnings management that occur so that it will cause discontinuity in the post-audit to be smaller than the pre-audit. Based on these explanations, the next hypothesis is written in the null form:

H4: There is no difference in the frequency of small profits (small losses) between pre- and post-audit earnings.

3. Data and variable measurement

3.1. Sample

The population in this study is banking companies listed on the Indonesia Stock Exchange in the period 2012-2016. This study uses a sample of 358 banking companies listed on the Indonesia Stock Exchange. Pre-audit financial report data were obtained from the Financial Services Authority website while the post-audit financial report data were obtained from the Indonesia Stock Exchange website. Banking companies are not required to report cash flow statements to OJK, so this research uses audited cash flow statements for operating cash flows and accrual calculations.

3.2. Measurement of earnings quality

Income smoothing and earnings persistence

In the income smoothing assessment, the variable used is POST*EBTP. The greater the coefficient, the more it shows the existence of income smoothing.

$$LLP_{i,t} = \beta_0 + \beta_1 POST*EBTP_{i,t} + \beta_2 EBTP_{i,t} + \beta_3 POST_{i,t} + \beta_4 LOANS_{i,t} + \beta_5 \Delta LOANS_{i,t} + \beta_6 NPL_{i,t} + \beta_7 \Delta NPL_{i,t} + \varepsilon \quad (1)$$

Assessment of earnings peristence uses POST*ROA. The higher the coefficient shows the higher earnings persistence.

$$ROA_{it+1} = \alpha_0 + \alpha_1 POST*ROA_{i,t} + \alpha_2 ROA_{i,t} + \alpha_3 POST_{i,t} + \alpha_4 CFO_{i,t} + \alpha_5 SIZE_{i,t} + \alpha_6 LEV_{i,t} + \alpha_7 DEPOSIT_{i,t} + \varepsilon \quad (2)$$

Accrual quality

This test aims to obtain the absolute value of discretionary accruals. This test uses the past, present, and future functions of cash flows (Dechow and Dichev 2002).

$$ACCRUAL_{i,t} = \alpha_0 + \alpha_1 CFOi_{,t-1} + \alpha_2 CFOi_{,t} + \alpha_3 CFO_{i,t+1} + \varepsilon \quad (3)$$

After obtaining the absolute value of discretionary accrual, we perform a T-test of residual value between pre-audit and post-audit. The greater the residual average value produced, the lower the level of accrual quality.

Signed and absolute accrual

Tests for signed and absolute accrual are as follows:

- comparing the difference in frequency between changes from positive pre-accrual to negative post-accrual and changes from negative pre-accrual to positive post-accrual;
- comparing the mean absolute value of negative accrual;
- comparing the mean absolute value of positive accrual.

Discontinuity in earnings distribution around zero

Discontinuity in earnings distribution around zero is tested by comparing the differences in the small profit frequency between pre_ROA and post_ROA and the difference in frequency of small losses between pre_ROA and post_ROA.

4. Empirical analysis

4.1. Descriptive statistics

Table 1 shows the sample distribution based on adjustment. There are 85 companies, or 47.49%, having downward adjustments, 79 companies or 44.13% having upward adjustments and 15 companies or 8.38% having no adjustment. Downward adjustments were more frequently found than upward adjustments (Kinney and Martin 1994). This is caused by the conservatism of the auditor (Lennox *et al.* 2016)

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Table 1. Sample distribution based on adjutment

Downward Adjustment Pre_earn>Post_earn		Upward Adjustment Pre_earn<Post_earn		No Adjustment Pre_earn>Post_earn		Total	
N	%	N	%	N	%	N	%
85	47,49%	79	44,13%	15	8,38%	179	100

Table 2 presents descriptive statistics on the pre-audit. The average value of LLP is 0.008; EBTP is 0.022; TA is Rp.112.800.000.000.000,00; and ACCRUAL is 0.001. Table 3 present the descriptive statistics on the post audit. The average value of LLP is 0.009; EBTP is 0.022; TA is Rp.124.700.000.000.000,00; and ACCRUAL is 0.001.

Table 2. Pre audit statistics descriptive

	Mean	Median	Minimum	Maximum
Pre_LLP	0.008	0.005	0.000	0.071
Pre_EBTP	0.022	0.020	-0.024	0.056
Pre_LOANS	0.646	0.666	0.283	0.790
Pre_ΔLOANS	0.260	0.152	-0.371	3.124
Pre_NPL	0.017	0.015	0.000	0.073
Pre_ΔNPL	0.003	0.001	-0.039	0.046
Pre_ROA_{t+1}	0.011	0.014	-0.100	0.046
Pre_ROA	0.014	0.014	-0.064	0.048
Pre_CFO_{t-1}	0.014	0.016	-0.174	0.178
Pre_CFO	0.013	0.017	-0.214	0.183
Pre_CFO_{t+1}	0.010	0.016	-0.214	0.178
Pre_TA	112.800.000.000.000	23.474.330.000.000	1.218.243.000.000	918.200.000.000.000
Pre_DEPOSIT	0.580	0.797	0.001	0.897
Pre_LEV	0.610	0.841	0.001	0.953
Pre_ACCRUAL	0.001	0.000	-0.178	0.160

Table 3. Post audit statistics descriptive

	Mean	Median	Minimum	Maximum
Post_LLP	0.009	0.005	-0.004	0.146
Post_EBTP	0.022	0.019	-0.024	0.140
Post_LOANS	0.645	0.666	0.005	0.791
Post_ΔLOANS	0.196	0.141	-0.371	1.578
Post_NPL	0.017	0.014	0.000	0.094
Post_ΔNPL	0.003	0.001	-0.040	0.064
Post_ROA_{t+1}	0.011	0.014	-0.097	0.095
Post_ROA	0.013	0.014	-0.076	0.052
Post_CFO_{t-1}	0.014	0.016	-0.174	0.177
Post_CFO	0.012	0.016	-0.214	0.183
Post_CFO_{t+1}	0.009	0.016	-0.214	0.177
Post_TA	124.700.000.000.000	23.250.685.000.000	1.217.521.000.000	1.039.000.000.000.000
Post_DEPOSIT	0.585	0.818	0.001	0.946
Post_LEV	0.593	0.832	0.001	0.930
Post_ACCRUAL	0.001	0.000	-0.178	0.157

4.2. Main analysis

Pearson correlation

Table 4 presents the results of Pearson Correlation in the income smoothing model. From the results of the analysis, it is known that, when a company has a high EBTP, the LLP level will move in line and show a higher level of LLP. Table 5 shows that the level of ROA has an effect on the level of ROA_{t+1}. When a Company has a high ROA, then the ROA_{t+1} level will move in line and show a high level of ROA_{t+1}.

Table 4. Income Smoothing Pearson Correlation

	LLP	EBTP	POST	LOANS	ΔLOANS	NPL	ΔNPL
LLP	1.000						
EBTP	0.243***	1.000					
	(0.000)						
POST	0.025	0.004	1.000				
	(0.637)	(0.935)					
LOANS	-0.010	0.075	-0.007	1.000			
	(0.852)	(0.157)	(0.895)				
ΔLOANS	-0.224***	-0.102*	-0.089*	-0.083	1.000		
	(0.000)	(0.054)	(0.092)	(0.117)			
NPL	0.458***	-0.107**	0.003	0.198***	-0.283***	1.000	
	(0.000)	(0.043)	(0.957)	(0.000)	(0.000)		
ΔNPL	0.049	0.023	0.008	0.047	0.002	0.479***	1.000
	(0.357)	(0.662)	(0.883)	(0.376)	(0.977)	(0.000)	

Note: This table displays the pearson correlation in the income smoothing model. The sample comprises banking companies on the Indonesian Stock Exchange (IDX) listed for years 2012-2016.Significance at * 10%, ** 5%, *** 1%.

Table 5. Earnings Persistence Pearson Correlation

	ROA_{t+1}	ROA	POST	CFO	SIZE	LEV	DEPOSIT
ROA_{t+1}	1.000						
ROA	0.691***	1.000					
	(0.000)						
POST	0.009	-0.014	1.000				
	(0.868)	(0.794)					
CFO	0.242***	0.316***	-0.003	1.000			
	(0.000)	(0.000)	(0.948)				
SIZE	0.344***	0.405***	0.012	0.112**	1.000		
	(0.000)	(0.000)	(0.818)	(0.034)			
LEV	-0.044	0.002	-0.018	0.134**	0.125**	1.000	
	(0.407)	(0.963)	(0.728)	(0.011)	(0.018)		
DEPOSIT	0.059	0.075	0.077	0.050	-0.000	0.136***	1.000
	(0.263)	(0.158)	(0.144)	(0.342)	(1.000)	(0.010)	

Note: This table displays the pearson correlation in the earnings persistence model. The sample comprises banking companies on the Indonesian Stock Exchange (IDX) listed for years 2012-2016.Significance at * 10%, ** 5%, *** 1%.

Income Smoothing

Table 6 is the regression result of income smoothing to determine the relationship between POST*EBTP and LLP. Testing the H1a hypothesis uses the regression model as follows:

$$LLP_{i,t} = \beta_0 + \beta_1 POST*EBTP_{i,t} + \beta_2 EBTP_{i,t} + \beta_3 POST_{i,t} + \beta_4 LOANS_{i,t} + \beta_5 \Delta LOANS_{i,t} + \beta_6 NPL_{i,t} + \beta_7 \Delta NPL_{i,t} + \varepsilon \quad (4)$$

Table 6. The Result of Regression on Post Audit EBTP and Loan Loss Provission

Variable	Predicted Sign	LLP	
		OLS	OLS robust
POST*EBTP	+/-	-0.195**	-0.195*
		(-2.42)	(-1.88)
EBTP	+/-	0.361***	0.361**
		(7.27)	(2.19)
POST	+	0.005**	0.005
		(2.31)	(1.61)
LOANS	+	-0.021***	-0.021**
		(-3.40)	(-2.46)
ΔLOANS	+	0.001	0.001
		(0.56)	(0.49)
NPL	+	0.661***	0.661***
		(12.00)	(5.92)
	+	-0.361***	-0.361

Variable	Predicted Sign	LLP	
		OLS	OLS robust
ΔNPL		(-5.58)	(-1.59)
Year dummy		*Included*	*Included*
r2		0.397	0.397
N		358	358

Note: The regression models related to the earnings before tax and loan loss provission and firm-specific control variables for the main sample (N=358) in this study. The dependent variable is LLP. The sample comprises banking companies IDX-listed firms from 2012 to 2016. Standard errors are clustered by year. All continuous variables are winsorized at 1% and 99% levels. Significance at * 10%, ** 5%, *** 1%.

Based on the regression results, Table 6 show that POST*EBTP is negatively and significantly related to LLP, while EBTP is positively and significantly related to LLP. The higher the EBTP, the higher the LLP of the company. This means that the company makes LLP adjustments based on the EBTP (Kanagaretnam *et al.* 2011, 2014, Acar *et al.* 2015). This indicates that the audit adjustment helps to reduce the level of income smoothing in banking companies. This result is consistent with previous studies where audit adjustments reduce the level of earnings smoothness (Lennox *et al.* 2016). From this result, H1a is accepted, which means income smoothing in pre-audit earnings is higher than in post-audit earnings.

LOANS has a negative significant effect on LLP, which means that with an increase in LOANS then LLP will be smaller. NPL has a positive and significant effect on LLP. This result is in accordance with predictions based on previous research (Kanagaretnam *et al.* 2011, 2014; Grougiou *et al.* 2014). When the number of bad loans gets bigger, then it should be accompanied by an increase in LLP. From the OLS results, it is known that policeman theory applies to the audit process of banking companies in Indonesia. The auditor acts to reduce the existence of earnings management.

Earnings persistence

Table 7 shows the regression result of earnings persistence to determine the relationship between POST*ROA and ROA_{t+1}. Testing the H1b hypothesis uses the regression model as follows:

$$ROA_{it+1} = \alpha_0 + \alpha_1 POST*ROA_{i,t} + \alpha_2 ROA_{i,t} + \alpha_3 POST_{i,t} + \alpha_4 CFO_{i,t} + \alpha_5 SIZE_{i,t} + \alpha_6 LEV_{i,t} + \alpha_7 DEPOSIT_{i,t} + \varepsilon \quad (5)$$

Tabel 7. The result of regression on post audit ROA and ROA_{t+1}

Variable	Predicted Sign	ROA_{t+1}	
		OLS	OLS robust
POST*ROA	+/-	-0.002	-0.002
		(-0.02)	(-0.03)
ROA	+/-	0.773***	0.773***
		(10.32)	(6.63)
POST	+	0.001	0.001
		(0.31)	(0.47)
CFO	-	0.019	0.019
		(1.18)	(1.19)
SIZE	+	0.001**	0.001*
		(2.10)	(1.88)
LEV	+	-0.022	-0.022
		(-1.38)	(-0.75)
DEPOSIT	+	0.003	0.003
		(0.51)	(0.82)
Year dummy		Included	Included
r2		0.496	0.496
N		358	358

Note: The regression models related to the return on asset and firm-specific control variables for the main sample (N=358) in this study. The dependent variable is ROA_{t+1}. The sample comprises banking companies IDX-listed firms from 2012 to 2016. Standard errors are clustered by year. All continuous variables are winsorized at 1% and 99% levels. Significance at * 10%, ** 5%, *** 1%.

Based on the regression results in Table 7, it was found that the pre-audit ROA had a positive and significant effect on ROAt + 1, whereas the post-audit ROA did not significantly affect ROAt + 1. This result indicates that the audit adjustment does not improve the quality of earnings related to the persistence of earnings in banking

companies, which causes H1b to be rejected. Firm size (SIZE) plays an important role in the level of persistence of profits owned by the company. Larger size of company will produce earnings persistently (Beatty *et al.* 2002, Kanagaretnam *et al.* 2014).

Accrual quality

This OLS analysis is conducted to obtain absolute residual values based on a regression model between CFO_{t-1}, CFO_t, and CFO_{t+1} with ACCRUAL levels before and after the audit. This research uses the following regression model:

$$ACCRUAL_{i,t} = \alpha_0 + \alpha_1 CFO_{i,t-1} + \alpha_2 CFOi_{,t} + \alpha_3 CFO_{i,t+1} + \varepsilon \quad (6)$$

Table 8 shows the OLS results to get the absolute discretionary accrual. The OLS results show that accruals are supported by operating cash flows from the past and future. This result is in accordance with the model used in previous research (Dechow and Dichev 2002, Lennox *et al.* 2016).

Table 8. The result of regression on operating cash flow and accrual

Variable	ACCRUAL	
	OLS	OLS robust
CFO_{t-1}	0.116***	0.116***
	(7.05)	(4.33)
CFO_t	-0.870***	-0.870***
	(-52.54)	(-22.51)
CFO_{t+1}	0.060***	0.060**
	(3.73)	(2.37)
Year dummy	*Included*	*Included*
r2	0.903	0.903
N	358	358

Note: The regression models related to the operating cash flow for the main sample (N=358) in this study. The dependent variable is ACCRUAL. The sample comprises banking companies IDX-listed firms from 2012 to 2016. Standard errors are clustered by year. All continuous variables are winsorized at 1% and 99% levels. Significance at *10%, **5%, ***1%.

Table 9 shows the results of the independent T-test absolute discretionary value from the regression model in Table 8. The T-test shows that the average value of post-audit absolute discretionary accrual is 0.013, while the value of pre-audit absolute discretionary accrual is 0.012. The difference in the average absolute discretionary accrual value between pre- and post-audit is 0.001 and does not indicate a significant difference. Accrual quality at pre-audit and post-audit is not significantly different. This is because a banking company in Indonesia is a company that has a set of rules for reporting high financial statements, as described previously. This result shows that there is no difference in terms of accrual quality between pre- and post-audit.

Tabel 9. T-test Accrual Quality

Variable	Post Audit	Pre Audit	Coef	t-value
RESID	0.013	0.012	0.001	0.817

Note: This table displays the absolute discretionary accrual between pre audit dan post audit.for the sample (N=179) in this study. The sample comprises banking companies IDX-listed firms from 2012 to 2016. Standard errors are clustered by year. All continuous variables are winsorized at 1% and 99% levels. Significance at *10%, **5%, ***1%.

Signed and Absolute Accrual

Table 10 shows the results of the independent T-test for the frequency of sign changes. The T-test results show that the frequency of accrual sign changes from positive to negative is greater than the change in accrual sign from negative to positive. These results indicate that the auditor tends to be conservative, so that it requires adjustments that cause a decrease in accrual value, but it is not significant.

Table 11 shows the results of the T-test for accrual negatives between pre- and post-audit and positive accruals at pre- and post-audit. The absolute negative accruals on post-audits is smaller than in pre-audits. This results shows that the audit adjustment does not affect the magnitude of negative accruals. The difference in the positive accruals between post-audit and pre-audit is -0.001 with t-value -0.099 and does not show a significant difference. H3c is rejected because audit adjustments do not affect the magnitude of positive accruals. Overall, the audit adjustment does not affect the level of accruals.

Table 10. T-test change of signed accrual

Variable	Positive to Negative	Negative to Positive	Coef	t-value
Change of sign	0.011	0.006	0.006	0.578

Note: This table displays the change of sign from positive pre accrual to negarive post accrual and change of sign from negative pre accrual to positive post accrual for the sample (N=179) in this study. The sample comprises banking companies IDX-listed firms from 2012 to 2016. Standard errors are clustered by year. All continuous variables are winsorized at 1 percent and 99 percent levels. Significance at * 10%, ** 5%, *** 1%.

Table 11. T-test negative accrual and positive accrual

Variable	Post Audit	Pre Audit	Coef	t-value
Negative Accrual	0.042	0.043	-0.001	-0.099
Positive Accrual	0.044	0.043	0.001	0.096

Note: This table displays the magnitude of negative accrual and positive accrual between pre audit and post audit for the sample (N=179) in this study. The sample comprises banking companies IDX-listed firms from 2012 to 2016. Standard errors are clustered by year. All continuous variables are winsorized at 1% and 99% levels. Significance at * 10%, ** 5%, *** 1%.

4.2.6. Discontinuity in earnings distribution around zero

Table 12 shows the T-test results of the small negative and the small positive ROA between pre-audit and post-audit. Overall, the average score in the post-audit is greater than the pre-audit in both the small positive ROA and small negative ROA.

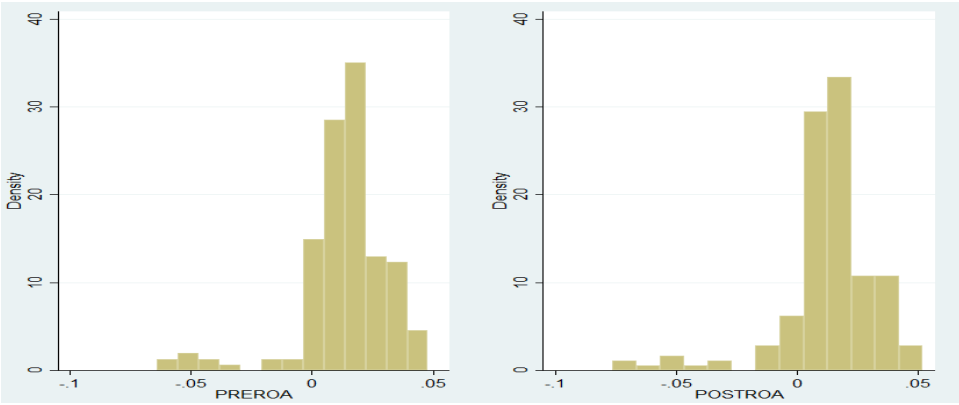
Table 12. T-test small positif and negatif ROA

Variabel	Post Audit	Pre Audit	Coef	t-value
Positif ∈[0, 0.01]	0.263	0.235	0.028	0.610
Negatif ∈[0, -0.01]	0.022	0.017	0.006	0.381
Positif ∈[0, 0.02]	0.637	0.615	0.022	0.436
Negatif ∈[0, -0.02]	0.028	0.022	0.006	0.337
Positif ∈[0, 0.005]	0.000	0.000	0.000	.
Negatif ∈[0, -0.005]	0.000	0.006	-0.006	-1.000
LOSS	0.078	0.073	0.006	0.200

Note: This table displays the magnitude of negative accrual and positive accrual between pre audit and post audit for the sample (N=179) in this study. The sample comprises banking companies IDX-listed firms from 2012 to 2016. Standard errors are clustered by year. All continuous variables are winsorized at 1% and 99% levels. Significance at *10%, ** 5%, *** 1%.

The results of the T-test show that there are no significant differences between pre- and post-audits in terms of small positive and negative ROA. This result is in accordance with previous research (Leuz *et al.* 2003, Lennox *et al.* 2016). The audit adjustment does not affect the existence of discontinuity in earnings distribution around zero. This result is related by Figure 1, which illustrate the existence of discontinuity in earnings distribution around zero found in pre- and post-audit ROA.

Figure 1 Earnings distribution



Previous research has found that more than two-thirds of banking companies from 48 countries, including Indonesia, have a half-bell distribution. The normally distributed earnings also show that the left side of earnings

distribution experiences is "shrunken" (Shen and Chih 2005). Previous studies indicated that, in Indonesia, the comparison between small profits compared to small losses is the highest among other countries (Leuz *et al.* 2003). The following images show that the discontinuity in earnings distribution around zero is not affected by audit adjustments.

Conclusion

Previous research (Lennox *et al.* 2016) found that audit adjustments produce higher earnings quality. The contribution related to this research is that the researchers examined the effect of audit adjustment on earnings quality with a focus on banking companies in Indonesia and measurements that were adjusted to the nature of banking companies. The results of this study indicate that audit adjustments help reduce the level of earnings management in the banking industry in Indonesia.

This study found that audit adjustments reduce income smoothing, but do not increase the persistence of existing profits. Second, the audit adjustment does not affect the company's accrual quality. Third, accruals are not affected by audit adjustments. Finally, the audit adjustment does not affect the existence of the discontinuity in earnings distribution around zero.

I acknowledge some limitations of my study which are potential avenues for future research. I hope, in future studies, to conduct research on all industries. In addition, I also hope that further researchers use other aspects of earnings quality or use other earnings quality measurement.

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Appendix 1. Variable definition

	Variable	Computation
Loan loss provision	LLP	Loan loss provission divided by total asset
Return on Asset	ROA	Earnings before tax divided by total asset
Accrual	ACCRUAL	Return on asset minus CFO
Earnings before tax and loan loss provision	EBTP	Earnings before tax plus loan loss provission divided by total asset
Cash flow from operation	CFO	Cash flow from operation divided by total Asset
Loans	LOANS	Total loans divided by total Asset
Change in loans	ΔLOANS	Total loans in *t* minus total loans in t-1 divided by total loans in t-1
Non performing loans	NPL	Total non performing loans divided by total Asset
Change in non performing loans	ΔNPL	Total non performing loans in t minus total non performing loans in t-1 divided by total Asset
Firm Size	SIZE	Ln Total Asset
POST	POST	Dummy variable 1 for post audit and 0 for pre audit
Leverage	LEV	Total debt divided by total Asset
Deposit	DEPOSIT	Total deposit divided by total Asset

The Disparity and Convergence of District. City Human Development Index in Central Java Province, Indonesia

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Abstract:

This study investigates, firstly, the disparities of the human development index (HDI) for 35 districts/cities in Central Java Province, Indonesia, and, secondly, its convergence during 2010-2018 periods. The result shows that the HDI disparities between districts/cities are relatively low, as indicated by the index number ranging from 0.06935 in 2011 to 0.05818 in 2018. The HDI sigma convergence during 2010-2018 shows a downward convergence sigma indicated by the coefficient of variation decreases over the years at different speeds. However, the standard deviation over years documents an increase particularly in 2014. The absolute β convergence equation estimation indicates the growth of districts/cities which the HDI is relatively low growing faster than the districts/cities that the HDI is relatively high. It means that there is an absolute convergence. The result b=ln(-0.006029+1)/-8=-0.0007 means that districts with low HDI should grow at least by 0.07% to be able to improve the HDI growth. Estimation of Conditional β convergence HDI equation shows the initial regression coefficient of HDI -0.02710, which means convergence, indicating a region which initially had a relatively low HDI successfully develops HDI faster in the pursuit of a region with high HDI.

Keywords: HDI; disparity; convergence; divergence; Central Java

JEL classification: E24; E25; E70

1. Introduction

Since 1990 the United Nations Development Program (UNDP) has introduced the Human Development Index (hereafter HDI) and published regularly in the annual report concerning the HDR (Human Development Report). As a part of UNDP efforts, HDI was initiated by a group of thinkers who seek to promote a shift of construction from the realm of economic development becomes more focus into a "people-centered" approach. It underlines that the purpose of development is to enlarge people's choices and capabilities, which are not fully reflected in the level of income (Antonio *et al.* 2014, Suyono *et al.* 2016, Riswan *et al.* 2017).

The next HDI concept adopted by various countries illustrates how people are able to get proper access to the results of development such as health, education, economy, etc. Moreover, since 1996 Indonesia is one of the countries that has been applying the concept of HDI and periodically calculates it every three years. However, since 2004 the calculation of HDI has been done annually to meet the needs of the Ministry of Finance particularly in calculating the General Allocation Fund (ICBS 2014). Therefore, HDI is presented at the national, provincial, and district/city by the Indonesian Central Bureau of Statistics (ICBS) to enable the province and district/city knowing the map of human development achievements, position, and regional disparities. Thus, it is expected that each region will be motivated to work harder in improving the performance of development by increasing the people's basic capacity.

Basically, the HDI is a reflection of the quality of people in a region, however, at the same time it can serve as an indicator of the gap among regions, wherein a region can be grouped based on the HDI value into four groups of human development levels, *i.e,* low, medium, high, and very high. Low level of human development occurs when the achievement is smaller than 0.550. Then, the medium level is for achievement between 0.550-

0.699, meanwhile, a high level is for achievement between 0.700-0.799. Finally, a very high level is when the achievement is more than 0.800 (UNDP 2016).

UNDP (2016) reported in 2015 that among 188 countries around the world the magnitude of HDI ranging from 0.352 to 0.949 where 26.13% is in the low level of human development, 26.13% is medium, 29.25% is high, and 27.13% is very high. Moreover, according to this report, Indonesia is in the group of *medium human development* with the value of 0.689 and ranked 113 where it is lower than neighboring countries such as Singapore (rank 5), Malaysia (rank 59), and Thailand (rank 87). This fact clearly reveals major differences between countries in terms of the human development index.

This HDI disparities phenomenon happens at the country level in the world and at the regional level as well. Roy (2012) revealed the presence of HDI disparities in the states of India with good views of Expectance Dimension Life Income Index, and the Education Index. Moreover, HDI in the states of India is ranging from 0.459 to 0.910. Again, UNDP (2013) reported that HDI in the provinces of China in 2010 ranging from 0.598 to 0.821. Meanwhile, the HDI of Russia is relatively distributed and ranging from 0.770 up to 0.873 (UNDP 2005).

Indonesia according to UNDP report (2016) has HDI of 0.689 where it places it as a country in the medium human development category. However, the disparity between provinces and districts/cities are still relatively high. For example, in 2016 HDI of Special Area of the Capital–Jakarta Province was 0.7960, meanwhile, HDI for the Papua Province which is far away from the Indonesian Capital was only 0.5805. It places the HDI of Papua Province as the lowest in Indonesia wherein the difference of HDI with Special Area of the Capital–Jakarta Province is around 0.2155, indicating very high of HDI disparity between provinces in Indonesia. Moreover, ICBS (2018) reports that the HDI provinces in Indonesia during 2011-2017 periods ranging from 0.545 up to 0.801, with a difference of 0.256. Meanwhile, at the district/city level in general, the disparity in human development also occurs in every province with varying intensity. Inequality occurs in the province of West Sulawesi and Papua, where the Province of Papua is the worst.

With the high disparity level as explained above, it becomes one of the Indonesian government important roles to address this problem where the HDI disparity should be minimized. It is because the disparities between regions show the difference in the level of development and welfare wherein several cases the disparity creates various other problems in the economy, social, and politics. Therefore, the efforts to reduce HDI disparity will be associated to other government responsibility such as poverty alleviation, improvement of basic facilities, improvement of income, and redistribution of the regional economy (Suyono *et al.* 2016, Riswan *et al.* 2017).

Based on the above arguments, this study argues that the Central Java Province of Indonesia is an interesting area that will be researched due to the economic disparities between cities and districts is quite high. Wahyuntari and Pujiati (2016) revealed that the Central Java province occupies Williamson index in the second rank within 6 provinces of Java. Moreover, Wahyuntari and Pujiati (2016) showed that the high disparity in Central Java province during 2009-2013 periods could be seen from the HDI value at the district/city is quite varied, ranging from 0.6398 to 0.8119. Moreover, in term of people longevity and healthy living, the life expectancy of the people ranges from 68.41 years to 77.46 years. Meanwhile, in term of knowledge dimension, school-age expectation ranges from 11.37 to 14.98 years, and the average school age ranges from 6.05 to 10.49 years (*e.g.,* Semarang City). Furthermore, expenditure per capita adjusted at the district/city ranges between 7.45 million per year to 14.81 million per year.

This study aims to analyze the disparities of HDI among districts/cities in Central Java province and its convergence during 2010-2018 periods. It is highly expected that this study is able to provide useful input for regional governments of Central Java Province at the provincial and districts/cities level in term of the policies-making process to reduce the disparities of HDI among districts/cities. Moreover, the findings of this study are important, particularly to contribute a piece of additional empirical evidence as a reference for further studies in the HDI topic.

2. Literature review

2.1. Disparity

Benni and Chowdappa (2017) explained that the disparity is a measure of income distribution, health, education, and resources which is not evenly distributed among people in different places. ILO states that performance regional disparities are differences in the economic and welfare between countries or regions (Pendse 2015). OECD (2002 2003) defines regional disparities as an expression of the intensity difference scope manifestation of economic phenomena within a certain region. Kutscherauer *et al.* (2010) concluded that the disparity is the difference or inequality of characters, phenomena or processes, identification and comparison makes some sense rational (cognitive, psychological, social, economic, political, *etc*.). Regional disparities indicate divergence

or inequality of characters. It another word, it could be concluded that the disparity is a picture of the facts which is not homogeneous that could be seen from different perspectives.

2.2. Convergence

Theoretically, there is a difference of views on regional disparities, whether convergent or divergent. Convergence is defined as a situation where the economy is in poor areas tends to be faster than rich regions. The idea of convergence in per capita income is derived from the Solow (1956) and Swan (1956) as part of the neoclassical growth model. The neoclassical model, due to diminishing returns, predicts that per capita income in poor countries will eventually converge with the rich countries. Mankiw (2006) explained that convergence depends on regional differences. Convergent movement is indicated by the region's economy that remains capable of pursuing a developed economy. However, if there is convergence, then the regions which are initially poor will remain poor.

According to Barro and Sala-I-Martin (1992), convergence can be based on two concepts, namely Sigma convergence (σ convergence) and Beta convergence (β convergence). Sigma convergence can be defined as a group of economies that are converging in the sense of o if the dispersion of their real per capita GDP levels tends to decrease over time. If the dispersion of real per capita income has decreased over time, it can be said that the inter-regional dispersion is decreasing or Sigma-convergence. Meanwhile, Beta convergence shows that poor economy areas tend to grow faster than the rich economy areas.

Moreover, in its development, β convergence can be divided into Absolute β convergence and Conditional β convergence (Villaverde and Maza 2009). The difference between the Absolute β convergence and Conditional β convergence lies in the parameters that determine income in steady-state, *i.e*, a situation where various quantities grow at a constant rate. According to Hendrani (2012), conditional β convergence is used to determine the effect of factors expected to determine the degree of convergence.

Absolute β convergence can be calculated by an equation as follows (Dvoroková 2014, Villaverde and Maza 2009):

$$\left(\frac{1}{T}\right)\log\left(\frac{y_{iT}}{y_{i0}}\right) = c + \beta\log\left(y_{i0}\right) + \mu_i \tag{1}$$

where: C is a constant, i refers region, Y_{i0} is the initial income, Y_{IT} is finalized revenue, T represents a sampling period, β is the regression coefficient, value $\beta = 1\text{-}e^{-bt}$ when broken down into b = -log (1- β)/T indicates the speed of convergence.

β Conditional convergence equation for the conditional expression is calculated by an equation as follows (Dvoroková 2014, Villaverde and Maza 2009):

$$\left(\frac{1}{T}\right)\log\left(\frac{y_{iT}}{y_{i0}}\right) = c + \beta\log\left(y_{i0}\right) + \gamma X_i^{'} + \mu_i \tag{2}$$

where: $X_i^{'}$ is a vector of conditioning variables.

2.3. Debates on the convergence and divergence

There are two great views about geographic disparities. The first view argues disparities towards the region will converge. This view stems from such neoclassical Solow (1956) and Swan (1956) known as the Neoclassical Growth Model Solow-Swan which uses a Cobb-Douglas production function. They claim that under the assumption of homogeneity of technology and identical preferences, market forces will lead to the same economic level in each region or country. This view is supported by several studies on convergence in many countries (Cashin and Sahay 1996, Bergstorm 1984, Button and Pantecost 1994) which showed that local revenue in a poor region will grow faster than local revenue in a rich region. It is because the regions with lower capital ratios will receive inflows of capital from the regions with high capital ratios. Therefore, this condition creates a process of convergence automatically.

On the other hand, a large number of studies support the view of the divergence of regional imbalances such as Myrdal (1957) and Perroux (1950). Myrdal (1957) developed the cumulative causation theory which

emphasized that economic development resulted in a process of causation and makes the rich benefit more and more, and those left behind become increasingly constrained. As a result, behind impact (backwash effects) tends to be larger and the impact of the spread (spread effects) tends to be smaller. Cumulatively, these trends further exacerbate regional disparities between the underdeveloped countries. In a similar vein, Perroux (1950) who developed a growth pole theory, argued that growth does not appear in any place simultaneously and synchronously. Growth creates and has a different intensity in the call center growth. Growth or development is not done in the whole layout but it is limited to some place or location. Such conditions will worsen regional disparities. This view supported by Sanga and Shaban (2017) in India which showed a divergence of 15 regions studied during the period 1970-1971 to 2013-2014, where the finding is contrary to the expectations of the convergence of neo-classical hypothesis.

2.4. Disparity and Convergence of Human Development Index

United Nations Development Program (UNDP) introduced the HDI (Human Development Index) through the *Human Development Report* (HDR), the first time in 1990, which then continues every year. Data HDI expands the availability of sizes and comparisons that can be used by governments, NGOs, researchers, academicians, and public users to understand the nature of the development itself (Stanton 2007). This index is adopted by many countries to measure the quality of man as a result of the development process.

As a measure of the quality of life, HDI is built through a basic on three-dimensional approaches, namely health, education, and standard of living. The health is proxied by life expectancy at birth, the education is proxied by expected years of study and mean years of study, the standard of living is proxied by gross national income (GNI) per capita. These three indicators used as an index in a single composite through the geometric mean.

There are several studies on HDI disparity topic with conflicting results. Noorbakhsh (2004) conducted research in several countries in Asia, Africa, and Latin America showed evidence of weak convergence HDI in those countries. Konya and Guisan (2008) conducted research in the European Countries during 1975-2004 periods and revealed the existence of a significant convergence of HDI. Mayer-Foulkes (2010) examined β convergence in 111 countries worldwide and found that the urbanization has a significant influence on β conditional convergence HDI. Benni and Chowdappa (2017) used simple statistics such as percentage, average, and coefficient of variation conducted a study related to HDI disparities in the region of Hyderabad Karnataka India. The results showed that the HDI uneven distribution includes its components. Hendrani (2012) conducted research on the convergence of HDI in Banten, Indonesia by using Gross convergence (Sigma convergence) and Beta convergence to analyze the trend of HDI disparities in the province. The results showed a negative value of β convergence meaning that the HDI has been moving closer to each other (catch up) even though it is relatively slow. Moreover, Hendrani (2012) showed that the value of α convergence also increasingly downgrade the negative trend although less significant but it could mean that HDI in districts and cities in Banten Province is more evenly.

3. Research methodology

Types and sources of data

This study uses panel data comprising of 35 districts/cities in Central Java Province for 2010-2018 periods. The selection is based on a new calculation of HDI done by the Indonesian Central Bureau of Statistics (ICBS) by considering the availability of data. Source of data comes from ICBS of Central Java Office and ICBS of offices in each district/city in the Central Java Province. HDI in 2018 is estimated by trend analysis because ICBS has not published the data.

Data analysis

The Williamson index is used to analyze the HDI disparities with the formula as follows (Dvoroková 2014, Villaverde and Maza 2009):

$$I_W = \frac{\sqrt{\sum_{i=1}^{n} (y_i - \bar{y})^2 (f_i/n)}}{\bar{y}}, \qquad 0 < V_w < 1 \tag{3}$$

where: I_w = Williamson index, y_i is the HDI in the district/city of i, $\bar{y}$ = Average HDI in the Central Java province, f_i = number of residents in the districts/cities in the Central Java province, and n = number of people in Central Java province.

Moreover, the Williamson index lies between 0 to 1, the closer to zero means a low HDI disparity and otherwise means a high HDI disparity. To analyze the Sigma convergence (σ convergence) is by using the following formula (Dvoroková 2014, Villaverde and Maza 2009):

$$\sigma = \frac{SD}{\overline{HDI}} \quad (4)$$

where: SD is the standard deviation, and $\overline{HDI}$ is the average value of HDI.

Mathematically, the estimate of a regression model of a cross-section of data for districts/cities in Central Java Province can be written as follows (Dvoroková 2014, Villaverde and Maza 2009):

$$\left(\frac{1}{T}\right) LN\left(\frac{HDI_{IT}}{HDI_{I_0}}\right) = C + \beta\, LN\,(HDI_{IO}) + \mu_I \quad (5)$$

We are referring to Noorbakhsh (2004) where HDI is the ratio of HDI of districts/cities to provincial HDI as the reference. $\left(\frac{1}{T}\right) LN\left(\frac{hdi_{iT}}{hdi_{io}}\right)$ is the annual HDI growth variable in districts/cities in the period 0 and T. If the initial regression coefficient (β) has a negative sign, it means that low HDI in an area grows faster than high HDI in other regions, so there is absolute β convergence

As a measure of Conditionals β convergence for HDI in districts/cities in Central Java Province can be written as follows (Dvoroková 2014, Villaverde and Maza 2009):

$$\left(\frac{1}{T}\right) LN\left(\frac{HDI_{IT}}{HDI_{I_0}}\right) = C + \beta_1 LN\,(HDI_{IO}) + \beta_2 LN\, ICAP_i' + \beta_3\, HF + \beta_4\, EF + \mu_I \quad (6)$$

where: the ICAP, HF, and EF are variables which are predicted to be the cause of convergence HDI between districts/cities in Central Java province; $ICAP_i$ is a per capita income in Indonesian Rupiah (IDR); HF is a proxy of the number of community health centers (*Puskesmas*); *0, T* index indicates the time (0 = 2010, T = 2018).

4. Finding and discussion

4.1. Disparities of Human Development Index

The HDI disparities in districts/cities of Central Java can be seen from the following calculation results of Williamson index as presented in Table 1 below.

Table 1. The Williamson Index HDI Central Java province for 2010-2018

year	The Williamson Index
2010	0.06932
2011	0.066935
2012	0.065313
2013	0.063717
2014	0.063204
2015	0.061663
2016	0.061104
2017	0.06014
2018	0.05818

Table 1 above shows the HDI disparities between districts/cities in the Central Java is not too large, as indicated by the index number ranging from 0.06935 in 2010 to 0.05818 in 2018. Although there are fluctuations in the trend is narrowing. Trend disparity or convergence can be seen from the result of estimates of trend as presented in Table 2 below.

Table 2. Results of Treatment on Disparities of HDI Trend Analysis Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.070	.000		157.327	.000
	T	-.001	.000	-.987	-16.002	.000

Note: a. Dependent Variable: IW

Based on the result from Table 2 above, the disparity trend line equation is formulated as follows:

HDI = 0.070 to 0.001 T (7)

The magnitude of the intercept of 0.070 has positive and significant figures show the starting point of the study period of 0.070. But with the passage of time disparity HDI undergo a process of convergence. It is shown the value of regression coefficient of -0.001 and a significance of 0.000 (< 0.05)

4.2. Analysis of Sigma Convergence (σ)

Convergence sigma (Σ) can be interpreted as a dispersion of HDI from one region to other regions in the macro-scope. The size of dispersion can be seen from the coefficient of variation and standard deviation. Sigma convergence of HDI in the Central Java province for 2010-2018 periods can be seen in Table 3 below.

Table 3. Variation coefficient of HDI in Central Java Province for 2010-2018 periods

Year	Standard deviation (S)	Coefficient of variation
2010	4.910645	0.07368
2011	4.786797	0.07104
2012	4.698762	0.06907
2013	4.619902	0.06724
2014	4.623282	0.06676
2015	4.558374	0.06506
2016	4.537127	0.06427
2017	4.480386	0.06295
2018	4.407254	0.06130

Table 3 above demonstrates a downward of Sigma convergence indicated by the coefficient of variation which decreases from over years, though at different speeds. However, the standard deviation for 2010-2018 shows that there is a slight increase in 2014 compared to the overall periods of convergence of HDI in the Central Java province.

4.3. Absolute analysis β convergence

The estimation of Absolute β convergence equation uses cross-section data and ordinary least-squares method (OLS) run by Eviews program. In order to ensure the best linear unbiased estimate, the classical assumption test of regression including heteroscedasticity, autocorrelation, and normality is done. The test results can be seen in the annex, which showed the Absolute β convergence equation met these requirements. The model equations will also be analyzed statistically, the individual test and simultaneously. The individual test results performed by t-test, while simultaneously testing the F-test is statistically significant at a level estimated 5%. Moreover, the coefficient of determination (R^2) of 0.673434 which means the initial variables (*i.e.*, the HDI in 2010) is able to explain the behavior of HDI change during the whole study periods.

Table 4 shows the estimation results in constant α and β parameters. The constant value of 0.119654 assumptions related to certain periods regressors variable has a value of zero. Through the estimation equation modeling, the *Absolute* β convergence can be shown in equation (8) below.

Table 4. Estimation *Absolute* β convergence

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000201	0.000187	1.075394	0.2900
LOG(HDI_2010)	-0.022355	0.002617	-8.542469*	0.0000
R-squared	0.688602	Mean dependent var		6.25E-05
Adjusted R-squared	0.679166	S.D. dependent var		0.001944
S.E. of regression	0.001101	Akaike info criterion		-10.73003
Sum squared resid	4.00E-05	Schwarz criterion		-10.64115
Log likelihood	189.7756	Hannan-Quinn criter.		-10.69935
F-statistic	72.97378	Durbin-Watson stat		1.654427
Prob(F-statistic)	0.000000			

Note: * denotes significant level at <0.01. *Source*: output of Regression

Then, the regression equation is presented as follows:

$$\left(\frac{1}{T}\right) LN\left(\frac{hdi_{2018}}{hdi_{2010}}\right) = -0.000037 - 0.006029\, LN\,(hdi_{2010}) \quad (8)$$

Equation (8) above showing parameter β = 0.006029 explains the growth of the district/city that is relatively low HDI, growing faster than the districts/cities that HDI is relatively high. It means that there is an absolute convergence. By referring to Villaverde and Maza (2009), the value of $\beta = -\left(1 - \frac{e^{-bT}}{T}\right)$, b indicates the speed of convergence where b $= \ln(\beta + 1)\,/-T$. The results obtained from the above equation b=ln(-0.006029 + 1)/-8 = -0.0007 means that the district/city with low HDI should grow at least by 0.07 percent in order to reduce the dispersion of HDI growth.

4.4. Analysis of β convergence on Conditional Human Development Index

Analysis of Conditional β convergence of HDI for districts/cities in Central Java Province for 2010-2018 periods is conducted to determine the variables that influence the development of HDI in the long term, thus leading to the equation of HDI. In this study, two variables are considered to affect the level of per capita income convergence *i.e*, health and education facilities. Conditional equation estimation β convergence cross section HDI uses data and the least-squares method (OLS). Therefore, prior to the regression analysis, this study carries out some classical assumption of regression test (*i.e*., heteroscedasticity, autocorrelation, and normality). The results can be seen in the annex, which shows that estimate β Conditional convergence equation of HDI meets all the requirements. Statistical analysis with individual and simultaneous tests 0.760753 means that the explanatory variables are able to explain the behavior of HDI change during the study period at 76.07 %.

Table 5 below shows estimates of the variables predicted to be the cause of disparities in HDI districts/cities in the Central Java province. The table shows the four variables simultaneously significant influence (Test F), but through the individual test, there is one variable, *i.e*., HF (health facilities) that does not influence significantly with the probability value of 0.2628 (>0.05).

Based on Table 5 below, the regression equation is formulated as follows:

$$\left(\frac{1}{T}\right) LN\left(\frac{hdi_{2018}}{hdi_{2010}}\right) = 0.004 - 0.027\, LN\,(hdi_{2010}) + 0.001\, LN\, ICAP_{2010} - 0.002 lN\, EF_{2010} + 0.0007\, HF_{2010} \quad (9)$$

Equation (9) above shows the level B conditional convergence which is happening at - 0.027<0 meaning that HDI districts/cities in Central Java Province tend to converge or relatively low where HDI originally developed more quickly. As for the per capita income variable (ICAP) of 0.001 and significant, so that when the per capita income increases by 1 percent, the divergence increases by 0.01 percent. It can be interpreted that income per capita more encouraging HDI in the region is relatively high. The finding of this study coincides with Mazumdar (2002), Sutcliffe (2004), Noorbakhsh (2006), Konya and Guizan (2008), Molina and Purser (2010), Mayer-Foulkes (2010), *etc*. who found that low-income countries succeeded in improving their HDI better than high-income countries.

Table 5. EstimationConditional β convergence HDI

Dependent Variable: GROWTH				
Method: Least Squares				
Date: 02/06/19 Time: 09:33				
Sample: 1 35				
Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003625	0.003330	1.088687	0.2850
LOG(HDI_2010)	-0.027101	0.003616	-7.495395*	0.0000
LOG(ICAP_2010)	0.000901	0.000492	1.830376**	0.0771
LOG(EF_2010)	-0.002326	0.001411	-1.64791***	0.1098
LOG(HF_2010)	-0.000679	0.000734	-0.924234	0.3627
R-squared	0.760753	Mean dependent var		6.25E-05
Adjusted R-squared	0.728853	S.D. dependent var		0.001944
S.E. of regression	0.001012	Akaike info criterion		-10.82218
Sum squared resid	3.07E-05	Schwarz criterion		-10.59999
Log likelihood	194.3881	Hannan-Quinn criter.		-10.74548
F-statistic	23.84836	Durbin-Watson stat		1.599495
Prob(F-statistic)	0.000000			

Note: * denotes significant level at <0.01, meanwhile, ** and *** denote significant level at <0.10 and <0.15 respectively

Moreover, the health facilities despite show a direction pressing convergence, however, it is not statistically significant. It happens probably because of this study uses the number of health centers without considering the quality of those health centers and other variables such as the number of hospitals, hospital quality, and the condition of paramedics in the districts/cities in the Central Java province. While educational facilities significantly affect the acceleration of convergence of HDI. It means that by more educational facilities, especially at the primary level to secondary expand citizen access to complete their education up to at least the level of senior high school.

Conclusion

Data is collected from 35 districts/cities in the Central Java province, Indonesia for 2010-2018 periods. The findings of this study conclude that:

- HDI disparity between districts/cities in Central Java province is still relatively low, and tends to be even lower;
- during the 2010-2018 periods there is a convergent sigma which means the disparity of HDI in between districts/cities in Central Java Province is getting lower;
- the overall observation periods show the absolute convergence, indicating the growth of districts/cities with the HDI initially relatively low, growing faster than districts with the HDI relatively high;
- the acceleration of convergence of HDI in Central Java Province is more driven by education facilities rather than per capita income or health facilities.

Even though there are several limitations such as in measuring health facilities which only calculates the number of health facility center without considering the quality of facilities, this study contributes a piece of empirical evidence with regard to the economic research area, particularly in HDI topic. Therefore, other researchers interested in HDI assessment may expand coverage such as district/city characteristics or local government service facilities. Moreover, this study also contributes to the local governments, particularly in the Central Java Province in term of the policymaker to reduce the HDI disparity between districts/cities.

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The Current Legislative Framework of Family Owned Small and Medium Enterprises: Case Study of the Czech Republic and Poland

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Abstract:

The research activity of the authors has focused on the synergy between family business and the legal environment in the Czech Republic. The findings are grounded in the empirical research conducted in more than 300 small and medium sized family enterprises in the Czech Republic and Poland. The paper examines especially the aspects of family business handover and the legal environment of the family entrepreneurship. The aim of the paper is to identify the key factors of development of family business in culturally close "post socialist" countries (the Czech Republic and Poland) in general and especially in relation to handover of family business to successors and the legal environment. To meet the research objective, a questionnaire survey was conducted in the Czech Republic and Poland. The paper points out theoretical dilemmas and practical disparities that arise as a result of underestimating the importance of family business development in the era of Industry 4.0 The main contribution of this study is to formulate a set of recommendations to support the family businesses regarding its definition and status in the legal framework. The presented findings deserve a wide theoretical discussion and further verification in practice with regard to new variants of dependence of family business and entrepreneurial environment in the Czech Republic.

Keywords: family businesses; small and medium enterprises; business environment; legal framework; legislative framework

JEL classification: D22; L26; M12

1. Introduction

The SME sector is an essential part of the business sector (Ključnikov, 2016), as well as an important prerequisite for regional development. Development of the business sector determines the regional development and also the competitiveness (Pietrzak *et al.* 2017, Beck 2016, Zimon 2018). The SME sector has been examined by many professionals, not only in the field of management and economics, but legal perspectives have also been applied. The importance of family businesses as a part of the SME sector is mentioned by numerous experts *e.g.* De Alwis

(2016), Ključnikov and Majková (2016), Martyniuk (2016) and Machová *et al.* (2017), Hudáková, and Dvorský (2018), Virglerová (2018). Family businesses, compared to non-family enterprises show many differences. Family businesses are often established and conduct their activity in the field larger enterprises do not succeed, or other entrepreneurs do not find attractive. It is worth mentioning the existence of different cooperation forms of SMEs e.g. establishing of business networks. SMEs require and increased attention and support on the level of nation states, as well as the EU. The issue was discussed in details by Havierniková *et al.* (2017), Kordoš (2015), Wyrwa, (2018), Havierniková *et al.* (2018), Nesterak and Gródek-Szostak (2016). The economic-managerial approach of the issue has been discussed by many authors. Less authors address the economic-legal framework of the family entrepreneurship and business support (Macháček 2017). It was the main motivation to conduct an empirical research and evaluation of data obtained in the context of legal regulations of family enterprises.

More than ten years of practical and theoretical research of entrepreneurship, competitiveness and innovation dynamism of family business resulted in generalization of findings and formulation of theoretical point of view about the current concept of family entrepreneurship. The presented findings were deduced from cognition of real economic and social development in the Czech Republic and Poland. The empirical research was carried out in 305 small and medium sized family businesses. It deals with specific findings from the Central European "post-socialist" region that experienced many fundamental turbulences of evolutionary and revolutionary nature in the last 150 years. This fact is projected onto the entrepreneurial environment, especially the legal framework in the Czech Republic that is less favorable to family business in comparison with those for example in Austria, Switzerland or Italy. It is necessary to point out the theoretical dilemmas and practical disparities that arise as a result of underestimating the development of family businesses in the era of Industry 4.0. The findings presented in this paper deserve a wide theoretical discussion and further verification in practice with regard to dependence of new synergic bonds of family business and the entrepreneurial environment in the Czech Republic.

The paper examines especially the aspects of family business handover and the legal environment regarding family entrepreneurship. These aspects seem to be very topical at the moment, due to ageing of founders of family companies, as well as the dynamism and development of the contemporary legal framework. The originality of the paper is based on empirical and up-to-date data from the surveyed countries. The comparison of these countries in the area of family businesses can bring new perspectives and solutions to this field of study.

2. Literature review

The team of authors approached the following definitions and methodological background. The topic of family companies is still up-to-date, lately it has been widely discussed abroad and in the Czech Republic.

Foreign authors, for example Vallone (2013), Siakas *et al.* (2014) focus them researches especially on finding a unified definition and they appeal at necessity of its approval, so the family companies could be better quantified, researched and compared. Authors from the Czech Republic have addressed this issue as well, for example Korába (2018), Mura and Mazák (2018), from Poland Lewandowska and Stopa (2018) or Balcerzak and Pietrzak (2016). The discussed issues solve various aspects of family companies. As an example can be mentioned the research of Machek (2017), Mészáros (2018), Horecký (2018), Lorincová (2018), Žuľová *et al.* (2018), who is concerned with position of employees in companies, or the work of Bílková (2017), who focused in her research on comparison of performance of family and nonfamily companies. The study of Antlová (2017) concentrated on studying the impact of family companies on region and community.

As the problem of handover of family companies' approaches, more and more research activity is focusing on handover in family companies. It is also addressed by the studies of foreign authors as Kwan (2013) and Shen (2011). These studies focus on the problem of handover in Chinese companies. In the Czech Republic, the topic of succession and inheritance of family companies is analyzed from different perspectives. Horčičková (2017) and Stamfestová (2016) examine this topic mainly from the perspective of management and planning of the handover process. Asmalovskij, Hradský and Sadílek (2017) focused on general analysis of state of succession in the Czech Republic. Other research studies focus on tax aspects and impacts of inheritance of enterprises (Hodinková 2015), or the impacts of the new Civil Code on family businesses (Janků 2017).

Based on the literature overview, it can be stated that the analyzed topic is examined abroad and in the Czech Republic as well. Foreign literature and studies deal in no way with the state of legal environment in the Czech Republic. However, the issue gained increased importance in the Czech Republic, nevertheless, there are still missing more complex studies that would examine the contemporary legislation in terms of taxes, inheritance, handover, sale of enterprises and their impacts on management, development and possibilities of succession in family companies.

Entrepreneurship is a process of creating something different that results in financial and personal satisfaction (Hishrich *et al*. in: Mikoláš 2016).

The core characteristic of the family business is that family members own and run the business. The family and entrepreneurial environment overlap. The contemporary (entrepreneurial) environment absorbs both global and local factors of family existence and entrepreneurship and it is also very turbulent (Mikoláš, Zamarský, Fialová, Nikolskaja, Virglerova, Dobes, Vojtovic 2016). Family business is defined by synergy (unification) of 4 subsystems, or more precisely by circles Mikoláš, Karpeta *et al*., Blava, Wisla, Amerika aj.): family, enterprise (family business), environment, outputs.

3. Research aim and methodology

The aim of the paper is to identify the key factors of development of family business in culturally close "post socialist" regions in the Czech Republic and Poland, especially in relation to handover of the family business to successors and the legal environment. There are two research questions to answer:

- What are the main reasons for not handing over the family business to successors?
- What are the main legal barriers of family business?

The research of family business sector is different from the research approach of businesses falling into other category. It is necessary to process not only quantitative data but also the data obtained during the interview survey. The qualitative analysis plays an important role in the research of family enterprises.

The findings presented in the paper rely on application of especially diagnostic approaches, including diagnostic mission in family businesses (Mikoláš 2016), critical analysis, descriptive statistic methods and synthesis, based on propositional calculus and Boolean logic in empirical research of hundreds of companies. For the purposes of this paper, 305 small and medium sized family companies in the Czech Republic and Poland were examined (in each of the mentioned enterprises diagnostic mission was realized and diagnostic anamnesis in the presence of company owner was processed) (Mikoláš, Karpeta, Mikolášová 2016, Mikoláš, Karpeta 2016).

The number of businesses involved in the survey seem to be adequate. The minimum number of participants is 156 for the expected deviation of basic cohort 4% and allowable rate of deviation 1% by required 95% certainty. The number of enterprises involved in the research in the Czech Republic (MVČR) exceeded the required minimum number of participants.

The research presented in this paper can be divided into three main phases. In the first phase, a questionnaire was applied in the regions of Czech Republic and Poland. The initial research sample in the Czech Republic counted 163 family businesses and it examined the innovation potential and competitive ability of the enterprises. The reference sample from Poland (the Voivodeship of Upper Silesia regions) counted 72 family businesses, applying the same methodological principles as it was applied in the Czech Republic. This paper above all discusses the aspect of handover of family business to successors and the reasons why handover of the business was not realized. Based on the results and comparison of results of both research samples (from Czech Republic and Poland) followed by casual analysis, the second phase of the research was carried out in the Czech Republic. It focused on most frequent restrictions of family business in the Czech Republic, namely the legal framework. Four main legal aspects were examined: the transfer of the enterprise, selling the enterprise, entering the stock exchange and the issue of taxes.

During this research phase, 70 enterprises were contacted and divided into two research samples according to regional specifics: a) Bohemia, b) Moravia and Silesia. The third phase of the research presents a discussion and analysis of legal framework of family business in the Czech Republic. It should identify main problems for family business concerning the legal framework. The results gained by own research were confronted with findings of partner universities in Slovakia, School of Economics and Management of Public Administration Bratislava and in Poland, Uniwersytet Ekonomiczny w Katowicach (Mikoláš, Karpeta, Mikolášová 2016, Mikoláš, Karpeta 2016). As a key contribution of the paper, a set of recommendations to support the family business regarding its definition and status in the legal framework is formulated.

4. Results of field research in the Czech Republic and Poland

Initial empirical research was conducted on a sample of 235 small and medium sized family businesses in the Czech Republic and in Poland. The statistical results of research in both countries are summarized in following table. The research in selected regions of Czech Republic took place in 2017 and at the beginning of 2018. The research sample is made up of 163 family enterprises.

Table 1. Statistical summary of research results in the Czech Republic

Answers concerning summarizing questions about handover of family company to successors	Number of answers provided by enterprises	Number of answers provided by enterprises (%)	Number of answers provided by enterprises (%)	Notes
I/Handover took place	31	19		
II/Plan of handover is worked out/prepared	12	7.4		
III/Plan of handover isn't prepared:	105	64.4		
III a/successors do not exist	10		9.5	
III b/owner is not interested in handover of the company	19		18.1	
III c/family members are not interested/competent to take over company	57		54.3	Out of: c1) incompetent successors (no proper qualification): 20; c2) incompetent successors (young, under 20 years of age or students): 34; c3) successors aren't interested: 3
III d/other reasons	19		18.1	Out of: d1) succession is considered (over 20 years, working in company, collecting experience): 18; d2) succession will be solved by inheritance procedure: 1
IV/ no answer, unclear answer	15	9.2		
Number of examined family businesses N =	163	100 %	100 %	

Source: authors of the paper

Poland

Research in selected regions of Poland took place in 2017 and at the beginning of 2018. The research sample is made up of 72 family enterprises.

Table 2. Statistical summary of research results in Poland

Answers concerning summarizing questions about handover of family businesses to successors	Number of answers provided by enterprises	Number of answers provided by enterprises (%)	Number of answers provided by enterprises	Answers concerning summarizing questions about handover of family businesses to successors
I/ Handover took place	23	31.9		Out of: succession just took place, new owner is too young, hasn't children yet: 1
II/ Plan of handover is worked out/prepared	19	26.4		
III/ Plan of handover is not prepared:	27	37.5		
III a/ successors do not exist	4		14.8	
III b/ owner is not interested in handover of the company	0		0	
III c/ family members are not interested/competent to take over company	16		59.3	Out of: c1) incompetent – young, under 20: 8; c2) incompetent – young, over 20: 2; c3) successors aren't interested: 4; c4) little experience: 1; c5) company is new on the market: 1.
III d/ other reasons	7		25.9	Out of: d1) there is no suitable candidate: 3; d2) successor works in the company, however succession in company is being planned, but it has not been realized yet:

Answers concerning summarizing questions about handover of family businesses to successors	Number of answers provided by enterprises	Number of answers provided by enterprises (%)	Number of answers provided by enterprises	Answers concerning summarizing questions about handover of family businesses to successors
				1; d3) succession should be realized: 1; d4) successor has no adequate qualification: 1; d5) the founder of the company isn't considering succession at moment: 1.
IV/ no answer, unclear answer	3	4.2		
Number of examined family businesses: N =	72	100 %	100 %	

Source: Mikoláš, Karpeta (2017)

Partial differences of results gained in the Czech Republic and Poland are obvious from following comparison of succession process (evolution of potential) of family entrepreneurship.

Results in the Czech Republic in percentage (total 100%)

Table 3. A-CZ Handover of family businesses to successors

I took place	II planned	III not planned	IV no answer
19.00	7.4	64.4	9.2

Source: authors of the paper

Table 4. B-CZ Reasons for not handing over the family businesses

IIIa no successors	IIIb lack of interest of the owner	IIIc - lack of interest of the successors (incompetence)	IIId other reasons
9.5	18.1	54.3	18.1

Source: authors of the paper

Results in Poland in percentage (total 100%)

Table 5. A-PL Handover of family businesses to successors

I took place	II planned	III not planned	IV no answer
31.9	26.4	37.5	4.2

Source: Mikoláš, Karpeta (2017)

Table 6. B-PL Reasons for not handing over the family businesses

IIIa no successors	IIIb lack of interest of the owner	IIIc - lack of interest of the successors (incompetence)	IIId other reasons
14.8	0	59.3	25.9

Source: Mikoláš, Karpeta (2017)

Partial synthesis of findings is presented in tables (first two research phases). The Czech Republic shows a significant influence of historical factors, which developed differently in Poland. In the period from 1938 to 1989, the entrepreneurship was significantly suppressed in Czechoslovakia. However, the pressure on family business was not so strong in Poland after 1945. It is the reason, why the SME sector has longer history and experience in Poland. The majority of family business have longer history. Entrepreneurship and family businesses in the Czech Republic restarted their activity and started to develop after 1990. As a consequence of this, the results of research (mentioned above) are partially different, but they basically confirm analogous standard trends.

In the Czech Republic, handover of family business to successor occurred (to date of realized research) in 19% out of examined enterprises. The owners of these enterprises started their business after the economic and political change of the 1990, at the age of 40 or older. In Poland 32% of the enterprises are handed over to successors because of the above mentioned reasons. Bigger difference can be seen by family businesses, where there is a plan to handover the enterprises to successors. In the Czech Republic it is only 7,4%, whereas in Poland it is 26,4%. The other cases concern those enterprises, where there is clear lack of interest of either owners or

successors in handover of the family businesses. The plan to hand over the enterprises is not worked out or other reasons emerged, which are not discussed in details.

5. Special research on the legal framework of family business in the Czech Republic

The research sample discussed above was expanded with research data about 70 family businesses, in order to investigate the impact of the legal environment on family enterprises in the Czech Republic. With regard to evident culture specifics and differences of the business environment, the research was structured into two regional subsystems: a) Bohemia (bohemian regions including the region of Vysočina), b) Moravia and Silesia (the South Moravian, Zlín, Olomouc and Moravian-Silesian regions). The respondents were asked the following questions: How advantageous/disadvantageous the legal regulations are regarding the transfer of enterprises (inheritance and gifts); regulations regarding selling the enterprise; regulations about entering the stock exchange and tax regulations. Respondents were provided a scale to evaluate the legal environment of businesses as the following: disadvantageous, rather disadvantageous, hard to evaluate, rather advantageous, advantageous.

The following research findings can be summarized: representatives of family businesses commented on the current legal framework regarding family entrepreneurship. Tables 6 and 7 offer a summary of answers from regions Bohemia, Moravia and Silesia. The questionnaire survey was answered by 70 respondents; question c) remained unanswered by one of the respondents, so to total number of received answers is 69.

Table 7. Total results (absolute frequency)

		1 - disadvantageous	2 - rather disadvantageous	3 -hard to say/evaluate	4 - rather advantageous	5 - advantageous	Total
a.	Legal regulations for transfer of company (inheritance, gifts)	1	9	22	30	8	70
b.	Legal regulations regarding selling the company	6	17	27	18	2	70
c.	Legal regulations entering the stock exchange	11	14	32	8	4	69
d.	Tax law and regulations	11	26	15	10	8	70
Total		29	66	96	66	22	

Source: authors of the paper – own research

Table 8. Total results (relative frequency)

		1 - disadvantageous	2 - rather disadvantageous	3 - hard to say/evaluate	4 - rather advantageous	5 - advantageous	Total
a.	Legal regulations for transfer of company (inheritance, gifts)	1.43	12.86	31.43	42.86	11.43	100
b.	Legal regulations regarding selling the company	8.57	24.29	38.57	25.71	2.86	100
c.	Legal regulations entering the stock exchange	15.94	20.29	46.38	11.59	5.80	100
d.	Law and regulations	15.71	37.14	21.43	14.29	11.43	100

Source: authors of the paper – own research

Especially the tax law and legal regulations were evaluated as disadvantageous; rather disadvantageous answer was provided by 37 respondents in total, i.e. 53%. In case of entering the stock exchange it was 25 respondents in total, *i.e.* 36%. On the other hand, evaluation of legal regulations regarding transfer of company to successor is advantageous and rather advantageous –38 respondents in total, *i.e.* 54 %. 23 respondents (33%) evaluated the legal regulations regarding selling the company as disadvantageous and rather disadvantageous, as well as 20 respondents (29%) felt them advantageous or rather advantageous.

Table 9. Results Bohemia (relative frequency)

		1 - disadvantageous	2- rather disadvantageous	3 - hard to say/evaluate	4 - rather advantageous	5 - advantageous	**Total**
a.	Legal regulations for transfer of company (inheritance, gifts)	0.00	16.67	20.83	41.67	20.83	100
b.	Legal regulations regarding selling the company	0.00	45.83	25.00	25.00	4.17	100
c.	Legal regulations entering the stock exchange	20.83	0.00	54.17	8.33	16.67	100
d.	Tax law and regulations	8.33	37.50	16.67	20.83	16.67	100

Source: authors of the paper – own research

Table 10. Results Moravia and Silesia (relative frequency)

		1 - disadvantageous	2 - rather disadvantageous	3 - hard to say/evaluate	4 - rather advantageous	5 - advantageous	Total
a.	Legal regulations for transfer of company (inheritance, gifts)	2.17	10.87	36.96	43.48	6.52	100
b.	Legal regulations regarding selling the company	13.04	13.04	45.65	26.09	2.17	100
c.	Legal regulations entering the stock exchange	13.33	31.11	42.22	13.33	0.00	100
d.	Tax law and regulations	19.57	36.96	23.91	10.87	8.70	100

Source: authors of the paper – own research

The research results differed according to the region (Bohemia, Moravia, Silesia) the respondents come from. Respondents from Moravia and Silesia felt tax regulations and law more disadvantageous than the respondents from Bohemia. While 57% of respondents from Moravia and Silesia evaluated tax law and regulations disadvantageous or rather disadvantageous, only 45% of Bohemian respondents provided the same answer. On the other hand, 20% of respondents from Moravia and Silesia expressed satisfaction with tax regulations. Satisfaction was expressed by 36% of Bohemian respondents.

The evaluation of answers regarding the legal regulations that influence the operation of family businesses, the Bohemian respondents proved to be more positive compared to respondents from Silesia and Moravia. The tables, summarizing the results clearly show that they felt legal regulations disadvantageous or rather disadvantageous, while Bohemian respondents provided an opposite answer. They felt the legal regulations advantageous or rather advantageous.

At the end of the chapter it is necessary to summarize the following findings. Legal consciousness of family businesses also depends on cultural and social differences, historical factors, life styles of regions, etc. It means that entrepreneurial environment and legal framework in the Czech Republic are “subjectivised” by family businesses and families through subjective (often emotional) perception of family entrepreneurs and the members of their families.

6. Discussion and summary of findings

The experts have been for a longer period of time discussing the necessity of elaborating a single definition for family entrepreneurship. According to Vallone, it would make possible to examine and compare family businesses more precisely including the results of international research. He emphasized handover of business to next generation in the family as a characteristic feature of family enterprises (Vallone 2013, Mura and Ključnikov 2018). This statement hides several questions regarding the inheritance issues of the business.

The question of inheritance of family businesses, as a condition for development is addressed by Korába and Murínová (2018), especially in case of delegating the authority and developing strategic business model in the company.

Our research expands the field of discussion about the necessity of implementation of adjustment of legal framework of family business into the Czech legislation. Findings gained by research in 70 family businesses (see chapter 4) were confronted with the Czech legislation at the beginning of 2018. Disregarding different views of specification or definition of family business and the findings of our research, the family business, similarly to other types of business has to follow relevant legislation norms, which adjust entrepreneurship. However, the current

legislation in the Czech Republic arises a number of dilemmas for family enterprises. Therefore, a draft of definition is discussed in expert groups, which is presented by AMSP ČR (Association of Small and Medium sized Enterprises and Self-employed Persons of the Czech Republic). The following types of business entities are recognized (https://www.podnikatel.cz/clanky/rodinne-podnikani-by-mohlo-ziskat-definici-v-zakone-a-v-budoucnu-i-podporu/):

- Family enterprise is a family trading company, self-employed in family business or family farm;
- Family trading company is a trading company whose shares are owned with overall majority by members of one company, and at least one member of this family is member of its statutory organ. A trading company is also considered to be a family trading company, if its shares are held or owned with overall majority in favor of one family by foundation or by wardship fund, and at least one member of the family is at the same time a member of the statutory organ of the foundation or wardship fund;
- Self-employment is a trade entrepreneurship at which at least two members of family participate with their work or property and at least one member of family is a holder of trade license;
- Family farm is an agricultural manufacture, at which at least two members of family participate by their work or property and at least one member of family is a holder of relevant certificate.

A few questions arise:

- how does the suggested definition correspond with the already existing legislation adjustment about the family entrepreneurship?
- how the mentioned draft adjustments can solve the problems of family businesses identified by the field research of authors of this paper (see chapters 3 and 4)?
- is it possible to find a support for this draft proposal and restrictions in other legislation norms?

If individual terms are discussed, such as family, entrepreneur, enterprise or company in terms of legislation, then the Czech legislation defines only some of these terms.

As stated above, especially sociology focuses on the topic of family. Family is not explicitly defined in legal codification, and it is therefore possible to consider the definition of family, and the family law, which is primarily defined in § 655-975, where especially the origin and termination of marriage, rights and duties of the married couple and relation between the parents and children are solved.

Entrepreneur is subsequently defined by Act 89/2012, Civil Code, § 420-435. The Civil Code also specifies that persons registered in business register are entrepreneurs, when they are persons who carry out their entrepreneurship on the basis of trade or other authorization according to another act (Act 455/1991, Trade Licensing Act). The entrepreneur can perform his entrepreneurial activity as natural person or as legal entity; whereas individual forms of cooperation or involvement of other persons are limited just by possibilities and restrictions of these legal forms of entrepreneurship.

The Civil Code subsequently specifies individual components of entrepreneurship, which are used by the entrepreneur for his entrepreneurial activity. These components are defined as trade company (hereinafter company) that is presented by “organized set of assets that an entrepreneur created and that serve to run the activity. The company constitutes everything which serves its operation”.

According to § 700-707 Act 89/2012, a company is considered to be a family enterprise if a married couple or at least one person from the married couple and their relatives up to third degree, or persons-in-law of the married couple up to second degree work there, and which is in ownership of one of these persons. Those, who continuously work for a family or for family business are considered to be family members participating in operation of the family company (“Nový občiansky zákonník”).

On the other hand, this act also clearly defines when it is not possible to use this specification, including the specification of rights and duties of family members who participate on operation of the family enterprise.

If above mentioned facts are summarized, a partial conclusion could be reached. According to Act 89/2012 Col., family business is defined as the following: a natural person doing business, where other family members participate actively at entrepreneurship. At the same time, neither they join this entrepreneurship as associates, nor they carry out this cooperation on the basis of labor-law relation. The family business is a set of assets that the entrepreneur created in cooperation with other family members. It serves the everyday operation of the company (if we apply the rights and duties in the definition of family company acc. to § 701-707 Act. 89/2012 Col., Civil Code).

In other terms of meaning, the term family business cannot be applied since regulations of law cannot be applied[1] about the rights and duties of family members participating in family business operations, and their rights and duties follow completely different legal regulations.

The comparative analysis of legal regulations in the Czech Republic confirms a legitimate negative attitude of the survey respondents (see chapter 4) and criticism of "unpleasant" legal framework for family business in the Czech Republic.

Family trade businesses, as proposed by AMSP ČR, will be dealt with in accordance with the Corporations Act. Conditions for their operations are determined by this act.

A further alternative in self-entrepreneurship is the self-employment and family farms. If the term "family business" is also applied for self-entrepreneurs and family farms, several obstacles appear that might endanger and make these forms of family entrepreneurship disadvantageous.

If the main goal of new definition provided by AMSP ČR is to specify the term family entrepreneurship, it is also important to specify the conditions of exercising the rights and duties regarding the establishment of family businesses. In general, family members have only two possibilities how to join the family business:

- co-worker – formally realized cooperation when the person co-working on the basis of formally and factually carried out cooperation – so called "co-working person";
- co-worker – informally realized cooperation as a co-working person on the basis of informally and factually realized cooperation.

The informal cooperation is a typical form of family business. The same conclusion is reflected in the second phase of the international research "Analysis of development and state of SME entrepreneurship in Slovakia and the Czech Republic" that was carried in cooperation with University of Entrepreneurship and Law in Ostrava and School of Economics and Management of Public Administration in Bratislava in 2015. The research results emphasize that the main goal of family entrepreneurship is to gain satisfaction from work performance and profit. This serves as a basis for company development (Hudáková *et al.* 2015). Some of the family members are not involved in family business to share profit, but their presence has different motivation than economic one.

If we consider cooperation in terms of legal regulations, the existing discrepancies in legal norms and regulations are evident.

The Civil Code, § 701 specifies that family members participating in operation of family business share the profit corresponding to the amount and type of their work. Only a competent person on legal basis can give up this right, in the form of official declaration.

Simultaneously, § 702 of the Civil Code specifies the extent to which the profit is used. It is defined as the following: "Decisions how to use the profit from family business or its growth, as well as the decision regarding issues concerning extraordinary economic activities, including the changes of the basic principles of enterprises operation or liquidation of the company are accepted by majority of votes of family members, participating in operation of family business. If the person is not competent, the legal representative acts on behalf of this person.

Comparing the rights and duties of family members defined in first regulations, some discrepancies can be detected. According to the Civil Code, the family members share the profit corresponding to the extent and type of work they conduct in the business, as well as distribution of income and expenses between the family members are directly specified, and are in direct conflict with the specifications of Civil Code.

If we study the Income Tax Act § 23(7), it is not surprising that family businesses choose the form of classical entrepreneurship and establish limited companies.

Discrepancies in the legislation, the specification of family enterprises, the needs and characteristic features of this business sector are not completed, neither the new definition provided for family enterprise is not sufficient. Without revision of regulations addressing the issue of family entrepreneurship, any kind of definitions would be useless and have very limited use in business practice.

Obvious disparities emerge if we compare attitude of family businesses the current legislative framework in the Czech Republic. These discrepancies need an efficient solution, in order to avoid negative impacts on entrepreneurship in this specific segment.

Drafts of AMSP ČR are considered to be a desirable background not as final version of legislation adjustment of family business in the Czech Republic. The authors consider the idea of independent legal regulation addressing the family enterprises non-systematic and non-conceptual.

Conclusion

The presented paper deals with the key factors of family entrepreneurship. The handover of family business to successors and the legal framework seem to be important aspects of the family business environment. Our research addresses the necessity of implementation of the legal framework of family business into the Czech legislation. Based on theoretical approaches and practical experience, the authors of this paper find the legal norms regarding the family enterprises non-systematic and non-conceptual. The authors propose the following recommendations:

- conduct in-depth statistical research in order to get information about the real number and situation of the family business sector in the Czech Republic (the statistical research should be processed by the Czech Statistical Agency based on the methodology in accordance with the Civil Code §700 and related paragraphs);
- to complete those parts of the Civil Code devoted to entrepreneurship and economic-activities;
- to provide a comprehensive definition of family entrepreneurship and elaborate it into all relevant Acts (Accountancy Act, Income Tax Act, Labor Code *etc.*) and legal regulations.

Elaboration of a new definition about family entrepreneurship provides a motivation to start professional discussion and determine the direction of the research. There are several objectives of research that should be addressed. The incomplete definition of family business and the lack of quantification of analyzed subjects seem to be significant obstacles to current research.

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Inflation and Growth in Indonesia: The Nexus and Threshold

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Abstract:

The intense discussions on how inflation affects the growth have triggered many studies to empirically investigate it. This paper is not an exception. The previous research in Indonesia focusing on how inflation and growth are correlated, and various thresholds of inflation suggested have provided puzzling indicators. Therefore, this paper aims to examine the impact of inflation on the growth in Indonesia by employing *Autoregressive Distributive Lag* (ARDL) technique, *Threshold Regression* (TR), and quadratic regression. ARDL is applied to reveal the nexus in the short-run and long-run whereas the TR and quadratic regression are employed to find the threshold of inflation. In the short-run and long-run time frame, the relationships are found to be a negative interaction between inflation and growth. Moreover, this paper empirically proves that the inflation threshold exists at the level of 14.31% after comparing two different approaches' results. Eventually, the finding of this paper suggests a room for less tight monetary policy that can be applied.

Keywords: inflation; growth; threshold regression; quadratic regression; Indonesia; ARDL

JEL Classification: C01; C58

1. Introduction

Inflation as a macroeconomic indicator that reflects the overall increase of price level is often justified as an unfavorable condition to people (Shiller 1997). Classically, the cost of inflation is addressed as a fall for the real wage as well as the purchasing power of people. On the other hand, economists see inflation as broader perspectives. Mankiw (2009) elaborated the cost inflation within two different impacts, the cost of expected inflation and the cost of unexpected inflation. He mentioned that the costs of inflation drag the policymakers to situate zero inflation. However, he also provided one favorable impact of inflation. Low inflation can be a good thing when it could provide a better labor market. Low inflation simply pulls the real wage back to the equilibrium level in which the unemployment rate yielded is lower.

The nexus between inflation and economic growth has been a popular topic to observe among economists. The impact of inflation could be positive or negative to economic growth mostly depends on the time of observation, measurement method, and country. Further, in Indonesia, suggested inflation thresholds (the boundary when inflation is considered beneficial for economic growth) by many researchers were heterogeneous. Therefore, this paper aims to provide a comprehensive approach and consideration to suggest a better inflation threshold for Indonesia.

2. Literature review of inflation and growth: Theoretical background and empirical evidence

The nexus between inflation and economic growth (hereafter growth) can be inferred from distinguished theories. *The Classical Growth Theory* suggested that higher inflation could lead to an increase in the nominal wage. Consequently, the higher cost burdened by the firms to pay higher wage could deaccelerate the process of production; thus, the growth drops. Here, the impact of inflation is implicitly negative on the growth. The *Keynesian Theory* divided the impact of inflation on the growth based on the short-run and the long-run interaction of Aggregate Demand (AD) and Aggregate Supply (AS). In the short-run, the impact is positive whilst in the long-run the impact is negative. The third theory that explained the inflation-growth nexus was *Monetarism Theory*. This theory implied in the long-run, the inflation is affected by the money's growth rate but with no effect on the growth (neutral).

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Another theory was *Neo-Classical Growth Theory* which puts more analysis on the variables such as capital, money growth, and consumption behavior of people. Tobin (1965) explained that inflation is positively related to growth. The higher inflation would put the real value of money down; thus, people would spend the money on capital. The increase of capital formation as an impact of higher inflation would stimulate growth. The impact of money growth on inflation would not put any impact on the growth was justified by Sidrauski (1967). He supported the theory of super-neutrality of money from *Monetarism*; hence, the impact of inflation on the growth is neutral. The consumption behavior of people was investigated by Stockman (1981) regarding the study of inflation and growth relationship. When inflation occurs, people will decrease their consumption both in goods and capital because of the shortage of purchasing power. Therefore, consequently, the capital formation would decline and push the growth down. The other theory as a comparable theory is the *Endogenous Growth Theory*. This theory highly puts not only on the physical capital but also on the human capital. The rate return of such capitals could impede the growth as it relates to the existence of inflation. The higher inflation puts the rate return of capitals down; therefore, the growth declines (Gokal and Hanif 2004).

The empirical evidence regarding the impact of inflation on growth can be seen from previous studies conducted in many countries. If the impact of inflation is differentiated into groups, there were three groups of relationships between inflation and growth; positive, negative, and mix (threshold theory). Thirlwall and Barton (1971) conducted a cross-country research in order to obtain the relationship between inflation and growth. They found the inflation is benefiting in the industrial countries (positive effect) and unfavorable in seven developing countries (negative effect). They also suggested that when the yearly inflation exceeds 10%, the impact becomes adverse on the growth. Fischer (1983) utilized the data from 53 countries comprising of 22 advanced countries and 31 developing countries. By using a bivariate approach, he found that inflation has a negative relationship with growth. Ghosh and Phillips (1998) used panel data from IMF member countries; they found low inflation positively affect the growth; oppositely, high inflation brings adverse impact on the growth.

Khan and Senhadji (2001) employed the threshold approach to identify the appropriate level of inflation when inflation turns to unfavorable. They suggested for the industrial countries, the thresholds for inflation range from 1% to 3% whereas for developing countries, the possible thresholds are 7% to 11%. Mubarik (2005) adopted the model developed by Khan and Senhadji (2001) to investigate the threshold level of inflation in Pakistan based on the yearly data range from 1973 to 2000, and he found the threshold of inflation in Pakistan is around 9%. Frimpong and Oteng-Abayie (2010) focused their research on inflation's threshold in Ghana. They found that inflation's threshold in the period from 1960 to 2008 is at 11%. At their research, the *Two-Stage Least Squared* (hereafter TSLS) was utilized as an additional method not only to accompany the threshold regression but also to prove the robustness of the model. Rutayisire (2015), by using a quadratic regression, found the value of inflation's threshold in Rwanda which is 12.7%. More recent evidence could be found in some research conducted by Aydin *et al.* in 2016 (inflation threshold is 7.97% for Turkish Republics), Jiranyakul in 2017 (inflation threshold is 3% in Thailand), Behera and Mishra in 2017 (suggesting 4% is the threshold level of inflation in India), Tran in 2018 (inflation threshold in Vietnam ranges from 3% to 4%), and Omay *et al.* in 2018 (the values of multiple-regime inflation threshold in 10 Southern-African-Development-Community countries are 12% and 32%).

In addition, there were previous studies about the inflation-growth nexus in which mainly focusing on Indonesia case. Chowdhury (2002) managed to elaborate on the theoretical and empirical evidence of the historical inflation-growth nexus in Indonesia in the period from 1950 to 1997. The study found that there is no statistical evidence of the relationship between inflation and growth in Indonesia. Chowdhury and Siregar (2004) utilized the quadratic regression to find the threshold of inflation in Indonesia. They found inflation of 20.50% is the lower bound for the adverse impact of inflation on the growth. Chowdhury and Ham (2009) found that the inflation thresholds in Indonesia range from 8.50% to 11%, by employing a threshold vector autoregression method. A similar method that is utilizing vector autoregression with instrumental variable was conducted by Pratomo and Kalirajan (2011), suggested that the inflation thresholds in Indonesia take an interval from 2% to 7%. Widaryoko (2013) decided the threshold of inflation in Indonesia is 9.53% after comparing linear regression and threshold regression. Winarno (2014) employed the dynamic panel threshold regression approach and found that the threshold for inflation in Indonesia is 4.62%. Azis and Nasrudin (2016) utilized the panel regression with a threshold applied for provinces in Indonesia and found that the value of inflation threshold is 4.64%. Eventually, Galih and Safuan (2017) found the threshold level of inflation in Indonesia is around 5.26%. The research conducted by Galih and Safuan employed quarterly data in the period from 2000 to 2016 and examined by the threshold vector autoregression method.

Selected previous studies showed that the difference in method, country, control variables, as well as the time of observation might produce the heterogeneous level of inflation thresholds. Furthermore, the studies in Indonesia were consistent with the evidence. This paper aims to provide the nexus of inflation and growth in term

of comparison of the methods (threshold and quadratic regression), timely coverage (short- and the long-run), with the additional review from inflation targeting policy from the Indonesian government. This paper also utilizes different preliminary test for the inflation-growth nexus in short- and the long-run which is *Autoregressive Distributed Lag* (ARDL) introduced by Pesaran *et al.* (2001). This paper has 3 sections remaining: methodology, result and discussion, and conclusion.

3. Methodology

This paper employs two stages of analysis in general. The first stage observes the relationship between inflation and growth in the short-run and in the long-run time frame using the ARDL method. The second stage deeply compares the calculation of inflation's threshold using the threshold regression of Khan and Senhadji (2001) (similar with Mubarik (2005)) and quadratic regression to obtain the optimum inflation's threshold in Indonesia. There will be an additional review to examine the real data of Indonesia's inflation targeting framework and actual inflation.

This paper uses the secondary data for the first stage of analysis which retrieved from BPS-Statistics Indonesia (BPS) and the World Bank with the utilization of EViews in the processing stage. The ARDL method utilizes the variables such as economic growth (source from BPS), inflation (source from BPS), investment of fixed assets in the form of growth of gross fixed capital formation (source from the World Bank), the growth of ratio of export to import (source from the World Bank); whereas in the inflation threshold examination, the growth rate of broad money is included as variable (source from the World Bank). All variables are expressed in percentage and take the period of observations from 1970 to 2016. The ARDL model by Pesaran *et al.* (2001) for Indonesia is initially specified as:

$$GR_t = \beta_0 + \beta_1 INF_t + \beta_2 INV_t + \beta_3 EXIM_t + \varepsilon_t \quad (1)$$

where: GR_t is the economic growth at year t; INF_t is inflation at year t; INV_t is the growth rate of gross fixed capital formation at year t; $EXIM_t$ is the growth rate of the ratio of export to import at year t; ε is error term; and β is the coefficient of regression. INV and EXIM are the control variables in this model.

The procedures in ARDL approach cover: unit root test (the variables should be integrated at I(0) and/or I(1) but not I(2)), maximum lag selection (comparison for the lowest value of *Akaike Information Criteria* (AIC), *Schwarz's Bayesian Information Criteria* (SBC), and *Hannan-Quinn Criterion* (HQC)), cointegration test using *Bound Testing*, estimation of the long-run equation, estimation of the short-run equation, and model's diagnostics (checking for normality in residuals, serial correlation test, heteroscedasticity test, and model stability using CUSUM plots). The ARDL model that inferred from Equation (1) is:

$$\Delta GR_t = \beta_0 + \beta_1 GR_{t-1} + \beta_2 INF_{t-1} + \beta_3 INV_{t-1} + \beta_4 EXIM_{t-1} + \sum_{i=1}^{p} \delta_{1i} \Delta GR_{t-i} + \sum_{j=0}^{q} \delta_{2j} \Delta INF_{t-j} + \sum_{k=0}^{q} \delta_{3k} \Delta INV_{t-k} + \sum_{m=0}^{q} \delta_{4m} \Delta EXIM_{t-m} + \varepsilon_t \quad (2)$$

where: β_1, β_2, β_3, β_4 are the long-run coefficients.

If the cointegration exists in the long-run; thus, the equation of the ARDL (p,q) can be expressed as:

$$GR_t = \alpha + \beta_1 INF_t + \beta_2 INV_t + \beta_3 EXIM_t + \mu_t \quad (3)$$

where: p and q are the optimum lags in the ARDL model and μ is the long-run error term.

Estimating the short-run equation is the next step by using the *Error Correction Model* (ECM) formulated as:

$$\Delta GR_t = \alpha + \sum_{i=1}^{p} \theta_{1i} \Delta GR_{t-i} + \sum_{j=1}^{q} \varphi_{1j} \Delta INF_{t-j} + \sum_{j=1}^{q} \varphi_{2j} \Delta INV_{t-j} + \sum_{j=1}^{q} \varphi_{3j} \Delta EXIM_{t-j} + \gamma ECT_{t-1} + \varepsilon_t \quad (4)$$

where: θ and φ denoted for short-run coefficients; γ is the speed of adjustment towards equilibrium.

The second stage of this paper is to investigate the threshold level of inflation. To obtain the appropriate threshold, this stage differentiates the equation into two comparable models. The first model is the *Threshold Regression Model* adopted from Khan and Senhadji (2001) and Mubarik (2005). The first model is expressed as:

$$GR_t = \beta_0 + \beta_1 (INF_t) + \beta_2 (D)(INF_t - k) + \beta_3 INV_t + \beta_4 M2_t + \beta_5 EXIM_t + \varepsilon_t \quad (5)$$

where: variables GR, INF, INV, and EXIM are adopted from Equation (1). M2 is the growth rate of broad money as utilized by Frimpong and Oteng-Abayie (2010) in their model. D is a dummy variable in which has a value

of 1 if the INF_t > threshold (k) otherwise, 0. The value of k is considered optimum when R^2 is maximized, and the coefficient of INF is significant (the model from Equation (5) hereafter is called Model 1).

The second model is the quadratic regression model (so-called Model 2 in this paper) that previously utilized by Chowdhury and Siregar (2004) in examining inflation threshold in Indonesia. However, this paper includes some control variables to the model. The quadratic model that also adopted from Equation (1) with modifications can be expressed as:

$$GR_t = \beta_0 + \beta_1 INF_t + \beta_2 INF^2{}_t + \beta_3 INV_t + \beta_4 M2_t + \beta_5 EXIM_t + \varepsilon_t \quad (6)$$

where: the expected value of β_1 is > 0 and β_2 is < 0; so, the first derivative of the quadratic regression with respect to INF will be yielding the optimum value of INF (denoted by INF*) when the first derivative of the Equation (6) is equal to zero.

Equation (6) becomes:

$$\frac{\delta GR_t}{\delta INF_t} = \beta_1 + 2\beta_2 INF_t = 0 \quad \text{thus} \quad INF_t{}^* = \frac{-\beta_1}{2\beta_2} \quad (7)$$

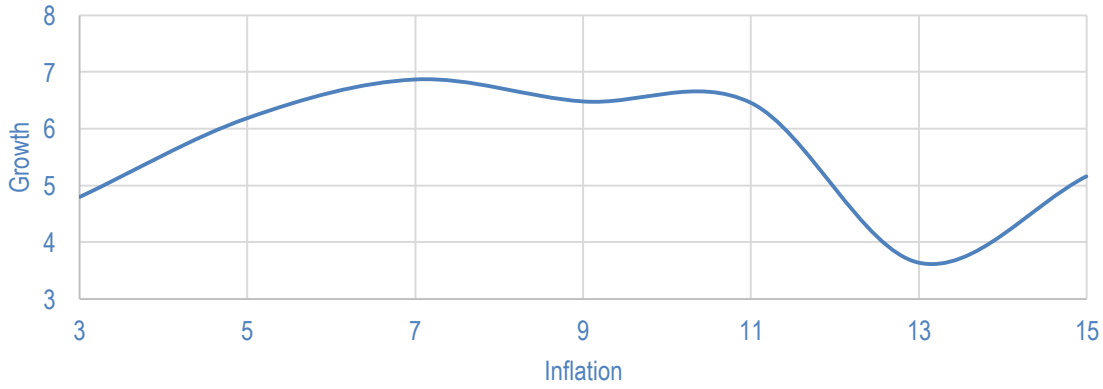
After all models provide the optimum value of k and pass the mandatory diagnostic checks (normality, serial correlation, and heteroskedasticity); sequentially, the value of R-squared, Adjusted R-squared, Sum Square Residuals (SSR), AIC, SC, and HQC from both models will be compared to obtain the better model's estimation. Additionally, there will be a review for the value of k regarding the experience from Indonesia's targeting inflation and the actual inflation in the period from 2001 to 2017.

4. Result and discussion

Previous studies in Indonesia were focusing on the relationship between inflation and growth as well as calculate the inflation's threshold yielded various thresholds. This is because of the difference in the method, control variables, and time span. Conventionally, the relationship between inflation and growth could be depicted in a graph using the method utilized by Mubarik (2005). The procedures are simple by sorting the values of inflation, grouping them into the respected numbers, and calculating the average growth in each group. This paper provides an example of grouping the inflation into the rate of 3%, 5%, 7%, 9%, 11%, 13%, and 15% (and above). By taking the interval by 2% starting from 3% of inflation, the result can be seen in Figure 1.

Figure 1 shows the graph from the average growth in relationship with its inflation level in Indonesia from 1970 to 2016. In general, it is clearly seen that the relationship between inflation and growth in Indonesia are positive at 7% and below; and negative when above 7%. From this simple test, there is a conclusion that the threshold exists at 7% level of inflation (7% in the figure comes from the inflations range from 6.4% to 7.01%). To justify this preliminary observation, the regression test should be conducted.

Figure 1. Average economic growth with respect to inflation



Source: Author's calculation.

The further stage of the analysis is the application of ARDL model. This is to identify the relationship between inflation and growth both in the short-run and the long-run. Initially, the variables GR, INF, INV, and EXIM (including M2 for the further stage of analysis) are tested using the *Augmented Dickey-Fuller* (ADF) test for their stationarity. The result can be seen in Table 1.

The main requirement of the ARDL model is that there should be none of the variables is integrated of order 2 or I(2). Table 1 shows that all the variables are stationary at level or I(0). Since no variables stationer at I(2), the ARDL can proceed.

Table 1. Stationarity Test Result using ADF

Variable	Level		First Difference		Stationer at
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	
GR	-4.6276	-4.8694	-	-	Level / I(0)
	(0.0005)	(0.0014)	-	-	
INF	-6.1578	-6.5007	-	-	Level / I(0)
	(0.0000)	(0.0000)	-	-	
INV	-4.7087	-5.2014	-	-	Level / I(0)
	(0.0004)	(0.0006)	-	-	
EXIM	-4.6739	-4.9004	-	-	Level / I(0)
	(0.0004)	(0.0013)	-	-	
M2	-3.5772	-5.3798	-	-	Level / I(0)
	(0.0101)	(0.0003)	-	-	

Notes: The value outside bracket is the t-statistic, and the p-value is in the bracket.
Source: Author's calculation.

The next stage for ARDL is to choose the optimum lag for the model. The process involves comparisons of the values of AIC, SC, and HQC from each lag. After thoroughly trying all possible lags and observing the residuals diagnostic check, the optimum lag is 4 and providing the model of ARDL (2, 4, 3, 3). In addition, the cointegration among variables should be checked using *Bound Testing* by Pesaran *et al*. (2001). The variables will be considered having a cointegration relationship if the F-statistic from F-Bound Test > critical value of *Bound Test*.

The F-Statistic from the *Bound Test* is 4.6526 for the total sample size 43. It is significant at 5% in Narayan (2005) case II (restricted intercept and no trend) for finite sample n = 40 (which is 3.1 for I(0) and 4.088 for I(1)) and n = 45 (which is 3.078 for I(0) and 4.022 for I(1)) . Hence, there is a cointegration exists among variables. To justify this result, at a later ECM equation, the coefficient of ECT could be monitored and should be negative and significant. As a complement for the *Bound Testing*, the long-run ARDL equation could be obtained, and it is provided in Table 2.

Table 2. Long-run ARDL model estimation

Variable	Coefficient	t-Statistic	Standard Error	Probability
INF	-0.0855	-1.8224	0.0469	0.0795
INV	0.4195	6.2701	0.0669	0.0000
EXIM	0.0964	1.5255	0.0632	0.1388
C	3.5028	4.0673	0.8612	0.0004
GR = 3.5028 - 0.0855INF + 0.4195INV + 0.0964EXIM + ε				

Source: Author's calculation.

Table 2 depicts the long-run relationship among variables in the model. Only 2 variables, INF and INV, put significant impact on the growth at α = 10% and 1% respectively. Here, the impact of inflation on growth is negative and significant, inferring that the inflation in the long-run time frame would bring an adverse impact on the growth. For further analysis, Table 3 provides the short-run equation of the ARDL model.

The result from Table 3 justifies the existence of long-run cointegration of variables since the coefficient of the Error Correction Term (ECT) is -0.9453 and significant at α = 1%. The speed of adjustment of the ECM into the equilibrium is 94.53%. The advantage of the ARDL model is the availability of the short-run coefficients to examine the dynamics of independent variables in the lags provided. Here, the focus is the coefficients of INF and its lags. The values of INF coefficients are negative at lag 0, 2, 3, and positive at lag 1. Interestingly, there are only negative coefficients that possess significances at α = 1% and 5% level. This result implies that, in the short-run, the negative impact of inflation on growth is more dominant and significant.

The last stage for the ARDL model is the diagnostics check. The summary of the checks is available in Table 4. From Table 4, the ARDL (2, 4, 3, 3) model is proven to pass the checks (probability value of respective tests are > 5% and CUSUM checks are stable). Thus, the model produces reliable estimations.

Table 3. Short-run ARDL model estimation (ECM)

Variable	Coefficient	t-Statistic	Standard Error	Probability
ΔGR_{t-1}	0.2108	1.4958	0.1409	0.1463
ΔINF	-0.1479	-5.6562	0.0262	0.0000
ΔINF_{t-1}	0.0025	0.0679	0.0367	0.9464
ΔINF_{t-2}	-0.0735	-2.1746	0.0338	0.0386
ΔINF_{t-3}	-0.0679	-3.0789	0.0221	0.0047
ΔINV	0.1923	4.5332	0.0424	0.0001
ΔINV_{t-1}	-0.1246	-1.7741	0.0702	0.0873
ΔINV_{t-2}	-0.1903	-4.1785	0.0455	0.0003
ΔEXIM	0.0257	0.9999	0.0257	0.3262
$\Delta EXIM_{t-1}$	-0.0581	-1.8381	0.0316	0.0771
$\Delta EXIM_{t-2}$	-0.0699	-2.6391	0.0265	0.0136
ECT_{t-1}	-0.9453	-5.1681	0.1829	0.0000
Adjusted R-squared = 0.8740, Standard Error of Regression = 1.4552				

Source: Author's calculation.

Table 4. Diagnostics checks result

Test	Value	Probability
Residuals Normality	Jarque-Bera = 2.3444	0.3097
Breusch-Godfrey Serial Correlation LM Test	Obs. R-squared = 1.9184	0.3832
Heteroskedasticity Test: Breusch-Pagan-Godfrey	Obs. R-squared = 14.0750	0.5198
CUSUM Stability Check	The line does not cross the boundaries	-
CUSUM of Squares Stability Check	The line does not cross the boundaries	-

Source: Author's calculation.

After the ARDL model robustly provided the result of inflation-growth nexus, the further analysis is to obtain the threshold of inflation. As mentioned in the previous section, this stage compares the Model 1 and Model 2. Despite the difference in models, initially, the aim of Model 1 and Model 2 is to get the highest R-square of regression. Furthermore, the comparison in this stage also utilizes indicators such as Adjusted R-squared, Sum Square Residuals, AIC, SC, and HQC.

The first implemented model is the threshold model from Eq. (5). After the initial calculation, the value of inflation's threshold appeared from k = 4. For the completeness of the analysis, the maximum value of k is set on the value of 15. Table 5 presents the result of threshold regression for the value of k from 4% to 15% of Model 1.

Table 5. Threshold Regression result of model 1

k (Percent)	Variable	Coefficient	Standard Error	t-statistic	Probability	R-squared
4	C	-1.542210	3.025714	-0.509701	0.6130	0.729747
	INF	1.451646	0.783675	1.852357	0.0712	
	D4*(INF>4)	-1.656226	0.802413	-2.064056	0.0454	
	INV	0.140761	0.043231	3.256024	0.0023	
	M2	0.090138	0.034304	2.627599	0.0120	
	EXIM	0.002099	0.031599	0.066431	0.9474	
5	C	-0.223862	2.041077	-0.109679	0.9132	0.740125
	INF	0.888545	0.428978	2.071308	0.0447	
	D5*(INF>5)	-1.101916	0.447333	-2.463302	0.0181	
	INV	0.134578	0.042406	3.173546	0.0029	
	M2	0.092075	0.033464	2.751481	0.0088	
	EXIM	0.000236	0.030842	0.007644	0.9939	
6	C	0.623359	1.623801	0.383889	0.7030	0.744566
	INF	0.587035	0.288704	2.033346	0.0485	
	D6*(INF>6)	-0.807361	0.307667	-2.624141	0.0121	
	INV	0.130447	0.042318	3.082537	0.0037	
	M2	0.093314	0.033175	2.812791	0.0075	
	EXIM	0.002413	0.030645	0.078743	0.9376	
7*)	C	1.095914	1.396698	0.784646	0.4372	0.748510
	INF	0.419454	0.214476	1.955720	0.0573	
	D7*(INF>7)	-0.647751	0.234393	-2.763524	0.0085	
	INV	0.128093	0.042033	3.047468	0.0040	
	M2	0.096074	0.033090	2.903434	0.0059	
	EXIM	0.005450	0.030526	0.178551	0.8592	

k (Percent)	Variable	Coefficient	Standard Error	t-statistic	Probability	R-squared
8	C	1.648455	1.230330	1.339848	0.1877	0.747690
	INF	0.285455	0.168656	1.692526	0.0981	
	D8*(INF>8)	-0.517029	0.189057	-2.734780	0.0092	
	INV	0.127534	0.042253	3.018374	0.0044	
	M2	0.095443	0.033102	2.883309	0.0062	
	EXIM	0.003187	0.030476	0.104582	0.9172	
9	C	2.124325	1.113528	1.907743	0.0634	0.744817
	INF	0.186582	0.138496	1.347196	0.1853	
	D9*(INF>9)	-0.418546	0.158955	-2.633115	0.0119	
	INV	0.128111	0.042652	3.003664	0.0045	
	M2	0.093738	0.033195	2.823833	0.0073	
	EXIM	0.001603	0.030597	0.052381	0.9585	
10	C	2.218061	1.047235	2.118017	0.0403	0.748505
	INF	0.155710	0.121741	1.279024	0.2081	
	D10*(INF>10)	-0.396985	0.143660	-2.763369	0.0085	
	INV	0.125574	0.042422	2.960117	0.0051	
	M2	0.095541	0.033035	2.892112	0.0061	
	EXIM	0.004686	0.030489	0.153701	0.8786	
11	C	2.294819	0.980331	2.340862	0.0242	0.753810
	INF	0.139276	0.109537	1.271498	0.2107	
	D11*(INF>11)	-0.390137	0.132390	-2.946876	0.0053	
	INV	0.122147	0.042064	2.903872	0.0059	
	M2	0.095593	0.032556	2.936258	0.0054	
	EXIM	0.006488	0.030221	0.214691	0.8311	
12	C	2.347648	0.922749	2.544189	0.0148	0.760027
	INF	0.130463	0.100342	1.300187	0.2008	
	D12*(INF>12)	-0.392000	0.124139	-3.157751	0.0030	
	INV	0.118085	0.041656	2.834761	0.0071	
	M2	0.095450	0.032006	2.982267	0.0048	
	EXIM	0.008183	0.029882	0.273840	0.7856	
13	C	2.443075	0.875785	2.789584	0.0080	0.764131
	INF	0.119783	0.093632	1.279302	0.2080	
	D13*(INF>13)	-0.389624	0.118241	-3.295173	0.0020	
	INV	0.115897	0.041321	2.804797	0.0077	
	M2	0.093851	0.031547	2.974956	0.0049	
	EXIM	0.009840	0.029682	0.331509	0.7419	
14	C	2.560850	0.829301	3.087962	0.0036	0.768184
	INF	0.108515	0.087407	1.241493	0.2215	
	D14*(INF>14)	-0.385303	0.112333	-3.430009	0.0014	
	INV	0.114279	0.040923	2.792571	0.0079	
	M2	0.091395	0.031070	2.941605	0.0053	
	EXIM	0.011200	0.029467	0.380092	0.7058	
15	C	2.648316	0.790763	3.349065	0.0017	0.772854
	INF	0.100940	0.082244	1.227321	0.2267	
	D15*(INF>15)	-0.386722	0.107883	-3.584648	0.0009	
	INV	0.111449	0.040593	2.745506	0.0089	
	M2	0.089914	0.030635	2.935029	0.0054	
	EXIM	0.013245	0.029241	0.452963	0.6530	

Notes: *) denotes the optimum value of K where R-squared is maximized, and threshold effect appears.
Source: Author's calculation.

Table 5 shows some findings; the first one is based on the values of R-squared. The values of R-squared increase from the value of k = 4 to k = 7, and decline starting from k = 8 to k = 9. From the values of k = 10 and above, the values of R-squared incline significantly and no signs of decreasing. It is obvious that the higher the k, the bigger the R-squared. However, when the values of significance from the variables INF and D*(INF-k) are taken into account, the reasonable range of k only from k = 4 to k = 8 where both variables are significant. Hence, the threshold effect disappears when k exceeds 8%. Eventually, the value of k = 7 is the optimum value for inflation's threshold. When inflation is less than or equal to 7%, 1% increase in inflation will make the growth increases by 0.42%. Conversely, when inflation exceeds 7%, 1% increase in inflation produces a decrease in growth by 0.23% (the value comes from -0.647751+0.419454).

The threshold model at k equal to 7 has R-squared around 0.748510 (Adjusted R-squared is 0.717840). This model passes the diagnostics checks for Normality (probability of Jarque-Bera is 0.186995), Serial Correlation (Obs. R-squared in Breusch-Godfrey test has probability around 0.2741), and Heteroskedasticity (Obs. R-squared in Breusch-Pagan-Godfrey test has probability around 0.1518). Thus, this model fulfilled the residuals' diagnostics checks.

The comparator of the threshold regression of Model 1 is the quadratic regression model in the form of Model 2. The purpose of this model is to find the maximum value of INF by taking the first differential of the quadratic regression model. The result of Model 2 could be seen in Table 6.

Table 6. Quadratic Regression result of model 2

Panel 1				
Variable	Coefficient	Standard Error	t-statistic	Probability
C	2.935610	0.598230	4.907156	0.0000
INF	0.145662	0.066364	2.194891	0.0339
INF^2	-0.005091	0.000957	-5.317669	0.0000
INV	0.073575	0.037409	1.966762	0.0560
M2	0.087057	0.026748	3.254766	0.0023
EXIM	0.019998	0.025806	0.774914	0.4428
Panel 2				
Indicators	Value			
INF*	14.30583			
R-squared	0.823439			
Adj. R-squared	0.801907			
Prob. of Jarque-Bera	0.129571			
Prob. of Breusch-Godfrey	0.6400			
Prob. of Breusch-Pagan-Godfrey	0.3356			
Prob. of Ramsey RESET Test	0.1471			

Source: Author's calculation.

Table 6 Panel 2 indicates that the inflation threshold for the quadratic regression model is around 14.31% (calculated from Equation (7) utilizing coefficients from INF and INF^2 from Table 6 Panel 1). This result is double than the threshold provided by Model 1. However, this result is still below the threshold suggested by Chowdhury and Siregar (2004) that employed a similar method in Indonesia which was 20.50%. In term of diagnostic checking, Model 2 could satisfy the tests for Normality, Serial Correlation, Heteroskedasticity, and Ramsey RESET test as indicated in Table 6 Panel 2 (all of probability values are > 5%).

If both models are compared, the value of R-squared from Table 6 at INF* = 14.31% is bigger than the result from Table 5 at k = 7% (0.823439 > 0.748510). For a complete comparison of Adjusted R-squared, Sum Square Residuals, AIC, SC, and HQC, the results are depicted in Table 7. It is clear that Model 2 could provide a better model as all indicators from Model 2 are better (bigger R-squared as well as adjusted R-squared, and smaller Sum Square Residuals, AIC, SC, and HQC).

Table 7. Post-estimation statistics comparison

K	Model	R-squared	Adj. R-squared	SSR	AIC	SC	HQC
7	Model 1	0.748510	0.717840	138.4802	4.173776	4.409965	4.262655
14.31	Model 2	0.823439*	0.801907*	97.22145*	3.820040*	4.056229*	3.908920*

Notes: * indicates the better indicator.
Source: Author's calculation.

The last resource for thresholds comparison is by observing the *Inflation Targeting Framework* (ITF) tabulation from the Central Bank of Indonesia (BI). Table 8 elaborates the ITF spans from 2001 to 2017 with the actual inflation and growth in the respected year. The first impression regarding the ITF in Indonesia is that the inflation targeting values are mostly set at the level below 10% (from 4% to 10%). The nexus of inflation's threshold analysis and the ITF policy are not empirically analyzed in this paper (the analysis of ITF in Indonesia has gone beyond of this paper's coverage); however, in a wider point of view, the purpose from both tools is to provide a good economic climate in Indonesia. The inputs from Table 8 are implicitly in line with the conclusion that the value of the threshold of inflation in Indonesia is around 7% (from the average, median, and mode of actual inflation). Table 8 also suggests that the tight monetary policy framework applied by BI to reach the low ITF's target in recent years. On the other hand, this paper yields inflation's threshold at 14.31% inferring that the room for a less tight monetary policy is still available.

Table 8. Inflation targeting in Indonesia 2001 – 2017

Year	Inflation Targeting (%)	Actual Inflation (%)	Growth (%)
2001	4 - 6	12.55	3.64
2002	9 - 10	10.03	4.50
2003	9+1	5.06	4.78
2004	5,5+1	6.40	5.03
2005	6+1	17.11	5.69
2006	8+1	6.60	5.50
2007	6+1	6.59	6.35
2008	5+1	11.06	6.01
2009	4,5+1	2.78	4.63
2010	5+1	6.96	6.22
2011	5+1	3.79	6.49
2012	4,5+1	4.30	6.23
2013	4.5+1	8.38	5.56
2014	4.5+1	8.36	5.01
2015	4+1	3.35	4.88
2016	4±1	3.02	5.02
2017	4±1	3.61	3.64
Average	5.53*	7.31	4.50
Median	5*	6.60	4.78
Mode	5*	7**	5.03

Notes: * indicates the values without deviation. ** indicates rounded to zero digits of the decimal.
Source: Central Bank of Indonesia, data processed.

Conclusion

The discussion in regard to the nexus between inflation and growth has expanded into various perspectives. The studies conducted in countries around the world from different economic backgrounds have provided diverse conclusions. Moreover, the theory of the existence of an inflation threshold where the impact of inflation on the growth swings from positive to negative, invited more methods to be applied in order to investigate the threshold. Relevant studies of the inflation's threshold conducted in Indonesia yielded in heterogenous numbers. This paper aims to add another test to investigate the nexus between such variables in short- and the long-run time frame as well as to find the threshold.

By utilizing the ARDL method, the nexus of inflation and growth in Indonesia has been examined. It is evidence that the relationship between inflation and growth in the long-run is negative and significant. Further, with help from analysis of ECM, the short-run dynamics between inflation and growth could be seen. Likewise, inflation could put adverse influential to the growth in the short-run. Thus, identifying the threshold of inflation becomes essential.

Initial observation using the graph showed that the threshold exists at around 7% of inflation. This finding then supported by the threshold regression's result. The threshold regression method produced the optimum R-squared at the significant probability value of threshold at k equal to 7%. Furthermore, the threshold regression was compared with the quadratic regression model to find the best model. It is evidence that the value of inflation is optimum at around 14.31% as the quadratic regression provided a better comparison for the models' post-estimation statistics. At the very end, the Inflation Targeting Framework (ITF) in Indonesia has been added as supplementary input for the decision. Although the ITF seemingly supported the result of the threshold regression by the evidence that the ITF practiced the inflation's targeting from 4% to 10% in the last decade; the result from quadratic regression revealed the possibility of less tight monetary policy in Indonesia. All in all, with respect to other methods that might suggest either lower or higher thresholds, this paper suggests the threshold of Inflation in Indonesia is at 14.31%.

The broader utilization of method, time of observation, as well as the entity (country or province) would be a better way to improve the suggested threshold. However; there is still a need to include additional input from various sources to strengthen the decision in picking the value of optimum threshold of inflation. So, the model produces a robust result from the methodological perspective as well as the policy-makers' sight.

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Determinants of Labor Productivity in Northeast Thailand

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Abstract:

This study aims to analyze the determinants of labor productivity in Northeast Thailand from 1981–2015, using multiple regression with log specification. Labor productivity is measured using two approaches: average product of labor (APL) and marginal product of labor (MPL). APL is directly calculated from secondary data while the MPL can also be derived from secondary data but it is more complicated. To circumvent this problem, the MPL is calculated from the Cobb-Douglas production function. The data analysis shows that labor productivity is highly dependent on the capital-labor ratio, government investment in education and health, the value of the output ratio of agriculture to industry, and the value of output ratio of services to industry. The results of both approaches are in accordance with the important determinants of labor productivity. The government and private sectors should focus on these factors to improve labor productivity in the Northeast which cause labor to gain the opportunity of receiving higher wages and better living standards.

Keywords: determinants; labor productivity; Northeast Thailand

JEL Classification: J24; O11

1. Introduction

Thailand's North-eastern region is the country's largest, constituting approximately one-third of the landmass and population. However, the North-eastern region still faces the lowest income per capita compared to other regions in Thailand, impacting on the development of the regional population's quality of life. According to the World Bank (2005), although poverty is decreasing at a faster rate in other regions, it has become more concentrated in the Northeast and about 60% higher in rural areas, where livelihoods depend mostly on agriculture, than in urban areas, which offer jobs in industry and services.

Labor productivity improvement is one of the key mechanisms for addressing such issues. Labor productivity growth is the basic source of improvement for real wages and living standards (McConnell, Brue, and Macpherson 20039. In other words, labor productivity helps to determine the difference in ability and income. That is, workers with high productivity can earn higher wages and have a better economic status than low productivity workers. Therefore, this study investigates the determinants of labor productivity in Northeast Thailand using two approaches, the first of which is the average product of labor (APL), explained by output per employee, and the second the marginal product of labor (MPL), in the form of the Cobb-Douglas production function. The effect of capital-labor ratio, government investment in education and health, and structural change on labor productivity can illuminate the outstanding sources to increase labor productivity.

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2. Literature review

What are the determinants of labor productivity in Northeast Thailand? This paper answers that question by examining the relationship between labor productivity and its determining factors in Northeast Thailand. However, in this section, besides reviewing the determinants of labor productivity, the measurement of labor productivity is also considered.

2.1. Labor productivity measurements

There are many different labor productivity measures. The choice depends on the purpose of labor productivity measurement and, in many instances, on the availability of data. The ratio used to calculate labor productivity provides a measure of the efficiency with which inputs are used in an economy to produce goods and services.

Labor productivity is equal to the ratio between a volume measure of output (gross output or value added) and the measure of input use (the total employed or number of hours worked). The general formula for calculating labor productivity can be expressed as follows:

$$\text{Labor productivity} = \frac{\text{output}}{\text{labour input}}$$

The most common method for empirically analyzing productivity is to start from the production function. The production function is used to describe the relationship between output and input in the production process (Besanko and Braeutigam 2011).

$$Q = f(L, K)$$

where: Q is the total output, L is the labor input, and K is the capital input.

Labor productivity can be explained by the average product of labor (APL); the average output per worker and the marginal product of labor (MPL); the change in output per unit change in labor is as follows:

$$\text{Average product of labor (APL)} = Q/L$$

$$\text{Marginal product of labor (MPL)} = \Delta Q \Delta/L$$

where: ΔQ is the change in output and ΔL is the change in labor input, giving APL and MPL as mentioned above. This is a measure of labor productivity based on discrete data. Whereas the continuous data measures the MPL from the production function, represented by the mathematical functions as follows:

$$\text{MPL} = \frac{\partial Q}{\partial L} = \frac{\partial f(L, K)}{\partial L} = f_L$$

Labor productivity can also be measured using the labor productivity index, based on a comparison with inputs and levels as follows:

▪ Measurement of the labor productivity index. In general, calculation of the labor productivity index (LPI) using the OECD formula is based on the type of output measurement consisting of gross output and value added. The quantity index of gross output is divided by the quantity index of labor input (gross output measure) and the quantity index of value added divided by quantity index of labor input (value added measure). Houseman (2006) used percentages for comparison with the base year in order to obtain a standard of change on the basis of constant change. The results indicate a change of direction in labor productivity relative to the base year. Two types of calculations are used in the labor productivity index: per employed person and per hours worked. The formula is calculated as follows:

- Labor productivity per employed person:

$$\text{Labor productivity index} = \frac{Q_t/Q_o}{L_t/L_o};$$

- Labor productivity per hours worked:

$$\text{Labor productivity index} = \frac{Q_t/Q_o}{H_t/H_o}$$

where: Q_t/Q_o is the index of output in the current period (output in current period divided by output in the base year), L_t/L_o is the index of labor in the current period (labor input in the current period divided by labor input in the base year) and H_t/H_o is the index of hours worked in the current period (hours worked in the current period divided by hours worked in the base year).

However, the LPI provides information about changes in labor productivity but does not explain the cause of such changes.

▪ Measurement of labor productivity based on comparison with inputs. This can be divided into two types, the first of which is partial or single-factor productivity, explained by the ratio of outputs to a single input. For example, as in the average product of labor (APL), derived from output per total employed, per man-hours or the average product of capital (APK), resulting from output per capital. The capital productivity ratio is measured using the interest revenue generated per dollar, while the material productivity ratio is measured by output per ton of material. Labor productivity is the most common measure of this type, although occasionally, capital or even materials are used.

The second is total factor productivity (TFP) or multifactor productivity (MFP), defined as the ratio of total output or net output (value added output) to the sum of all input factors. Therefore, total productivity reflects the cooperative impact of all inputs in producing the output. TFP is commonly recognised as a variable representing the total output not directly related to the number of inputs, such as capital and materials. For example, companies can have the same amount of resources but one produces more than the other which may be attributed to greater output from the winner, such as hiring more skilled labor or having better educated middle management.

However, in the measurement of labor productivity based on comparison with inputs, both partial and TFP have different advantages and limitations as shown in Table 1.

Table 1. Advantages and limitations of the labor productivity measurement based on comparison with company inputs.

Advantages	Disadvantages
Partial Productivity	
1. Easy to understand	1. If used alone, it can be very misleading and may lead to costly mistakes
2. Easy to obtain	2. Does not have the ability to explain overall cost increases
3. Easy to compute the productivity indices	3. Tends to shift the blame to the wrong areas of management control
4. Easy to sell to management because of the above three advantages	4. Profit control through partial productivity measures can involve a hit-and-miss approach
5. Some partial productivity indicators (e.g. output per man-hour) are available industry-wide	
6. Good diagnostic tools to pinpoint areas for productivity improvement, if used along with total productivity indicators	
Total Factor Productivity	
1. The data from company records is relatively easy to obtain	1. Does not directly capture the impact of materials and energy inputs
2. Usually appealing from the corporate economist perspective	2. The value added approach to defining the output is not always appropriate in a company setting
	3. Not appropriate when material costs form a sizeable portion of the total product cost
	4. Only labor and capital inputs are considered in the total factors
	5. Data for comparison purposes is relatively difficult to obtain, although for some specific industries and time periods, indices have been published

Source: Sumanth (1988)

▪ Measurement of labor productivity on the basis of level. Productivity takes various forms. At the enterprise or micro level, it helps in ascertaining performance. At the macro level, productivity measurement is a useful guide for policymakers in setting wages or combating inflation (Prokopenko 1987). Similarly, the measurement of labor productivity based on level is considered using data, divided into two types: the micro level (individual industrial establishment) and the macro level (overall, such as sector, region, and country). As previously mentioned, the measurement of labor productivity based on level can be conducted in several ways, such as output per labor input or APL, MPL, in terms of the index, or by partial or total factor productivity. At micro level, labor productivity measurement is represented by individual industrial establishments.

Labor productivity at firm level is important for demonstrating the ability of employees to work for an organization. When labor productivity improves, it facilitates the production of more goods and services. In other words, an increase in labor productivity may lead to lower costs. As a result, entrepreneurs can maintain their competitiveness.

The measurement of labor productivity at firm level involves the choice of whether to use value added per unit of labor or per unit of working time. These measures include the following (Velucchi and Viviani 2011, Rogers and Tseng 2000):

- Labor productivity per person employed = $\frac{\text{Value added}}{\text{Total employed persons}}$;
- Labor productivity per hours worked = $\frac{\text{Value added}}{\text{Total hours worked}}$

The value added method can be calculated from Hiba (1998):

Value added = current income (before tax) + personnel expenses + financial costs + rent + tax + depreciation cost.

The value added computation data is taken from an organization's financial statement. In the absence of a financial statement, small enterprises could use the volume of output per labor input and value of output per labor input. Furthermore, Santipolvut (2002) found that the total labor value added can be calculated using the following formula:

Total labor value added = total revenue – total cost (except labor cost);

Total revenue = Total sales of goods produced by the establishment + Revenue from goods produced for other establishments + Total sales of ready-made products bought and sold in original condition + Total sales of goods produced by contracted manufacturers + Other revenue related to the establishment's production process;

Total cost = Total cost of production, except labor cost = Cost of raw and other materials + Total salaries, wages, overtime, welfare, and other fringe benefits paid to all production workers (excluding foreign employees) + Total contracted labor expenses paid to contracted and other manufacturers where goods for the establishment were wholly or partially produced + Costliness or production expenses + Job or products in process as of 1 January 1998 (if any) - Job or products in process as of 31 December 1998 (if any) + Other production costs apart from those specified above + Value of ready-made products as of 1 January 1998 (at cost) + Cost of purchasing ready-made products (cost of products + purchasing cost) - Value of ready-made products as of 31 December 1998 (at cost) + Sales and administration costs (not including labor compensation) + Total salaries, wages, overtime, welfare, and other fringe benefits paid to all non-production workers (excluding foreign employees).

At macro level, the measurement of labor productivity concerns a country, region, or sector. An increase in labor productivity is very important for competitiveness. This is because labor productivity represents the performance of inputs to comparative economic achievement with the ratio of output to the amount of labor in the economy. In this study, labor productivity is measured on a macro level basis. Labor productivity is measured by the average product of labor (APL) based on discrete data, and marginal product of labor (MPL) using the standard Cobb-Douglas production function. The Cobb-Douglas production function is the most widely used in economics for representing the relationship between output and input (Alani 2012). The Cobb-Douglas production function is represented by:

$Y = AK^{\alpha}L^{\beta}$

where: Y is output, *K* is physical capital, *L* is labor input, and *A* is the efficiency parameter. Moreover, α and β represent the output elasticity of physical capital and labor.

However, such a measurement not only provides information about changes in labor productivity but can also explain the cause of such changes.

2.2. Determinants of labor productivity

Studies investigating labor productivity are numerous and varied. In general, the dependent variable is labor productivity and there are many independent variables. This research focuses on other similar studies. Shimizu, Wainai, and Nagai (1991) and Reynolds, Masters, and Moser (1991) classified groups of factors influencing labor productivity. The first group includes labor, human capital, physical capability (age, gender, amount of labor), and quality of labor (health, skill development, expertise, education, and training), all of which are essential to the production process. As mentioned by Adam Smith in "The Wealth of Nations", the key to human capital is that one's educational expenses or the talent improvement of a worker can be compared to the machinery or instrument of trade which facilitates and abridges labor. Schultz (1961) asserted that human capital refers to various competencies that a person has had since they were born or knowledge accumulated such as education and training. That is, the more education and training, the higher the accumulated human capital stock. As a result, such investment generates higher productivity.

Becker (1964), Welch (1970), and Mincer (1974) confirmed that education and training are key factors in effective production in that such investment generates higher productivity. These factors are key tools in developing and enhancing the knowledge and skills for human resources to provide experience and understanding under the ever-changing environment and economy. Cörvers (1996), who examined the effects of human capital on labor productivity in the manufacturing sector, states that human capital is measured by the employment share of intermediate and highly-skilled workers. Other variables are capital intensity and average firm size, both of which have a significantly positive effect on labor productivity at sector level, while the effects of intermediate and highly-skilled labor are also positive. Aggrey, Eliab, and Joseph (2010) focus on the influence of human capital development on labor productivity in organizations. Their results indicate that the employment of a highly-educated labor force could raise labor productivity in East Africa. In Tanzania, the education of managers contributed more positively to labor productivity than education of the labor force at performance level. Human capital was shown to be essential for increasing labor productivity. Abomeh and Peace (2015) examined the influence of training on employees' productivity in Nigeria insurance industry, found that training is an important factor which improves labor productivity.

However, studies on other human resource factors indicate that health affects labor productivity. If workers are healthy, they will be able to work more efficiently and at full power. Todaro and Smith (2012) explained that besides education and training, human capital also involves health issues. Their study discusses more comprehensive human capital factors. Economists often use education, health, and human capabilities to increase the productivity represented by human capital. Subsequently, Umoru and Yaqub (2013) investigated the effects of health capital on labor productivity in Nigeria, using the variables of a healthy labor force, educated labor force, and government investment in health and education. Their main findings show a positive relationship between labor productivity and human capital. The results strongly indicate that an educated, healthy labor force is one of the key determinants of labor productivity in Nigeria. Similarly, health capital investment is a positive and significant determinant of labor productivity. However, government investment in education is estimated as being both negative and insignificant, while it is slightly different from the study of Mačiulytė-Šniukienė and Matuzevičiūtė (2018) analyzed the impact of human capital development (health and education expenditure) on EU member states' productivity. Their results indicate that human capital is positively significant in improving the growth of labor productivity in the EU. Hassan, Norashidah and Nor (2016), who investigated the impact of health care expenditure per capita and infectious diseases such as HIV/AIDS and tuberculosis (TB) on labor productivity performance in Africa illustrated that the health-care expenditure per capita is positive but insignificant to labor productivity performance in the region. In addition, the results also confirm the negative impact of infectious diseases on labour productivity performance. The government effectiveness and control of corruption are positive and significant to the improvement of health care expenditure in Africa.

Capital and quality improvement are organized as a second group. Capital consists of buildings, machinery, and tools. In addition, firms must apply and maintain new machinery and equipment as well as improving the tools to suit the production process. The appropriate machinery and equipment must be provided, and when necessary, fixed or replaced with new. In economic theory, physical capital is generally considered as one of the three primary factors of production, the other two being labor and land (natural resources). According to Samuelson and Nordhaus (2005), empirical studies consider the most important physical capital to be machinery, buildings, tools, equipment, and land. Physical capital is sometimes referred to as fixed capital. According to Fallahi, Sojoodi, and Aslaninia (2010); Kataria, Curtiss, and Balmann (2012); and Turner and Tamura (2013), a larger stock of physical capital per worker creates a more productive economy and also leads

to increased labor productivity. The net fixed assets or net capital stock divided by employment is used to represent the *capital-labor ratio,* contributing to an accelerated labor productivity growth rate. Sala and Silva (2013) include other variables such as vocational training, intensity of research, and education. Their major finding indicates that all independent variables have a positive relationship with labor productivity. Samargandi (2018) examined the role of compensation, human capital, oil rent, trade, financial development, innovation, and industrialization in labor productivity in the context of Middle East and North Africa (MENA) countries, finding that size of employment and compensation are negatively associated with labor productivity, while human capital and capital stock are positively associated with it. The oil rent, financial development, trade openness, and industrial value addition play significant roles in promoting labor productivity. In addition, innovation was found to be an important factor in expediting labor productivity.

The third group consists of technology and technology and technological progress, application levels or work processes for tools, machinery, equipment, and investment in modern machinery. New processing techniques resulting from research and development (R&D) are also required to create new products and improve existing ones, as well as adjusting the production method to reduce costs. Griliches (1979) reiterated the importance of knowledge capital, which aside from traditional inputs such as physical capital and labor, plays a determinant role in output. Knowledge capital is also recognized as a stimulus for economic growth. Romer (1986, 1990) offered that capital consists of buildings, machinery, and tools and should also include the returns from investment in R&D, such as innovation or an idea for inventing a new product. Knowledge capital is, therefore, a new kind of capital accumulated from the past. Griliches (1986), Hall and Mairesse (1995), and Del Monte and Papagni (2003) emphasize the importance of knowledge capital for changes in productivity as a result of new technology applications. In many studies, knowledge capital is stated as the accumulated and still productive research capital derived from previous R&D expenditure. Wakelin (2001) examined the influence of R&D, capital, and labor on productivity in 170 UK quoted firms from 1988–1992, finding that R&D had a positive and significant role. This is similar to the study by Tsai and Wang (2004), who investigated 156 large Taiwanese quoted firms from 1994–2000, reporting a positive and significant R&D effect on productivity. Most studies on R&D expenditure use the proxy of knowledge capital. It is evident that as technology improves, the output level per worker increases, so any determinant such as R&D expenditure for technology improvement increases labor productivity. Papadogonas and Voulgaris (2005) and Parham (2007), consistent with Doraszelski and Jaumandreu (2013), studied firm productivity growth as an outcome of R&D expenditure. Furthermore, Khanna and Sharma (2018) examined the effects of technological investments on labor productivity from Indian manufacturing by looking at investments in Information Technology (IT) and Research & Development (R&D), finding that there is a complementarity between IT and R&D in creating labor productivity growth. There are also empirical studies by Nekrep, Strašek and Boršič (2018), who confirmed empirically supporting evidence of the impact of investment in research and development on labor productivity.

Furthermore, structural change is an interesting influential variable in labor productivity. Structural change in society often influences national and enterprise productivity. Commonly used methods for measuring structural change are output and employment share. According to Prokopenko (1987), structural changes in the economy have gradually shifted away from agriculture towards manufacturing and services. Output has shifted from agriculture to manufacturing and from manufacturing to services, thereby creating an economy-wide increase in productivity. Fisher (1939) and Clark (1940) point out that economic growth essentially brings about structural change in the sectoral composition of output as a result of a shift from primary (agriculture) to secondary (manufacturing) and tertiary sectors (services). Nabar and Kai Yan (2013) analyzed the aspects of structural change in China, emphasizing the service sector share of GDP and the transition from manufacturing to services. The service sector share of GDP can, therefore, be expressed as a product of relative service productivity compared to the overall economy, and the ratio of employment when focusing on the shift from industry to services.

In similarity to international studies, the majority of Thai studies have concentrated on the determinants of labor productivity for the overall economy and sub-sectors at national level, but little attention has been paid to the regional level. Even though the same factors are used to explain those influencing labor productivity, presumably some are different due to the nature of the structural change taking place in the Northeast region. Structural change is one factor expected to affect labor productivity in the Northeast and might be due to the change in use. Therefore, based on the literature review this leads to the selection of variables. There are many factors affecting labor productivity, and these can be classified into five key elements: capital-labor ratio, knowledge capital (amount of R&D expenditure), education (government investment in education), health

(government investment in health), and structural change (two proxies—value of the agriculture to industry output ratio, and value of the services to industry output ratio).

3. Methodology

As previously mentioned, this paper examines the factors influencing labor productivity. To achieve the objective, labour productivity is measured using two approaches; APL and MPL in the Northeast overall and the Northeast divided into eight sub-sectors consisting of agriculture, mining and quarrying, manufacturing, construction, electricity and water supply, transportation and communication, wholesale and retail trade, and services. The APL was measured by output per employee with the MPL being derived from the Cobb-Douglas production function. However, the starting point for calculating the MPL through the Cobb-Douglas production function accords with equation (1).

$$Yi = AKi^{\alpha}Li^{\beta} \quad (1)$$

where: *Y* is output at sub-sector *i*, *K* represents units of physical capital and *L* units of labor, and *A* is the efficiency parameter. Moreover, *α* and *β* represent the output elasticity of physical capital and labor, respectively.

Taking the natural logarithms of equation (1).

$$\ln Y = \ln A + \alpha \ln K + \beta \ln L \quad (2)$$

Operate differential equation (2) with respect to L, holding A and K constant.

$$\frac{d\ln Y}{dL} = \beta \frac{d\ln L}{dL}; \qquad \beta = \frac{d\ln Y}{dL} \times \frac{dL}{d\ln L}; \qquad \beta = \frac{d\ln Y}{d\ln L};$$

$$\beta = \frac{1/Y\, dY}{1/L\, dL}; \qquad \beta = \frac{dY}{dL} \times \frac{L}{Y}$$

where: dY/dL is the marginal product of labor (MPL).

$$\beta = MPL \times \frac{L}{Y}$$

Therefore, the MPL for any sector (i) can be calculated as follows:

$$MPLi = \beta i \times \frac{Yi}{Li} \quad (3)$$

The process shows the calculation of MPL from the coefficient of labor, multiplying the output per employee in each sub-sector *i* as equation (3). The coefficient of labor (β) is estimated using the Ordinary Least Squares (OLS) method.

As aforementioned, the calculation of labor productivity is demonstrated using APL and MPL approaches as the next step to explain what factors affect labor productivity in the Northeast. Based on the literature review, the factors affecting labor productivity are discussed in section 2. This study runs a regression using the APL and MPL in the Northeast overall and each sub-sector as the dependent variable along with the independent variables shown in equations (4) and (5). The following multiple regression model is proposed.

$$\ln APL_{it} = a_0 + a_1 \ln K/L_{it} + a_2 \ln R\&D_{it} + a_3 \ln Edu_{it} + a_4 \ln Hea_{it} + a_5 \ln A/I_{it} + a_6 \ln S/I_{it} + \varepsilon_{it} \quad (4)$$

where: the variables are as follows: *APL* is the average product of labor (output per worker) at sub-sector *i* at time *t*; *K/L* is the capital-labor ratio; *R&D* is the amount of research and development expenditure; *Edu* is government investment in education; *Hea* is government investment in health; *A/I* is the agriculture to industry sector value of output ratio; *S/I* is the services to industry sector value of output ratio; and *ε* is the error term.

$$\ln MPL_{it} = \beta_0 + \beta_1 \ln K/L_{it} + \beta_2 \ln R\&D_{it} + \beta_3 \ln Edu_{it} + \beta_4 \ln Hea_{it} + \beta_5 \ln A/I_{it} + \beta_6 \ln S/I_{it} + \eta_{it} \quad (5)$$

where: MPL is the marginal product of labor, derived from equation (3) and η is the error term while other variables remain the same.

According to the theory, the estimated coefficients are expected to have the following signs: a_1 and $\beta_1 > 0$, a_2 and $\beta_2 > 0$, a_3 and $\beta_3 > 0$ or < 0, a_4 and $\beta_4 > 0$, a_5 and $\beta_5 < 0$, and a_6 and $\beta_6 > 0$.

4. Data description

This study employs time-series data for the period 1981–2015 (35 years) to analyze the determinants of labor productivity. Data sources and details of the variables are shown in Table 2. Gross regional product (GRP) is utilized for the Northeast overall and each sub-sector (i) from 1988 through to 2015. The data is taken from the Office of the National Economic and Social Development Board (NESDB). Labor is measured by the number of employed in the population aged 15 years or older living in the North-eastern area. This data is taken from the Labor Force Survey Whole Kingdom Quarter 3: July–September of the National Statistical Office (NSO), Ministry of Information and Communication Technology. Although the labor force is surveyed four times a year, labor data in quarter 3 (July–September) is used since it represents a period of full employment in Thailand.

Regarding the net capital stock in the Northeast, the data at regional level for Thailand is constrained and only available at national level. Thus, net capital stock in the Northeast is calculated from an assumption of its ratio to GRP, to equate with the ratio of net capital stock to GDP at national level. Data on net capital stock has been taken from that constructed by the NESDB. Gross R&D expenditure in the Northeast uses data from the private sector, government, academia, non-profit organizations, and state enterprises. Since separate data on R&D expenditure is limited for each sector, this study uses integrated data for all sectors, to represent the amount of total R&D expenditure. Data was collected from several institutions, including the National Research Council of Thailand, National Science and Technology Development Agency, and National Science Technology and Innovation Policy Office.

Table 2. Data sources and descriptive statistics of variables

Variables	Description	Source	Mean	Std. Dev.	Max	Min	Range
APL	Gross regional product per worker (million baht per person)	Office of The National Economic and Social Development Board (NESDB) at http://www.nesdb.go.th/main.php?filename=gross_regional and National Statistical Office (NSO)	0.049	0.032	0.133	0.015	0.119
MPL	Calculated from the Cobb-Douglas production function in equation (3) (million baht per person)	Office of The National Economic and Social Development Board (NESDB) at http://www.nesdb.go.th/main.php?filename=gross_regional and National Statistical Office (NSO)	0.012	0.008	0.032	0.004	0.028
K/L	Net capital stock divided by employees in the Northeast (million baht per person)	Office of The National Economic and Social Development Board (NESDB) at http://www.nesdb.go.th/main.php?filename=capital_stock and National Statistical Office (NSO)	0.138	0.098	0.388	0.031	0.357
R&D	Gross expenditure on R&D in the Northeast for the private sector, government, academia, non-profit organizations and state enterprise (million baht)	National Research Council of Thailand, National Science and Technology Development Agency, and National Science Technology and Innovation Policy Office	306.270	292.320	1,127.510	23.246	1,104.264
EDU	Government investment in education measured using total government spending on education at the basic education level, vocational level and higher education level in the Northeast. (million baht	Office of the Basic Education Commission, Office of the Vocational Education Commission, and Thailand Bureau of the Budget	8,240.160	11,500.650	38,263.324	342.179	37,921.144
HEA	Government investment in health measured using the total annual budget classified by province in the Northeast (million baht)	Ministry of Public Health	10,843.650	5,194.010	24,145.840	5,403.568	18,742.272

Variables	Description	Source	Mean	Std. Dev.	Max	Min	Range
A/I	Value of the output ratio of agriculture to industry in the Northeast	Office of The National Economic and Social Development Board (NESDB) at http://www.nesdb.go.th/main.php?filename=gross_regional	2.190	1.460	6.149	0.943	5.205
S/I	Value of the output ratio of services to industry in the Northeast	Office of The National Economic and Social Development Board (NESDB) at http://www.nesdb.go.th/main.php?filename=gross_regional	0.930	0.720	2.366	0.239	2.127

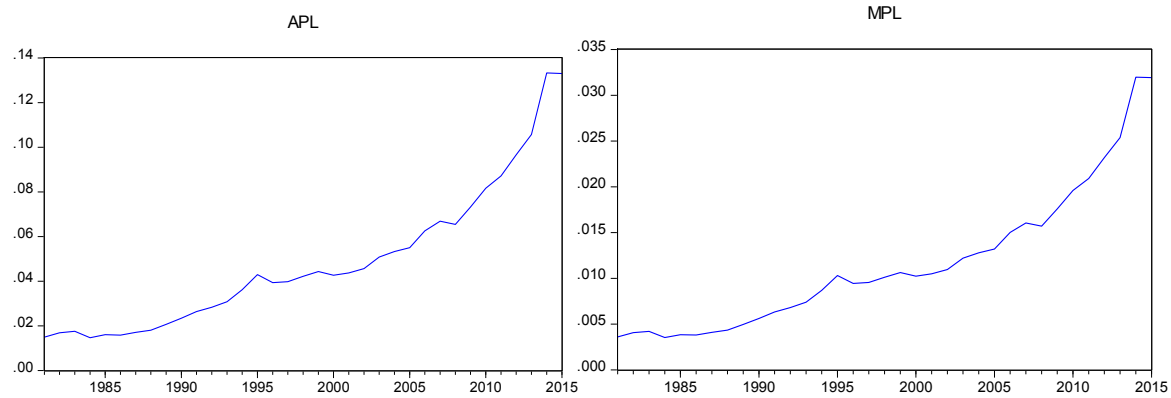
Government investment in education (Edu) is measured by the sum of government spending on education at three levels of education in the Northeast: basic, vocational, and higher. Basic level education is separated into kindergarten, primary school, and secondary school under the Office of the Basic Education Commission. The number of students in each school was multiplied by government subsidy cost per student. For vocational education, the annual budget data for vocational institutions in the Northeast was compiled and provided by the Office of the Vocational Education Commission. Finally, for higher education annual budget data for universities in the Northeast was taken from the Report of Thailand's Budget in Brief, Bureau of the Budget.

As indicated above, government investment in health (Hea) was measured using the total annual government budget for hospitals and public health centres in each province in the Northeast in accordance with the data obtained from the Ministry of Public Health. In this study, an attempt was also made to measure structural change. Prokopenko (1987), Fisher (1939), and Clark (1940) point out that structural changes in the economy are a result of output shifting away from primary (agriculture) to secondary (manufacturing) and tertiary sectors (services), thereby increasing in productivity. Therefore, structural change is identified by two variables: the proportion output value of agriculture to industry sectors and services to industry sectors. The output data for each sector was taken from the NESDB.

5. Results of the structural break test

The data on labor productivity variables in Table 2 exhibits that the APL is greater than the MPL, which means that the Northeast overall uses only the labor factor in production more than the interoperability of capital and labor factors. However, the APL and MPL in the Northeast overall for the period from 1981-2015 show the same trend and movement (see Figure 1) as well as an average growth rate of 6.94%, implying no difference.

Figure 1. The average product of labor and marginal product of labor in the Northeast overall from 1981–2015



Furthermore, Figure 1 shows apparent changes in 1996 when Thailand was facing an economic crisis, which may have caused labor productivity to decrease. Initially, this study ran regressions for two periods from 1981–1995 and 1996–2015 to investigate the determinants of labor productivity in the short-term. The results of factors affecting labor productivity in both periods are different (Appendix). It is possible that the factors affecting labor productivity vary according to changes in economic and social conditions during each period. For this reason, structural breaks were also tested using the Chow Test. The Chow Test is used to determine whether the coefficients from two regression analyses are the same. Three regressions were run, one for each group. The

first group identifies the period from 1981–1995, the second group 1996–2015, and the third group the entire sample period from 1981–2015. The F test was then used to determine whether the models were significantly different from one another. The test statistic is formally stated as follows:

$$F = ((RSS_W - RSS_1 - RSS_2)/k) / ((RSS_1 + RSS_2)/(T-2k))$$

where: RSS_W is the residual sum of squares for the whole sample (restricted model). RSS_1 is the residual sum of squares for the first group and RSS_2 is the residual sum of squares for the second group. T is the total number of observations for the whole sample. k is the number of regressors (including the intercept term).

Table 3. Chow Test outcome

RSS_W	RSS_1	RSS_2	F-statistics	F(k, T-2k) at the 5% significance level	Decision
11,600,726.00	46,495.95	6,507,788.90	2.31	2.49	Two groups are not separate.

Table 3 demonstrates the results of the Chow Test. The critical value at the 5% significance level is 2.49. Since the F value is less than the critical value, the null hypothesis that the coefficients from two regression analyses are the same can be accepted. Consequently, the relevant conclusion is that there is no difference in the sub-groups. The sub-group model can be explained by the whole sample. This provides statistical evidence justifying the decision to estimate the entire sample model.

6. Empirical results

This section provides the results of the study using time-series analysis to examine the factors influencing labor productivity in the Northeast overall, and eight sub-sectors. The regression results of 35 annual observations to investigate the relationships among the APL and MPL on capital-labor ratio, amount of R&D expenditure, government investment in education, government investment in health, value of the output ratio of agriculture to industry sectors, and value of the output ratio of services to industry sectors are also provided. The estimation results shown in equations (4) and (5) are entirely in accordance with both approaches. As the analysis results for both APL and MPL approaches are similar, only the latter is described since it is more consistent with the concepts and theories of economics. Moreover, autocorrelation was used to test the hypothesis of zero at the 1% significance level, and some of the models were found to be autocorrelated. The problem was solved by the Cochrane-Orcutt method which is conducive to the D-W statistic in Tables 4 and 5 and does not cause a serial correlation issue in the error term.

Equation (5) estimates labor productivity measured by the MPL approach for the Northeast overall and each sub-sector. The natural log on both sides can be considered from the regression analysis results exhibited in Table 4, with the estimated parameters representing the elasticity of variables. When considering sub-sectors, the regression analysis results show four factors affecting labor productivity in the entire Northeast. These are capital-labor ratio, government investment in education, value of the output ratio of agriculture to industry, and value of the output ratio of services to industry. The first factor has a positive, highly significant statistical effect on labor productivity at the 1% level. Government investment in education and value of the output ratio of services to industry have a statistically significant positive impact on labor productivity at the 5% level. The coefficients are different, ranging from 0.06 to 0.88. This implies that an increase in the capital-labor ratio, government investment in education, and value of output ratio of services to industry can raise labor productivity. However, the value of the output ratio of agriculture to industry has a negative effect at the 5% statistical significance level. A decrease in value of the output ratio of agriculture to industry can raise labor productivity since it demonstrates a shift in structural change from agriculture towards manufacturing. The results coincide with the aforementioned hypotheses.

As to the sub-sectors, the results are described by dividing them into three groups according to the classification by Colin Clark, with the agricultural sector as the primary group. The secondary group consists of three sub-sectors: mining and quarrying, manufacturing, and construction. In the tertiary group, there are four sub-sectors: electricity and water supply, transportation and communication, wholesale and retail trade, and services. In the primary group, three factors have a significantly positive effect on labor productivity: the capital-labor ratio, government investment in education, and value of the output ratio of agriculture to industry.

In the secondary group, three factors affect labor productivity: the capital-labor ratio, value of the output ratio of agriculture to industry, and value of the output ratio of services to industry. The capital-labor ratio and the value of the output ratio of services to industry have a significantly positive impact and consequently raise labor

productivity. On the other hand, the value of the output ratio of agriculture to industry has a significantly negative effect on labor productivity. In other words, a decrease in the value of the output ratio of agriculture to industry can improve labor productivity.

Finally, in the tertiary group, five factors influence labor productivity. These variables consist of capital-labor ratio, government investment in education, government investment in health, value of the output ratio of agriculture to industry, and value of the output ratio of services to industry. The capital-labor ratio and the value of the output ratio of services to industry have a significantly positive impact on labor productivity. Therefore, an increase in these factors can raise labor productivity. Nevertheless, government investment in education, government investment in health, and value of the output ratio of agriculture to industry have a significantly negative effect on labor productivity. This means that an increase in these factors can diminish labor productivity

Table 4. Regression of the marginal product of labor (MPL) with independent variables in Northeast Thailand, 1981–2015

Variables	Northeast Overall	Primary	Secondary			Tertiary			
		Agriculture	Mining and quarrying	Manufacturing	Construction	Electricity and water supply	Transportation and communication	Wholesale and retail trade	Services
Constant	-3.47 ***(-3.64)	-8.99 ***(-4.77)	-14.56 (-1.15)	6.81 (0.70)	7.13 (0.83)	-2.10 (-0.75)	4.33 (1.26)	9.13 (1.48)	-2.27 (-0.64)
K/L	0.88 ***(10.02)	1.29 ***(9.82)	2.07 **(2.33)	0.86 ***(3.05)	-0.60 (-0.80)	0.85 ***(4.33)	0.55 ***(2.91)	-0.01 (-0.04)	0.86 ***(3.36)
R&D	0.04 (0.74)	-0.15 (-1.20)	-0.53 (-0.61)	0.08 (0.25)	0.23 (0.62)	-0.15 (-0.82	-0.01 (-0.02)	0.06 (0.28)	-0.18 (-0.98)
EDU	0.06 **(2.31)	0.11 *(1.95)	0.34 (0.88)	-0.06 (-0.13)	0.10 (0.21)	-0.20 **(-2.31)	-0.04 (-0.53)	0.02 (0.09)	-0.05 (-0.22)
HEA	0.02 (0.33)	-0.10 (-0.84)	0.36 (0.45)	0.11 (0.28)	0.11 (0.27)	-0.40 **(-2.24)	-0.12 (-0.58)	-0.03 (-0.08)	-0.01 (-0.02)
A/I	-0.06 **(-2.52)	0.99 ***(8.36)	-1.04 (-1.30)	-0.98 ***(-4.11)	-0.62 *(-1.96)	0.16 (0.88)	-0.08 (-0.44)	-0.49 **(-2.58)	-0.44 **(-2.52)
S/I	0.09 **(2.19)	-0.15 (-1.37)	1.95 **(2.68)	-0.10 (-0.42)	0.46 (1.09)	0.29 *(1.78)	-0.05 (-0.30)	0.40 ***(2.80)	0.74 ***(4.30)
R squared	0.993	0.965	0.379	0.898	0.610	0.941	0.930	0.660	0.890
Adjusted R squared	0.991	0.957	0.246	0.861	0.490	0.928	0.904	0.556	0.850
F statistic	***625.23	***127.47	**2.85	***24.40	***5.08	***74.06	***36.69	***6.32	***22.44
D.W.	2.09	1.93	1.79	1.94	1.98	1.80	1.95	1.93	1.97
No of observations		35							

Note: t-statistics in parentheses; * sig. at the 10% level, ** sig. at the 5% level, *** sig. at the 1% level

In addition, when considering the factors influencing labor productivity, even though the effect of the capital-labor ratio and output ratio value of services to industry remain positive and significant, the effect of government investment in health and the output ratio value of agriculture to industry are mostly significant and negative. Government investment in education has both a significantly positive and negative effect on labor productivity but the R&D expenditure variable is insignificant.

The capital-labor ratio has the expected positive effect, indicating at least a 5% level of statistical significance for the mining and quarrying sector although this is mostly at 1% for the Northeast overall and sub-sectors of agriculture, manufacturing, electricity and water supply, transportation and communication, and services. The coefficients of the capital-labor ratio are different, ranging from 0.55 to 2.07. This means that, as expected, the effect of the capital-labor ratio is high and strong, especially for the mining and quarrying sectors. Although two sub-sectors (construction, wholesale, and retail trade) have a negative effect, the results are not statistically significant. Government investment in education shows the anticipated positive effect with strong statistical significance at the 10% level for agriculture and significant at the 5% level for the Northeast overall. On the other hand, the electricity and water supply sector has the expected negative highly statistically significant effect at the 5% level. Similarly, government investment in health has the expected, highly statistically significant negative effect at the 5% level while for the entire Northeast and other sub-sectors it is not a significant factor in determining labor productivity. Since the analytical results of these two factors indicate a significantly negative effect on labor productivity, it is possible that government spending on education and health may be ineffective and inconsistent with labor demand, particularly in the electricity and water supply sector. There is a lack of suitable labor with the ability to carry out the job. As a result, labor productivity has decreased. Similarly, Umoru and Yaqub (2013) found that although government investment in education is estimated to be negative, it is not a statistically significant determinant of labor productivity.

As to other important factors, the output ratio value of agriculture to industry has an expected negative effect, with the results indicating at least a 10% statistical significance level for the construction sector. For the Northeast overall, as well as the sectors of wholesale and retail trade and services, the statistical significance is mostly at the 5% level. Whereas such factors have an anticipated positive and highly statistically significant effect at the 1% level for agriculture. The same direction of value output ratio of agriculture to industry and labor productivity indicates unclear structural changes from agriculture to industry sectors. An increase in these factors can raise labor productivity in the agriculture sector since the value output of such a rise is due to an improvement in labor skills. The value of services to industry output ratio has the anticipated positive effect with at least a 10% strongly statistical significant level for the electricity and water supply sector, but mostly at the 5% level for the Northeast overall and mining and quarrying, and highly statistically significant at the 1% level for wholesale and retail trade, and service sectors. However, two of these factors are proxies of structural change. Surprisingly, structural change has a significant impact on labor productivity both in the entire Northeast and nearly all sub-sectors. Consistency during the 1960s and 1970s, protection of capital-intensive manufacturing, and export taxes on rice and other commodities suppressed the size of the agricultural sector. While these policies were abandoned during the 1980s, economic development brought about a shift from agriculture. The share of GRP for this sector in the Northeast fell from more than one-third in 1981 to less than one-quarter in 2015, whereas industry increased from less than 10 to 18%, although services decreased from 10% to 6%.

In contrast, R&D expenditure is not statistically significant. The insignificant coefficient of R&D expenditure may suggest that it has been ineffective in the Northeast. One possible explanation for this is that there is less R&D expenditure in the Northeast since it is predominantly an agricultural region and consequently, R&D investment may play a minor role. Furthermore, the World Bank (2005) illuminated that R&D deficiency has been a hindrance to technological upgrading in the Northeast, with firms lagging behind in the technological capability which is important for the diffusion of knowledge and innovation. Low agglomeration and weak technological capability ultimately lead to low efficiency in combining capital and labor to generate output.

Conclusion

This study investigates the effects of different factors on labor productivity in Northeast Thailand from 1981–2015, producing the following results. In the primary group, three factors affect labor productivity: the capital-labor ratio, government investment in education, and value of the output ratio of agriculture to industry. In the secondary group, three factors affect labor productivity: the capital-labor ratio, value of the output ratio of agriculture to industry, and value of the output ratio of services to industry. As to the tertiary group, five factors influence labor productivity: the capital-labor ratio, government investment in education, government investment in health, value of the output ratio of agriculture to industry, and value of the output ratio of services to industry.

As previously mentioned, the empirical analysis demonstrates that the major determinants of labor productivity are the capital-labor ratio, government investment in education and health as well as structural change (value of the output ratio of agriculture to industry and value of the output ratio of services to industry), especially the capital-labor ratio and structural change variables since these factors have a strongly significant impact on labor productivity both in the Northeast overall and all groups or almost all sub-sectors. This may be because of a change in the economic structure from agriculture to manufacturing. Following implementation of the National Economic and Social Development Plan in 1961, the country urgently needed to develop its economy to increase production in the manufacturing sector. Moreover, the Ministry of Industry defined the strategic plan as an approach to industrial development and expanded the role of the manufacturing industry in the region. In particular, the North-eastern area of the country was seen as an important input source (labor and area).

However, R&D expenditure has had an insignificant impact on labor productivity, indicating that the government's efforts to build technological capacity have not been effective. Although it has been making an effort to upgrade technological capacity, government policies have been mostly directed towards industrial estates in the Central and Eastern areas of Thailand, with the Northeast region receiving little attention. Therefore, this study could serve to provide fundamental information for policymakers in both the government and private sectors to encourage greater focus on these determining factors of labor productivity in the Northeast. In addition, the results offer guidelines for improving labor productivity to provide higher wages and better living standards for the labor force.

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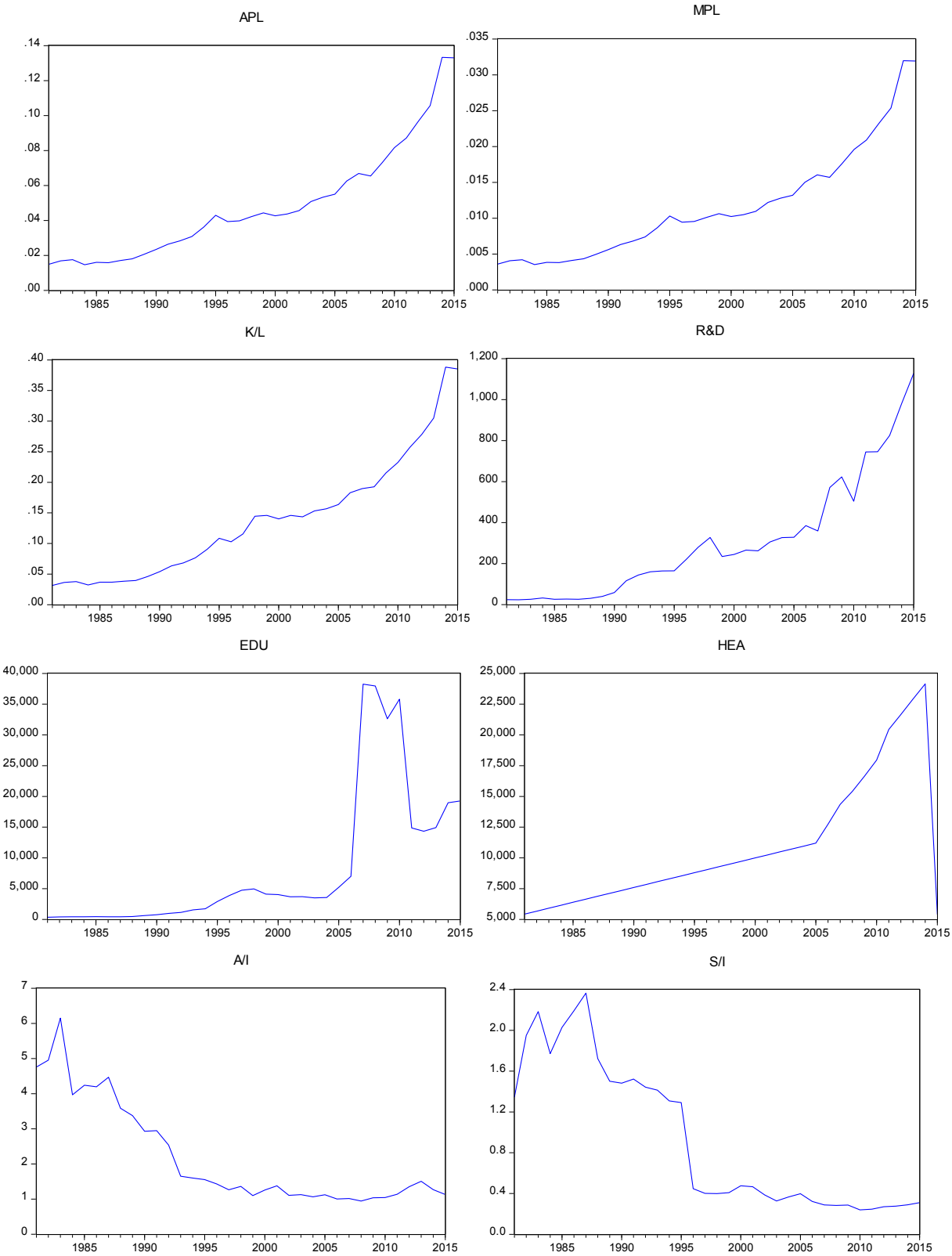
APPENDIX

Figure A shows the characteristics of variables used to estimate the factors influencing labor productivity in the Northeast from 1981 to 2015.

Figure A. Characteristics of variables in this study



Tables A1 and A2 show the regression of the marginal product of labor (MPL) with independent variables in the Northeast for two periods. Maybe a problem since F-stat is not sig (mining and quarrying sector).

Table A1. Regression of the marginal product of labor (MPL) with independent variables in Northeast Thailand, 1981–1995

Variables	Agriculture	Mining and Quarrying	Manufacturing	Construction	Electricity and Water Supply	Transportation and Communication	Wholesale and Retail Trade	Services
Constant	-2.68 (-0.19)	57.06 (2.08)	71.99- (-1.00)	-150.60 (-1.28)	-65.53 ***(-5.31)	-18.13 (-1.27)	-34.34 (-1.30)	-83.65 **(-2.74)
K/L	1.29 (1.50)	11.68 (1.51)	-3.42 (-1.06)	-5.07 (-1.03)	-1.42 (-1.31)	-1.04 (-0.91)	-1.62 (-1.11)	-0.81 (-0.34)
R&D	-0.02 (-0.13)	-0.72 (-0.35)	0.02 (0.03)	-0.32 (-1.30)	0.35 (1.40)	0.03 (0.15)	0.11 (0.25)	0.08 (0.07)
EDU	0.33 (0.68)	-6.95 (-1.14)	1.07 (0.37)	1.82 (0.61)	0.69 (0.84)	0.08 (0.14)	0.51 (0.39)	0.27 (0.23)
HEA	-0.49 (-0.84)	-0.74 (-0.08)	4.31 (1.73)	8.07 (1.67)	3.12 ***(6.68)	1.72 **(2.99)	2.18 *(2.18)	4.15 ***(4.06)
A/I	1.30 ***(5.04)	-4.45 (-1.14)	-0.94 (-0.68)	-0.26 (-0.14)	0.81 **(3.22)	-0.97 **(-3.31)	-0.16 (-0.30)	0.18 (0.18)
S/I	-0.57 (-1.57)	3.66 (0.97)	-0.08 (-0.08)	0.57 (0.65)	-0.45 *(-2.19)	0.36 (1.84)	-0.62 (-1.64)	0.12 (0.25)
R squared	0.901	0.620	0.923	0.914	0.983	0.968	0.880	0.965
Adjusted R squared	0.770	0.113	0.785	0.799	0.952	0.911	0.719	0.919
F statistic	**6.85	1.22	**6.69	**7.96	***32.15	16.83***	**5.47	***20.80
D.W.	2.03	1.88	2.02	2.26	2.35	2.46	2.16	1.88
No of observations		35						

Note: t-statistics in parentheses; * sig. at the 10% level, ** sig. at the 5% level, *** sig. at the 1% level

Table A2. Regression of the marginal product of labor (MPL) with independent variables in Northeast Thailand, 1996–2015

Variables	Agriculture	Mining and Quarrying	Manufacturing	Construction	Electricity and Water Supply	Transportation and Communication	Wholesale and Retail Trade	Services
Constant	-5.93 (-1.70)	-16.78 (-0.71)	-0.62 (-0.14)	4.32 (0.34)	-12.99 (-1.10)	3.80 (0.57)	7.93 (1.34)	-1.68 (-0.17)
K/L	1.20 ***(3.98)	-0.51 (-0.29)	0.51 (1.11)	0.33 (0.48)	0.56 (0.75)	1.07 *(2.05)	-0.02 (-0.08)	1.41 *(1.87)
R&D	-0.03 (-0.13)	1.03 (0.70)	0.25 (0.64)	-0.02 (-0.07)	1.03 (1.49)	-0.11 (-0.32)	0.38 (1.37)	-0.31 (-1.09)
EDU	0.11 (0.13)	0.38 (0.97)	-0.03 (-0.42)	0.17 **(2.46)	0.-48 ***(-7.76)	0.03 (0.87)	0.10 (0.99)	-0.06 (-0.30)
HEA	-0.06 (-0.37)	0.19 (0.24)	0.01 (0.05)	-0.12 (-0.14)	0.41 (0.86)	-0.17 (-0.41)	-0.37 (-0.90)	0.03 (0.04)
A/I	0.64 **(2.58)	0.28 (0.14)	-0.39 (-0.63)	0.64 (0.98)	-2.22 ***(-3.83)	0.44 (1.73)	1.12 ***(3.82)	-0.01 (-0.03)
S/I	-0.80 *(-2.22)	1.31 (0.55)	-0.81 **(-2.20)	0.70 (1.34)	0.38 (0.42)	-0.19 (-0.46)	-0.19 (-0.50)	-0.18 (-0.35)
R squared	0.991	0.331	0.966	0.667	0.934	0.975	0.895	0.932
Adjusted R squared	0.982	0.022	0.942	0.424	0.876	0.952	0.800	0.871
F statistic	***117.10	1.07	***39.30	*2.75	***15.85	***42.70	***9.48	***15.23
D.W.	1.96	1.81	1.75	2.06	2.10	2.01	2.02	1.73
No of observations		35						

Note: t-statistics in parentheses; * sig. at the 10% level, ** sig. at the 5% level, *** sig. at the 1% level.

A Study on the Chain of Cost Values – Online Trust: Applications in Mobile Commerce in Vietnam

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Abstract:

Mobile commerce (m-commerce) is making a big difference in the perception of cost, value, and online customer trust in the business. Besides monetary cost, the spiritual cost also contributes to the change in not perceived value but also online trust. Based on qualitative and quantitative research with Structural Equation Model (SEM), the paper examines as well as confirms the negative relationship between perceived cost (monetary and spiritual) and perceived value; moreover, the study also explores perceived value that has a mediating role in the negative relationship between perceived spiritual cost and online customer trust to m-commerce business in Vietnam. Besides, some managerial implications are proposed for m-commerce business via electronic devices.

Keywords: perceived monetary cost; perceived spiritual cost; perceived value; online trust; m-commerce

JEL Classification: M31

1. Introduction

M-commerce refers to conducting e-commerce using mobile devices and wireless networks (Siau *et al.* 2001). Activities of m-commerce include B2C, B2B, mobile government, information exchange, and money transfers. Like e-commerce applications, m-commerce is an electronic transaction process using mobile devices via the Internet, intranet, private line, or via other wireless networks to execute transactions (Turban *et al.* 2017). According to the report of the Department of E-Commerce and Digital Economy (2018), 85% of customers search for information via mobile devices (iPad, tablet, and smartphone) when in need of online shopping. In electronic devices often used when ordering online, 75% of customers use mobile phones, and 13% of customers use Ipad or tablet. 41% of online transactions are made via a mobile application with the ubiquity to allow customers to shop anytime and anywhere, as long as their mobile devices can connect wireless. Convenience and capabilities that customers always carry with their smartphones, easy and quick interactivity via messages or social networks, personalization features because these are personal devices and localization of global positioning technology (GPS) are undeniable benefits that m-commerce brings to customers (Turban *et al.* 2017).

A loud explosion of m-commerce trend was marked in 2015. Along with the development of mobile infrastructure, the business has invested more in business operations on this new platform, from upgrading compatible website in a mobile platform to developing a mobile application. However, this trend seems to slow down with the proportion of website compatible with mobile devices does not increase. The proportion of websites with mobile versions decreased from 26% in 2015 to 19% in 2016 and 17% in 2017. Similar to the website version in a mobile platform, the proportion of enterprises having applications on mobile devices in 2017 is also 15% and equal to 2016, lower than in 2015 (18%). It can be seen that many enterprises have not seen the effectiveness of this platform and the demand for shopping on mobile platforms is only suitable for developed cities like Ha Noi and Ho Chi Minh City. In general, the level of development is not high and uneven in Vietnam (Vietnam E-commerce

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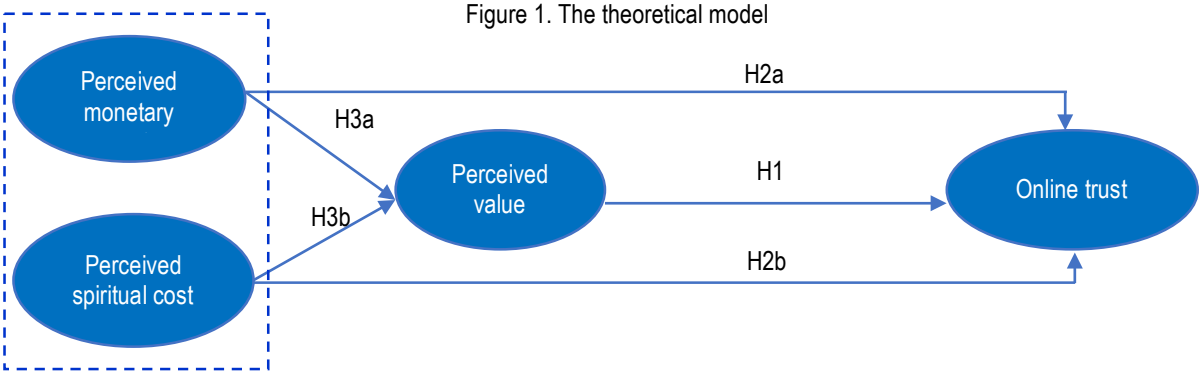
Association 2018). Although there are many benefits, m-commerce is still limited; therefore, consumers do not believe. The cost that customers have to accept when buying online is still relatively much in both monetary and spiritual aspect. Specifically, 77% of online shoppers believe the products that they receive are not as advertised, 36% of customers concerned that personal information will be leaked, 35% of customers find that the product price is unclear or not lower when buying at the store; and, 32% of consumers said they were disappointed with customer service (Vietnam eCommerce and Digital Economy Agency 2018). The adverse effects of costs lead to a decrease in the perceived value of customers on m-commerce, as well as, also has a negative impact on customers' trust in business through mobile (Parasuraman and Grewal 2000, Grewal *et al.* 2003).

Many researchers have researched the relationship between cost, perceived value, and customer trust. There is a negative relationship between factors belong to cost and perceived values (Dodds *et al.* 1991, Grewal *et al.* 1998, Xu *et al.* 2011). Consumer online trust is an important structure in only traditional commerce but also e-commerce. Online trust antecedents are researched to determine their influence on online trust. The antecedents of online trust have been shown to include the disposition to trust; perceived risk; perceived security and privacy; perceived reputation; perceived system quality, perceived information quality, perceived service quality, and design quality (Kim and Peterson 2017). The studies on the chain of cost - value - online trust have not been extensive, especially in the field of m-commerce. This study aims to explore the relationship between factors in the chain of cost (monetary and spiritual) - perceived value - the online trust of customers in the context of m-commerce in Vietnam.

2. Literature review

M-commerce creates many opportunities for business to provide new services to existing customers and attract new customers to shop anytime, anywhere. Initially, small screen sizes and slow bandwidth limited the usefulness of mobile devices to consumers. However, the above limitation is improving quickly due to the widespread use of smartphone and tablet, as well as, the development of wireless, 3G and 4G networks (Turban *et al.* 2017). Also, it is required from researchers to develop an understanding of the relationship between concepts, between customer perceptions of service quality when customers and service providers interact with each other. The goal of this study is to develop not only a better understanding of the structures but how they relate to each other to promote customers' online shopping behavior. The perceived value of customers is a concept that is closely related to the cost that customers have to spend during the purchase process (Zeithaml 1988). According to Zeithaml (1988), these costs can be determined through monetary and spiritual values (non-monetary) that customers suffer in the process of purchasing and using products or services. Parasuraman and Grewal (2000) proposed a model on how cost and spiritual factors affect the perceived value and customer behavior. Gambetta (1989) points out that customers' trust is subjective, and influenced by what they cannot control. The level of trust will depend on the perception of values that the merchant creates. This study based on the previous studies, as well as integrated empirical perspectives to build customer trust in the context of e-commerce as a basis for the concept of relationship. The relationship between the perceived cost, value, and online trust of consumers in the context of m-commerce. The theoretical model is presented in Figure 1.

Figure 1. The theoretical model



Source: Own development

The term "trust" is defined (1) based on or having confidence in the quality or attributes of a person or an object, (2) accepting or the following something without investigation or evidence, (3) an expectation of something, (4) attributes of reliable value; honest, reputable, loyal (Oxford 2010). Online trust is often seen as a reliance on a specific company of stakeholders for the company's business operations in an online environment and the company's online system (Kim 2012). Specific trust in integrity, competence, and benevolence is considered a

prerequisite for overall trust (McKnight *et al.* 2002). For the consumer, online trust helps them minimize concerns about vulnerabilities such as security and privacy violations related to online trading (Blut *et al.* 2015). With the same point of view, Ang *et al.* (2001) proposed that three aspects of trust are the integrity of online business to deliver products or services as promised, the competence of online business to overcome if purchase transactions do not meet the need of customer, and the presence of security policies or security information about the transaction system. Trust has been studied in many areas and applications in an online context. If online trust can be understood and enhanced by business in a mobile context, the number of buyers through mobile applications will increase significantly. More importantly, when a reliable online environment is created, buyers will feel more comfortable disclosing sensitive personal information. Simply put, the future of m-commerce depends on the trust of online customers.

Perceived value is a two-part concept including the benefits (economic, social and relations) and the costs (costs, time, effort, risk, and convenience) (Cronin Jr. *et al.* 2000). Perception of value is the overall consumer appreciation of the utility of a product or service based on their perceptions of what is received and what must be taken out (Zeithaml 1988). Some consumers perceive the value when there is a low price; others feel value when there is a balance between quality and price (Sweeney and Soutar 2001). Thus, with different consumers, the components of perceived value may be different. Therefore, this is a personal and subjective concept (Parasuraman *et al.* 1991). The value and trust that have a direct positive relationship (Singh and Sirdeshmukh 2000, Harris and Goode 2004). Karjaluoto *et al.* (2012); Sirdeshmukh *et al.* (2002) asserted that if buyers are aware of the value in the product, they can trust that product. Also, the level of customer trust depends on the perceived value which the seller create for the customer in the transaction (Gambetta 1989). User value systems received in the context of m-commerce are viewed as behavioral guidelines. So, the value from experience explained by arranging the criteria given by the customer to evaluate and understand the meaning of events, and actions in the world around. Values contribute to the general experience and create trust, or can create a tendency to trust beyond specific situations and relationships (Gustavsson and Johansson 2006). Then, we have the following hypothesis:

H1: The perceived value has a positive impact on online trust when buying in m-commerce

The perceived cost includes money for payment and non-cash items such as time and efforts to be spent (Bolton and Lemon 1999). According to the concept of Zeithaml (1988), customer cost is assessed through perceived factors what customers have spent. According to Ahola *et al.* (2000), transaction cost is the total cost that customers accept to trade in the process of using products or services (perceived monetary cost, time cost, energy cost, and spiritual cost). According to Zeithaml (1988), the price that customers pay for a service includes monetary and non-monetary prices. Moreover, the cost of transactions can also be divided into monetary and non-monetary costs (Parasuraman and Grewal 2000). Based on previous studies, this study focuses on the perceived monetary cost and the perceived spiritual cost that customers spend when shopping in m-commerce. While, perceived monetary cost are intuitive costs, such as advertised selling price, shipping and handling price; and the spiritual costs associated with psychological trade-offs include effort, waiting, product evaluation and decision making. The perceived monetary cost in m-commerce is the price of the product that customers have to pay to achieve the desired utility. In other words, it is the price paid for the product or service for the customer (Gefen and Devine 2001). In addition, the perceived monetary costs of purchasing goods through mobile applications also include delivery cost (Clay *et al.* 2002), return cost According to a theory developed by Sheth *et al.* (1991), the perceived spiritual cost is the ability to evoke emotion or emotional state and to be measured according to the emotional impression of the product or service. Thus, the spiritual costs of buying in m-commerce are closely related to the emotional costs of customers when buying products through mobile applications and devices. Positive emotions are related to satisfaction, happiness, love, and pride, while negative emotions involve anger, anxiety, worry and shame (Laros and Steenkamp 2005). Customers can express feelings of disappointment if they are not satisfied with the result of inadequate reimbursement from the business. When an incident occurs or feel the injustice of the purchase process via mobile application (Weiss *et al.* 1999), feeling worried in waiting for goods or in the process of online transactions (Kim and Forsythe 2008); feeling annoy due to unwanted calls or emails, advertising reports from businesses because personal or private information is used for improper purposes (Stewart and Segars 2002, Chellappa and Sin 2005, Khoa 2017). A mental cost of perceiving disorders in procurement behavior due to subjective preference or shopping too quickly leads to shopping addiction (Schlosser *et al.* 1994, Black 2007). Also, compulsive online buying disorder will also occur when shopping on e-commerce sites; mobile applications are increasingly comfortable, convenient and widely used (Andreassen 2014). Financial risk and psychological risk are indicative of perceived monetary costs and perceived spiritual cost to customers. The exact relationship between risk and trust has been discussed a lot. The risk is the behavioral manifestation of vulnerability

due to external influences. Customers often do not need to risk to believe; however, they must take risks to participate in trusting actions. Despite this valuable insight, most studies suggest that the need to build trust is based on the presence of some degree of risk (Jarvenpaa *et al.* 2000, Yao-Hua Tan 2000). The low level of cost is related to a higher level of trust in e-commerce sites or m-commerce applications. Empirical evidence from previous e-commerce research supports the negative relationship between perceived cost and trust (Jarvenpaa *et al.* 1999, Pavlou 2003). Since then, two hypotheses are proposed:

H2a: The perceived monetary cost has a negative effect on online trust when buying in m-commerce

H2b: The perceived spiritual cost has a negative effect on online trust when buying in m-commerce

Xu *et al.* (2011) found that, despite the great benefit which provided by location awareness marketing services (LAM), the privacy concerns of customer appear as a deterrent to accept LAM; especially, when they use a mobile device with a global positioning system (GPS). The study extends the private calculus model to explore personal paradoxes, particularly in LAM, with the consideration in personal character and two approaches with the individual (secret and public). The economic cost of a bad decision is a risk factor. Customers who buy through the phone know that he/she can return an item if they prove that the product is unsatisfactory and therefore may not realize any financial loss. However, that customer may feel a significant risk of losing time (having to return the purchase, delaying the purchase of a necessary item); face loss and frustration (dissatisfaction due to poor purchase); and do not achieve their buying goals (Cox and Rich 1964, Cunningham *et al.* 2004). Empirical research shows that the effects of perceived cost vary for each and their expectations. Therefore, the study has two hypotheses:

H3a: The perceived monetary cost has a negative effect on perceived value when buying in m-commerce

H3b: The perceived spiritual cost has a negative effect on perceived value when buying in m-commerce

3. Methodology

The mixed method including qualitative research method and quantitative research method is used to achieve the research objectives set out. Qualitative research is done to determine the factors that are considered to be the cost of the transaction through mobile devices as well as adjusting the questionnaire. Methods of data collection in qualitative research are focus group discussion (Rabiee 2004, Silverman 2016). Participants of the discussion included ten customers selected by the snowball method, having experience in m-commerce for over a year. The discussion took place under the presidency of the author with a discussion guide.

The results of qualitative research show that the costs that ten customers find include the monetary and spiritual cost of the transaction through devices such as smartphones and tablets. Also, all participants agreed that the perceived cost has a negative impact on their perceived value as well as their trust in an online seller. Besides, the scale in the study of perceived monetary costs, emotional costs, perceived values as well as online trust in the field of m-commerce is also adjusted to suit the Vietnamese buyer and m-commerce context. The next step, the questionnaire is designed to be able to conduct quantitative research. Subjects surveyed by questionnaires focus on customer aged 18 to 45, the job is the student, office worker, lecturer, civil servant, housewife, trader, worker because these are the people who need online shopping and have a good awareness of m-commerce (Department of E-Commerce and Information Technology 2017). According to Hair *et al.* (2010), the number of samples must be at least five times the number of observed variables; the research result ensures accuracy. Tabachnick and Fidell (2007) argue that sample sizes that will give research results corresponding to 50 are very poor, 100 is poor, 200 is pretty good, 300 is good, 500 is very good, and 1000 is excellent. Therefore, the number of samples in the study was 587. In order to achieve the research goal of the study, the sampling technique in this study selected non-probability, judgemental sampling technique. Since the study is intensive in the field of m-commerce, it is recommended to use purpose-based sampling to select the survey respondents to understand the research problem and thereby expand the sample easily (Neuman 2002).

The scale of all research concepts in the paper is based on the previous studies, adjusted through qualitative research and presented in the form of a statement. The scale uses 5 points Likert scale from (1) Strongly disagree to (5) Strongly agree.

Out of 600-panel members who were invited to participate in the study, 592 members responded, which represents a 98,67 percent response rate. After data cleaning, five responses were removed due to lack of information, selecting the answer that violates the reverse question. Leading to a total of 587 responses being used for further analysis.

Table 1. Statistics of factors used in the study

Factor	No of observed variables	Source
Perceived monetary cost	6	Gefen and Devine (2001), Clay *et al.* (2002), Bower and Maxham III (2012), focus group discussion.
Perceived spiritual cost	4	Weiss *et al.* (1999), Chellappa and Sin (2005), Kim and Forsythe (2008), Black (2001), focus group discussion.
Perceived value	5	Sirdeshmukh *et al.* (2002), Cronin Jr *et al.* (2000), focus group discussion.
Online trust	4	Jarvenpaa *et al.* (2000), focus group discussion.

Source: Own development

In particular, respondents did not have much difference in the proportion of men (49.7%) and women (50.3%). The occupation of participants is office worker (28.1%), civil servant (18.1%), trader and student (together with 16.5%), this is a group of people who often trade online. The age of the respondents is in the range of 20-45, accounting for 83.5% and the level of education in College, University and Master/Ph.D. graduate is 490 people, accounting for 79.7%. Thus, the research sample is suitable for research purposes. This data will help to make the study an appropriate assessment of the relationship between cost, value and online trust in m-commerce.

Table 2. Demographic profile

Characteristics		Frequency	%
Gender	Male	292	49.7
	Female	295	50.3
Age	Under 20	97	16.5
	20 – 24	85	14.5
	25 – 29	167	28.4
	30 – 34	119	20.3
	35 – 45	119	20.3
Occupation	Student	97	16.5
	Lecturer	53	9.0
	Office worker	165	28.1
	Housewife	54	9.2
	Trader	97	16.5
	Civil servant	106	18.1
	Worker	15	2.6
Level of education	High school graduate	119	20.3
	College graduate	185	31.5
	University graduate	173	29.5
	Master/PhD graduate	110	18.7

Source: Own development

4. Results and discussion

4.1. Research result

Descriptive statistic

Table 3 shows the mean of all items in the study as well as the normal distribution of data. In general, the level of agreement with statements regarding perceived cost in the transaction (monetary and spiritual) is low. Meanwhile, the level of agreement in observed variables of perceived value and online trust is higher than 3.5. The skewness and kurtosis values of all variables that meet the normal distribution requirements (skewness less than 3, kurtosis is less than 10) (Kline 2015). Thus, all variables meet normal distribution requirements to perform the next analysis.

Reliability and validity assessment

This study carried out a two-step process to analyze the collected survey data (Anderson and Gerbing 1988). First, the study will analyze the confirmative factor analysis (CFA) to evaluate the validity of the concepts in the study, and then implement the structural equation model (SEM) to determine the relationship between the concepts in the theoretical model. This study also used Cronbach's Alpha test to check the reliability of scales and the results of exploratory factor analysis (EFA) to test the internal consistency of the scale.

Table 3. Descriptive statistics

Items	Mean	Std. Deviation	Skewness		Kurtosis	
			Statistic	Std. Error	Statistic	Std. Error
I can buy items on mobile apps may be more expensive than other types (PMC1)	2.62	1.302	0.365	0.101	-0.926	0.201
I can save money if I buy goods in other forms instead of via mobile devices (PMC2)	2.74	1.287	0.304	0.101	-0.896	0.201
I can get more discounts from other forms than m-commerce (PMC3)	2.61	1.332	0.375	0.101	-0.967	0.201
I can buy cheaper goods on mobile than other forms (PMC4)*	2.60	1.286	0.380	0.101	-0.878	0.201
Buying mobile devices will cost me money for delivery (PMC5)	2.65	1.279	0.363	0.101	-0.891	0.201
I spend the cost of return when the goods are not suitable after buying goods on mobile devices (PMC6)	2.67	1.223	0.254	0.101	-0.819	0.201
I worry after ordering on mobile devices (PSC1)	2.71	1.328	0.341	0.101	-0.994	0.201
I am bothered after buying goods from a mobile application (PSC2)	2.68	1.285	0.244	0.101	-0.939	0.201
I am disappointed after buying from a mobile application (PSC3)	2.78	1.334	0.183	0.101	-1.120	0.201
I am addicted to shopping after buying goods on mobile devices (PSC4)	2.63	1.343	0.328	0.101	-1.086	0.201
Considering the cost, I have to spend when trading, m-commerce is a useful method (PV1)	3.89	1.044	-1.306	0.101	1.325	0.201
Considering the efforts I have to try when trading, m-commerce is worthiness (PV2)	3.95	1.059	-1.152	0.101	0.731	0.201
Considering the risks that may be encountered when trading, m-commerce is worthwhile (PV3)	3.95	1.074	-1.265	0.101	1.068	0.201
Overall, m-commerce meets my needs (PV4)	3.94	1.050	-1.115	0.101	0.670	0.201
Overall, m-commerce gives me good value (PV5)	3.98	1.080	-1.290	0.101	1.047	0.201
M-commerce providers are able to fulfill their capabilities (OT1)	3.63	0.994	-0.992	0.101	0.772	0.201
M-commerce providers keep their promises and commitments to customers (OT2)	3.57	0.897	-0.816	0.101	0.448	0.201
M-commerce providers are always interested in customers (OT3)	3.60	0.883	-0.881	0.101	0.802	0.201
M-commerce providers are credible (OT4)	3.58	0.945	-0.953	0.101	0.756	0.201

Source: Own development

According to Table 4, the results show that all scales are reliable, Cronbach alpha values ranged from 0.881 to 0.941, well exceeding the thresholds of 0.70 (Nunnally and Bernstein 1994). The measurement model showed a satisfactory fit to the data (χ^2= 246.649, df = 146, χ^2/df = 1.689, GFI = 0.958, TLI = 0.986, CFI = 0.988, RMSEA = 0.034).

Table 4. Results of exploratory factor analysis, reliability analysis, and discriminant validity

Items	CA	FL	λ	CR	AVE
Perceived monetary cost (PMC)	0.908			0.908	0.623
PMC1		0.846	0.819		
PMC2		0.778	0.797		
PMC3		0.791	0.783		
PMC4		0.775	0.802		
PMC5		0.774	0.802		
PMC6		0.706	0.73		
Perceived spirit cost (PSC)	0.881			0.882	0.651
PSC1		0.793	0.785		
PSC2		0.802	0.801		
PSC3		0.791	0.783		
PSC4		0.837	0.857		
Perceived value (PV)	0.941			0.941	0.763

Items	CA	FL	λ	CR	AVE
PV1		0.810	0.899		
PV2		0.742	0.83		
PV3		0.753	0.885		
PV4		0.798	0.863		
PV5		0.751	0.889		
Online trust (OT)	0.902			0.903	0.7
OT1		0.861	0.879		
OT2		0.825	0.868		
OT3		0.825	0.716		
OT4		0.831	0.874		
KMO		0.944			
Sig. (Bartlett's Test of Sphericit)		0.000			
Total Variance		75.152%			
Eigenvalues		1.159			

Note: CA: Cronbach's Alpha; FL: Factor Loading; AVE: Average Variance Extracted; CR: Composite Reliability; λ: Estimate in Standardized Regression Weights. *Source:* Own development

The fit indices were all in the acceptable range (Bentler and Bonett 1980). All factor loadings were statistically significant, suggesting convergent validity (Anderson and Gerbing 1988). The reliability of the construct was examined by computing the composite reliability (Fornell and Larcker 1981). All met the recommended criterion of 0.60 or above (Bagozzi and Yi 1988). Discriminant validity was assessed by using Fornell and Larcker (1981) criterion that the average variance extracted (AVE) for each construct should be higher than the squared correlation between that construct and any other construct in the model. For each construct, the AVE was higher than its squared correlation with other constructs, thus providing support for discriminant validity. They are calculated for each construct, resulting in AVEs greater than 0.50. In summary, the measures of the constructs demonstrate reliability and validity. Table 4 presents standardized factor loadings, Cronbach's alpha, composite reliabilities and average variances extracted for both measurement models.

As mentioned above, the perceived cost is considered as a multi-dimensional scale consisting of two components (perceived monetary costs and a perceived spiritual cost). The CFA results show that this scale measurement model is consistent with market data with χ^2 (34) = 99.516 (p = 0.000); GFI = 0.969; TLI = 0.975; CFI = 0.981 and RMSEA = 0.057. The results showed that the Estimate in Standardized Regression Weights in CFA is greater than or equal 0.728 and statistically significant (p <0.001, Table 5). Therefore, the scale of each the concept in perceived cost achieves uni-dimension and convergent value. Next, the correlation coefficient between two components of the perceived cost with standard error is 0.453 (0.029) less than 1 (p <0.001, table 5). By these criteria, we concluded that the measures in the study provided sufficient evidence of reliability, convergent and discriminant validity (Steenkamp and Van Trijp 1991).

Table 5. Correlations table

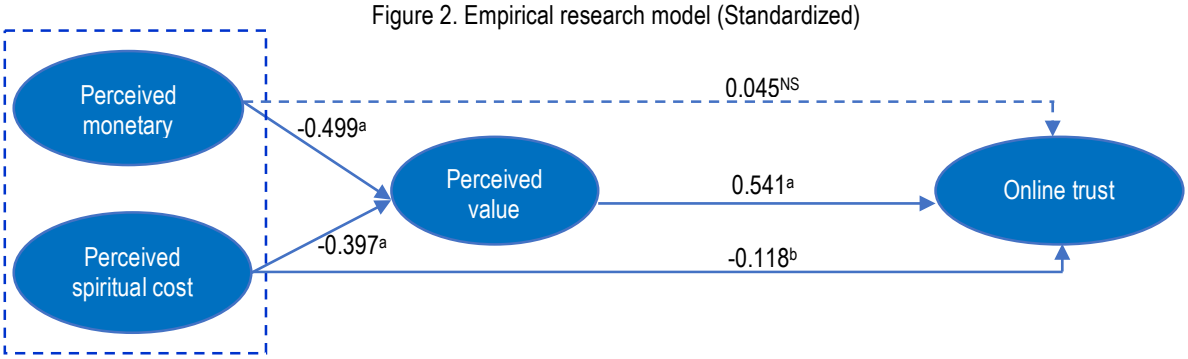
Relationship			R	se	T	P
PMC	<-->	PV	-0.679	0.030	55.32	0.000
PMC	<-->	OT	-0.375	0.031	44.87	0.000
PMC	<-->	PSC	0.453	0.029	18.56	0.000
PV	<-->	OT	0.584	0.027	15.50	0.000
PV	<-->	PSC	-0.623	0.026	62.76	0.000
OT	<-->	PSC	-0.434	0.030	48.15	0.000

Note: r: Correlation, se: Standard Error, T: t(1-r), p: significant. *Source:* Own development

Hypotheses test

We tested the proposed conceptual model (Figure 1) using structural equation modeling. The empirical estimates for the main-effects model are shown in Table 6. The results indicate that the data fit our conceptual model acceptably (χ^2(146) = 246.649 (p = 0.000); GFI = 0.958; TLI = 0.986; CFI = 0.988; RMSEA = 0.034). Table 5 presents the regression weights of the main parameters in the model and Figure 2 presents Standardized Regression Weights. Note that during the estimation of CFA and SEM models, the Heywood phenomenon does not appear in any model and the variance of errors is smaller than |2.58|.

Figure 2. Empirical research model (Standardized)



Note: (a) p < 0.001; (b) p < 0.05; NS: non-significant

Table 6 shows the hypothesis H1 is accepted that the perceived value has a positive relationship with online trust when purchasing in mobile commerce (β = 0.541; p <0.001). Hypotheses H2a that the positive relationship between perceived monetary cost and online trust is rejected (β = 0.045; p> 0.05). The statistical result also supports the hypothesis H2b, which is the perceived spiritual cost that has a positive effect on customers' online trust when using mobile applications to buy goods (β = -0,118; p <0.05). The study results also confirmed the perceived monetary cost (β = -0.499; p <0.001) and the perceived mental cost (β = -0,397; p <0.001) negatively impacted the perceived value of customer when they buy products via mobile devices by the application. The results support the hypothesis of H3a and H3b.

Table 6. Hypothesis testing

Relationships			β/γ	Se	t	p	Hypothesis	Result
PV	--->	OT	0.504	0.06	8.374	0.000	H1	Supported
PMC	--->	OT	0.037	0.045	0.832	0.405	H2a	Rejected
PSC	--->	OT	-0.09	0.039	-2.283	0.022	H2b	Supported
PMC	--->	PV	-0.439	0.035	-12.596	0.000	H3a	Supported
PSC	--->	PV	-0.324	0.031	-10.352	0.000	H3c	Supported

Note: β/γ: Estimate, *se*: standard error, *t*: *t(1-r), p*: significant. *Source:* Own development

The mediating effect of the perceived value

Bootstrapping method of Preacher *et al.* (2007) provides advantages for demonstrating a mediating variable. Let A be the correlation coefficient between the perceived spiritual cost and the perceived value, B be the correlation coefficient between the perceived value and online trust, implementing Bootstrapping with N = 1000, we have the following Table 7.

Table 7. Bootstrapping estimation for the mediating effect of the perceived value

Parameter	Estimate	Lower	Upper	P	Standard Errors
A x B	-0.154	-0.201	-0.113	0.002	0.026

Source: Own development

According to Table 7, the mediator analysis method confirms that the increase in perceived value will reduce the spiritual cost of perceiving and increasing the online trust of customers when purchasing goods through mobile applications of the provider. The study result shows an average estimate of -0.154 within the confidence interval of -0.201 and -0.113 with p = 0.002 and a standard error of 0.026 with 99% confidence.

4.2. Discussion

This study examines and explores the relationship of cost - values – online trust in the context of mobile commerce in Vietnam. Research on this chain has not been much researched, especially in the context of mobile commerce in an emerging market as Vietnam. The result with the 587 samples in Vietnam gives us a theoretical and practical implication.

Firstly, the perceived value is explored as the factor that builds customers' online trust when purchasing products on mobile applications besides other factors such as trust orientation; perceived risk; perceived security and privacy; reputation; system quality, perceived information quality; perceived service quality, and design quality (Kim and Peterson 2017). Also, the perceived value is also a mediator between the perceived spiritual cost and online trust in mobile commerce. The mediating role of perceived value has received little attention from marketing

researchers, even though its role as an antecedent of other important constructs as repurchase or brand preference (Kwon *et al.* 2007). The mediator role of perceived value in this study is the discovery of the study to set the stage for further research on the chain of the spiritual cost - perceived value - online trust.

Secondly, the perceived spiritual cost has a negative impact on online customer trust in mobile commerce. At the same time, research has shown that perceived monetary costs do not affect online trust. The mental loss is a psychological risk factor; customers do not want to encounter when dealing online (Featherman and Pavlou 2003). Thus, today, researchers need to pay more attention to the impact of mental and psychological factors in analyzing customer behavior.

Also, the negative relationship of perceived costs (both monetary and spiritual aspects) with perceived values is also confirmed in the study. This result is not different from previous studies of monetary costs and non-monetary costs (Bolton and Lemon 1999, Parasuraman and Grewal 2000). However, the study goes more in-depth into understanding the perceived cost from a psychological perspective.

Conclusion

With a combination of qualitative and quantitative method, the study has identified two aspects of cost to Vietnamese consumers in the context of mobile commerce; those are monetary cost and spiritual cost. In addition, the study also pointed out that the perceived spiritual cost has a negative impact on online trust and the perceived monetary cost is not. The perceived value is proving to be a mediating variable in the relationship between the perceived spiritual cost and online trust. The result confirms that the perceived cost has an adverse effect on the perceived value in the context of mobile commerce.

Based on this result, business needs to create the value which the customers expect to increase their online trust as well as reduce the perceived spiritual cost of the purchase via electronic devices or mobile applications. Enterprises should invest in designing mobile applications, focusing on User Experience (UX) and User Interface (UI) to make the customer spend less effort to learn but still be able to use and create trust in customers when providing private information. Also, it is necessary to provide clear terms and detailed instructions for customers when manipulating purchases and providing information on mobile applications. For business, it is necessary to provide clear images and origins of products and services on mobile applications to limit customers' worry about models of product and service. Besides, business should have a flexible return policy for customers, or have instructional videos to use the product to reduce frustration if the goods are not suitable. Enterprises also need to strengthen the confidentiality of information for customers, not use customer information for advertising purposes. Finally, there should be ethics in the promotion and stimulation of shopping customers, specifically promoting only the real usage of products and proposing an appropriate product to the customer, not taking advantage of programs. Reduce prices to stimulate excessive consumption. Enterprises can rely on research results to provide cost solutions to increase the perceived value of customers when they buy products from the business application. One of the solutions to create value is the discount code when using mobile applications for shopping. Alternatively, the business should assist customers with delivery costs by providing coupons for delivery services. It is recommended to set up a return policy by each case, the customer's error when ordering or the supplier's error when packing and shipping. Also, the spiritual costs of customers can also be reduced to increase the perceived value based on solutions such as reducing anxiety, limiting disappointment, reducing bother and limiting symptoms of addiction in customers.

This study has several potential limitations. Firstly, the study was conducted in an emerging market as Vietnam and mobile commerce context. Thus the scope for generalization of the results to other contexts may be limited. Secondly, the study is only a general experiment of mobile commerce, although mobile commerce is a relatively broad field with many types of goods and business form. Thirdly, regarding the sampling method, the study uses a non-probability sample with judgmental sampling technique, which reduces the reliability of the study. Thirdly, the study has introduced the concept of the perceived spiritual cost through the inheritance of the related previous studies and the development of qualitative research but has not gone into the analysis of these types of the perceived mental-based or spiritual cost.

Further research may overcome some of the limitations of this study by focusing on a specific business or specific commodity in the study. Also, it is possible to build a sampling frame and select samples for the probabilistic investigation to create higher reliability for research. Study the types of spiritual expenses in a more specific and detailed way. Some research variables can be strengthened to enable extensive research, especially research variables on perceived benefits.

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Why Expected Discount Factors Yield Incorrect Expected Present Values

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Abstract:

Compound and discount factors determine the relationship between present and future values. When interest rates are stochastic, expected compound factors are computed by probability weighting all possible compound factors. It is customary to proceed likewise to compute expected discount factors. It has been noted that risk neutral certainty equivalent interest rates differ when computed from expected compound or expected discount factors, yielding alternative project rankings. This paper shows that expected discount factors yield incorrect expected present values because, unlike in the deterministic case, they are not the reciprocals of the corresponding expected compound factors.

Keywords: Weitzman-Gollier puzzle; declining discount rates; discounting

JEL classification: D61; H43

1. Introduction

In "On Expected Value vs. Expected Future Value" Elisha A. Pazner and Assaf Razin (1975) assert that when the discount rate (cost of capital) is uncertain, the equivalency of the present value and future value criteria for investment project ranking no longer holds. That is, they lead to inconsistent investment project rankings. Their analysis is conducted from the point of view of risk neutral investors, only concerned about the expected value of their wealth, and the probabilities describing the interest rate uncertainty are real.

Pazner and Razin (1975) conclude: "As the two criteria discussed here are equally likely, on a priori grounds, to be used as guides to investment decision making, and as their use may provide different rankings of investment prospects, the question arises as to what is the correct way to approach the problem in general."

The discrepancy between the two criteria has also been observed in the literature devoted to the choice of the social discount rate to be used in cost-benefit analysis. Weitzman (1998) proposed adopting the expected present value criterion and noted that it would lead to a declining term structure[1] of certainty equivalent interest rates in the far distant future if interest rates are stochastic and subject to persistent, non mean-reverting shocks. Christian Gollier (2004) noted that using the future value criterion under the same assumptions would lead to an increasing term structure. This discrepancy became the "Weitzman-Gollier Puzzle," which has never been truly solved in its own terms, that is, under the assumption that investors are risk neutral.

Commenting on this puzzle, Groom, Hepburn, Koundouri and Pierce (2005) state: "So, confusingly, whereas in the absence of uncertainty the two decision criteria are equivalent, once uncertainty regarding the discount rate is introduced the appropriate discount rate for us in CBA depends upon whether we choose ENPV or ENFV as our decision criterion. In the former case, discount rates are declining and in the latter they are rising through time. It is not immediately clear which of these criteria is correct."

This paper explains the observed discrepancies by pointing out that expected discount factors computed by probability weighting all possible discount factors are not the reciprocals of the expected compound factors corresponding to the same probability distributions of interest rates, and therefore lead to computing wrong expected present values. In other words, what is generally called the expected present value criterion is not really what its name implies, for the customary method of computing expected present values is wrong. When the correct calculation is made, the discrepancy between the two decision criteria vanishes.

[1] Throughout this paper "term structure" refers to the time pattern of risk neutral certainty-equivalent rates that corresponds the probability distribution of interest rates assumed. No modeling of the term structure of real market interest rates is implied. In fact, in all the models considered in this paper, the expected values of the stochastic interest rates are constant through time.

Section 2 summarizes the argument presented by Pazner and Razin (1975); Section 3 shows that the expected value of discount factors leads to the wrong expected present value; Section 4 provides another explanation of this fact, and an interpretation of what the incorrect method measures; Section 5 explores the effect of autocorrelation of interest rates on the size of the discrepancy between correctly and incorrectly calculated certainty equivalent discount factors; and Section 6 presents conclusions, including a summary comparison of alternative calculation methods.

2. Summary of Pazner and Razin's analysis

For their analysis Pazner and Razin (1975) consider the evaluation of projects having an initial investment of B_0 and a stream of benefits {*Bt*}, where *t* ranges from 1 to *T*. If the cost of capital *r* used to discount benefits $\{B_t\}$ is stochastic, then the expected present value (EPV) and the expected future value (EFV) of the projects are given by the following expressions, in which the expectation operator applies to the random interest rate *r*, the probabilities of which are not explicitly shown:

$$EPV = \mathrm{E}\left[\sum_{t=0}^{T}\prod_{i=0}^{t}\frac{1}{1+r_i}B_t\right] \quad (1)$$

$$EFV = \mathrm{E}\left[\sum_{t=0}^{T}\prod_{i=t}^{T}(1+r_i)\,B_t\right] \quad (2)$$

A project should be undertaken, under either criterion, if the expected value is greater than or equal to zero. It is well known that when *r* is deterministic, the two criteria are equivalent. Pazner and Razin (1975) show, however, that this equivalency breaks down when *r* is stochastic. To this end, they simplify the above expression by setting *T* = 1. The certainty equivalent discount rate *r** can be calculated from the expected present value criterion as follows:

$$B0 + 1/(1+r^*)\,B1 = B0 + E\,[\,1/(1+r)\,B1] \equiv PREPV \quad (3)$$

The above is identical to expression (3) from Pazner and Razin (1975), except that their expected present value abbreviation EPV is replaced here by PREPV for attribution, and to distinguish it from an alternative formulation to be presented below. Notice that the term E[1/(1+r) B1] = E[1/(1+r)] B1 is not stochastic, as the Bt are not stochastic, and that E[1/(1+r)] is the probability weighted expected value of the discount factors corresponding to all possible values of the stochastic interest rate r. Similarly, they define r**, the certainty equivalent discount rate derived from the future value criterion, as follows:

$$B0\,(1 + r^{**}) + B1 = E\,[(1 + r)\,B0] + B1 \equiv EFV \quad (4)$$

where: *EFV* stands for expected future value.

Given that 1/(1+r) is strictly convex, Pazner and Razin observe[2] that by Jensen's Inequality

$$1 + r^* = \frac{1}{\mathrm{E}\left[\frac{1}{1+r}\right]} < \mathrm{E}[1 + r] = 1 + r^{**} \quad (5)$$

Therefore, it follows that *r** < *r***, which leads to the ranking discrepancy noted. This derivation is perfectly correct, but the conclusion is predicated on the assumption that ^{PR}EPV, as defined in (1) above, is the correct expression for expected present value.

3. The expected value of discount factors leads to the wrong Expected Present Values (EPV)

To analyze this question, the above example will be simplified even further by assuming that $B_0 = 0$ and $B_1 = 1$. In that case *EFV* = 1. The EPV of 1 can be derived from the textbook definition of present value, namely, it is the amount that will compound to the *EFV* at the going (stochastic) market rate *r*:

$$E[1+r]\,EPV \equiv 1 \quad (6)$$

Consequently,

$$EPV \equiv \frac{1}{\mathrm{E}[1+r]} \quad (7)$$

[2] Expression (5) is the same as Pazner and Razin's (1975) own expression (5), and is derived from the following instance of Jensen's inequality $\mathrm{E}\left[\frac{1}{1+r}\right] > \frac{1}{\mathrm{E}[1+r]}$.

We can see that the correct *EPV* is different from ^{PR}EPV:

$$EPV \equiv \frac{1}{\mathrm{E}[1+r]} \neq \mathrm{E}\left[\frac{1}{1+r}\right] \equiv {}^{PR}EPV \tag{8}$$

It is easier to see the nature of this inequality if we make the expectation operator explicit, with a simple two states of the world example. Let the stochastic r be one of $\{r_1, r_2\}$ with probabilities $\{p_1, p_2\}$. Expression (8) then becomes:

$$EPV \equiv \frac{1}{p_1(1+r_1)+p_2(1+r_2)} \neq \frac{p_1}{(1+r_1)} + \frac{p_2}{(1+r_2)} \equiv {}^{PR}EPV \tag{9}$$

in which the basic reason for the inequality is the following:

$$\big(p_1(1+r_1) + p_2(1+r_2)\big)^{-1} \neq p_1(1+r_1)^{-1} + p_2(1+r_2)^{-1} \tag{10}$$

We have seen from (6) and (7) that *EPV* is the correct certainty equivalent discount factor (EPV of 1). That ^{PR}EPV is not the correct certainty equivalent discount factor is proven by the fact that ^{PR}EPV does not compound to the future value of 1. For our simple example this is shown by the following:

$$(p_1(1+r_1)^{-1} + p_2(1+r_2)^{-1})\big(p_1(1+r_1) + p_2(1+r_2)\big) \neq 1 \tag{11}$$

which can be generalized as follows:

$$\mathrm{E}\left[\frac{1}{1+r}\right] \mathrm{E}[1+r] \neq 1 \tag{12}$$

The startling conclusion that can be derived from this is that the probability weighted expectation of the scenario specific discount factors is not the correct risk neutral certainty equivalent discount factor! ^{PR}EPV is an incorrect EPV measure, and the certainty equivalent rate r* derived from it is also incorrect.

The correct EPV is given by expression (7), as it compounds to EFV, in compliance with the definition of present value. The correct certainty equivalent discount rate r** can be derived from (7) as follows:

$$EPV \equiv \frac{1}{\mathrm{E}[1+r]} = \frac{1}{1+r^{**}} \tag{13}$$

from which we get that $(1 + r^{**}) = \mathrm{E}[(1 + r)]$, the same as in (4) above. When EPV is correctly calculated, the certainty equivalent rates derived from both the EPV and EFV criteria are identical. There is no discrepancy between them.

Returning to the full example of Pazner and Razin (1975), we can now state that their expression (1) will not compute the correct EPV of any project. The correct result will be given only by the following expression:

$$EPV = \sum_{t=0}^{T} \frac{B_t}{\mathrm{E}\left[\prod_{i=0}^{t}(1+r_i)\right]} \tag{14}$$

Because the B_t are not stochastic, expression (2) can be rewritten as follows:

$$EFV = \sum_{t=0}^{T} \mathrm{E}\left[\prod_{i=t}^{T}(1+r_i)\right] B_t \tag{15}$$

Notice that both discounting and compounding is done with certainty equivalent discount and compound factors, respectively, which are not stochastic. Because the same certainty equivalent rate r** can equally be derived from both, the EPV and EFV rules will yield the same conclusion for any project. This is formally demonstrated for expressions (14) and (15) in the Appendix.

4. A more intuitive explanation of the preceding finding and an interpretation of the incorrect method

Since certainty equivalent compound factors are calculated as the probability weighted expectations of the scenario specific compound factors, it is understandable that the applicability of the same method to discount factors should be a widely held belief. Even though the previous section has proven this notion to be wrong, it is useful to provide another, perhaps more intuitive, explanation of why it is wrong, and also to provide an interpretation of what the incorrect calculation method actually is.

To do this we modify the simple two period model from the beginning of Section II by allowing t to vary, but keeping $B_0 = 0$, and $B_t = 1$. It will therefore serve to calculate the amount that a risk neutral investor would be willing

to pay for a zero-coupon bond, with a face value of 1, due at time *t*. Using the continuous time formulation proposed by Weitzman (1998) will be most convenient.[3]

Weitzman proposed the following certainty equivalent discount factor, which, for this simplified model, is the equivalent of (1) above, and which is also the result of probability weighting scenario specific discount factors:

$$A = \mathrm{E}[e^{-rt}] \tag{16}$$

A is incorrect, because it is not the inverse of the certainty equivalent compound factor *C* that describes the assumed market conditions:

$$C = \mathrm{E}[e^{rt}] \tag{17}$$

The correct certainty equivalent discount factor *D* is, of course, the inverse of *C*:

$$D = \frac{1}{\mathrm{E}[e^{rt}]} \tag{18}$$

Notice, however, that *A* corresponds exactly to *C* when the product *rt* is negative. Having negative *r* would correspond to a capital market in which resources are stored for a fee, rather than being lent to someone willing to pay a positive interest rate. Having *t* negative would imply reversing the flow of time. Discounting with Weitzman's *A* is like compounding with the negatives of the assumed market interest rates, but from the future to the present. We could call it time reversed negative compounding.

To compare the behavior of *A* and *D* as a function of time, we assign numeric values to the simple two-scenario model. Let's assume that the states of the world are equiprobable, and that r_1 = 1% and r_2 = 5%. The difference between discounting and time reversed negative compounding will be explained with the help of Figure 1 and Figure 2.

Figure 1. Compound and discount factors (5% interest p.a., logarithmic scale)

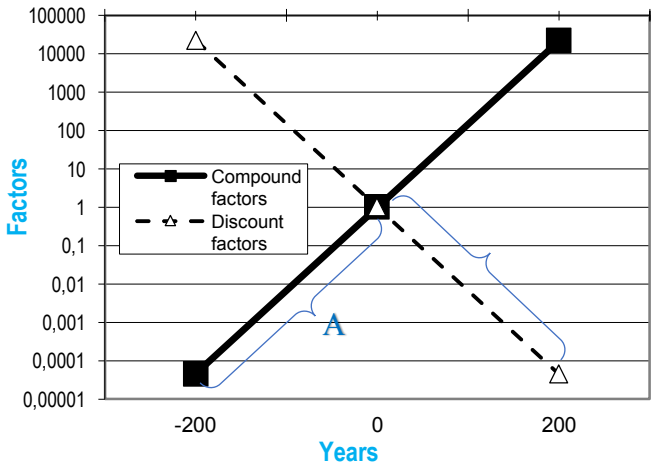


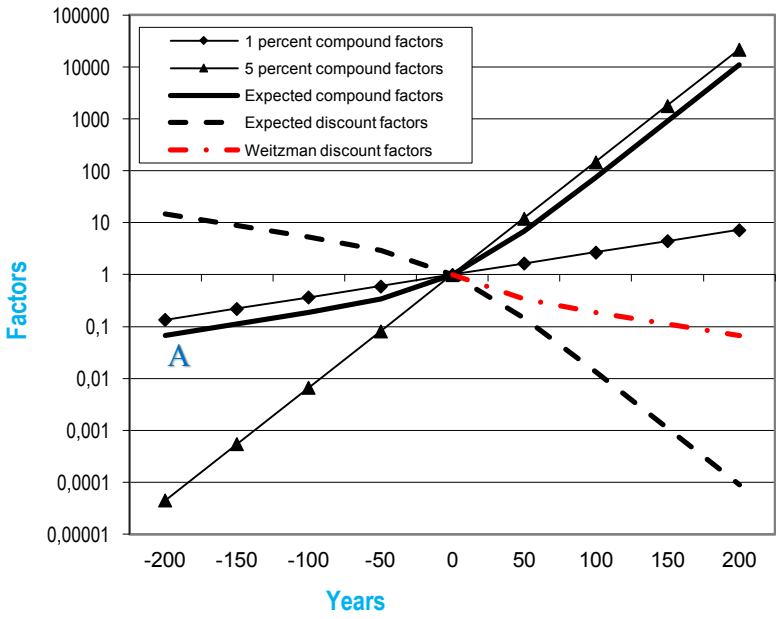
Figure 1 shows the compound and discount factors curves applicable to an investment of $1 made at time 0, in continuous time, with a deterministic annual interest rate of 5%, between years - 200 and 200. (We have negative compounding and discounting to the left of year 0.) The equations being plotted are $e^{0.05t}$ for the compound factors curve, and $1/e^{0.05t}$ for the discount factors curve. The vertical scale in Figure 1 is logarithmic, which is why both the compound factors and discount factors curves are seen to be linear. The fact that one is the inverse of the other is evidenced by their symmetry with respect to the horizontal line passing through the value of 1. Note that the negative range of the compound factor curve (which is what *A* is) is symmetrical to the positive range of the discount factor curve *D* around the vertical axis (year 0), which means that in the deterministic case *A* = *D* for any absolute value of *t*. In other words, discounting and time reversed negative compounding are equivalent if interest rates are not stochastic.

Figure 2 illustrates the stochastic case. It shows the compound factor curves corresponding to interest rates of 1% and 5%, both of which are linear in logarithmic terms. Their expectation is no longer linear, however. Moving forward in time (positive range of years), compound factors corresponding to the high interest rate grow

[3] This section is largely taken from Szekeres (2017), an unpublished working paper by the author.

proportionally larger relative to those of the low interest rate, thereby pulling their expected value ever closer to the compound factors curve of the high rate. The same happens moving backwards into the past (negative range of years), in which case it is the compound factors corresponding to the low interest rate that grow relatively larger, and it is therefore towards the compound factors curve of the low interest rate that their expected values tend asymptotically. In other words, the higher compound factors pull the expected compound factors upwards over the entire time range, this effect being stronger as the absolute value of time increases.

Figure 2. Compound factors at 1% and 5%, their expected value and the corresponding discount factors, logarithmic scale



The immediate consequence of this is that the expected compound factors curve is no longer linear logarithmically. This is also true of the expected discount factors curve, which is the inverse of the expected compound factors curve. Because of this lack of linearity, the negative range of the expected compound factors curve is not symmetrical to the positive range of the expected discount factors curve with respect to the vertical axis, and cannot be used, therefore, to calculate EPVs correctly. As Figure 2 shows, the negative range of the compound factors curve is significantly higher than the positive range of the discount factors curve for all absolute values of time.

This is the reason why the probability weighted average of the conditional discount factors of alternative interest rate scenarios (which is what the negative range of the expected compound factors curve is) does not yield the correct EPV of amounts compounded to the future. To facilitate comparison with the correct discount factors, the negative range of the expected compound factors curve (*A*) is mapped to the positive range of years and labeled Weitzman discount factors in Figure 2. It significantly overstates the PV of future sums.

As Figure 2 shows, when interest rates are perfectly autocorrelated (because *r* is constant), the expected compound factors will be above the deterministic average of the low and high interest rates. This average is not shown in Figure 2 but would be represented by a straight line corresponding to 3%, half-way between the 1% and 5% lines. As this (peculiar) market's growing yields constitute the opportunity cost of any alternative long-term investment project, it is the role of discounting to see if such a project can do better than this market.

The incorrect discounting method singularly fails at this task. It misrepresents the assumed market conditions, because it implies, as shown in Figure 2, that the opportunity cost of long term investments is declining, when in fact it is growing through time. Investors using this method of computing EPVs do so at their peril. They will systematically overstate the EPVs of their projects.

5. The effect of autocorrelation of interest rates

The nature of the market described in the previous Section results from the assumption of perfect autocorrelation of interest rates. In this Section we explore the effect of the degree of autocorrelation of interest rates on the size of the discrepancy between the correct and incorrect methods of discounting. To do so, we compute the value of zero-coupon bonds with a face value of $1 for different frequencies of compounding and different probability distributions of interest rates *r*.

In the first example time will be discrete (years) and the stochastic constant interest rate r will be compounded annually. For any time horizon t, the correct certainty equivalent discount factor will be $1/E[(1+r)^t]$, while the incorrect one, based on probability weighting the scenario specific discount factors, will be $E[1/(1+r)^t]$. To illustrate what happens in this case we use the numeric values of the two-scenario model already proposed: the states of the world are equiprobable, r_1=1% and r_2=5%. We obtain then the following illustrative results[4].

Table 1. Alternative certainty equivalent discount factors and rates

t	$1/E[(1+r)^t]$	r^{**}	$E[1/(1+r)^t]$	r^*	Error
1	0.9709	3.00%	0.9712	2.96%	0.038%
10	0.7317	3.17%	0.7596	2.79%	3.819%
20	0.5163	3.36%	0.5982	2.60%	15.86%
30	0.3527	3.53%	0.4867	2.43%	37.96%

For year 1 – a single compounding period (row 1) – the certainty equivalent is r** = E[r]. For later years, however, r^{**} is no longer E[r], because the fast-growing compound factor associated with r_2 raises the expected compound factor above E[r]. In the case of r^* the converse is true, the expected discount factor is skewed towards that of the lower rate. The year 1 value is already wrong.

The large error that results from calculating with the wrong expression (a 37.96% overestimate of the value of a zero-coupon bond maturing in 30 years) is largely due to the assumption of perfect autocorrelation of interest rates. The term structures of certainty equivalent discount rates that results from the alternative calculations diverge markedly. The correct one is growing, as it should be, reflecting the accelerating effects of compound factors associated with the higher rate, while the incorrect one is declining instead, divorced from the reality of the assumed market.[5]

Notice, incidentally, that the calculations in this Section also provide empirical corroboration of the main assertion of this paper. The correct certainty equivalent discount factors shown in the tables are the reciprocals of the certainty equivalent compound factors. Someone, who on the basis of the incorrect calculation, would be willing to invest $0.4867 for the zero-coupon bond to get $1 in year 30 would suffer a year 30 opportunity loss of 0.4867/0.3527–1= $0.3799 by not investing in the market instead. This is the meaning of the error measures shown in the tables. One calculates EPVs to determine where to invest. It is therefore imperative to calculate correctly.

To explore what happens when the degree of autocorrelation is less than perfect, Monte Carlo simulations were conducted. This required an alteration of the model. Rather than there being a constant stochastic interest rate r for all years, we assume that there are as many interest rate variables as there are years. We assume that the yearly rates are identically distributed, with the same distribution as before, but with a degree of autocorrelation that will be specified in each examined case.

The correct discount factor for any time period t is[6]:

$$D = \frac{1}{E[\prod(1+r)]} \tag{19}$$

where: r distribution is sampled independently for each year. With these assumptions, the following results were obtained, based on 10,000 simulations:

Table 2. Alternative certainty equivalent discount factors and rates, coefficient of autocorrelation = 0

T	$\frac{1}{E[\prod(1+r)]}$	r**	$E\left[\frac{1}{\prod(1+r)}\right]$	r*	Error
1	0.9709	3.00%	0.9712	2.96%	0.038%
10	0.7449	2.99%	0.7465	2.97%	0.225%
20	0.5543	2.99%	0.5566	2.97%	0.418%
30	0.4127	2.99%	0.4152	2.97%	0.625%

[4] All numerical results presented in this paper can be found (and reproduced) in an Excel workbook available from the author. Send an email to szsz@iid.hu.

[5] The frequency of compounding has no bearing on these results when r is constant, and therefore perfectly autocorrelated, provided that the periodic rate is such that the effective annual rate remains constant.

[6] We assume that values accrue at the end of the period to which the interest rates pertain. Indexing of r is omitted for simplicity, but it is implicitly from 1 to t.

As we can see the discrepancy in this case is not as serious as before, but it is still present. The term structure of certainty equivalent discount rates is flat with both calculation methods. Notice, however, that the first rows of Table 1 and Table 2 are identical. This shows the intrinsic error of the incorrect formula, over a single compounding period. In Table 1 the error is compounded due to the perfect autocorrelation of interest rates, while in Table 2 the accumulation of errors through time amounts to much less, because when a high *r* is followed by a low one, the acceleration effect in compounding is partially undone.

To map the effects of the autocorrelation assumption we calculated the results for two additional cases. The results for a coefficient of autocorrelation of 0.9 are the following:

Table 3. Alternative certainty equivalent discount factors and rates, coefficient of autocorrelation = 0.9

t	$\frac{1}{E[\prod(1+r)]}$	r**	$E\left[\frac{1}{\prod(1+r)}\right]$	r*	Error
1	0.9709	3.00%	0.9712	2.96%	0.038%
10	0.7375	3.09%	0.7565	2.83%	2.577%
20	0.5444	3.09%	0.5735	2.82%	5.352%
30	0.4091	3.02%	0.4227	2.91%	3.341%

Even with this high degree of autocorrelation the term structures are basically flat in both cases. This reflects the fact that the effects of even such a high degree of autocorrelation are soon eroded, as autocorrelation across years diminishes with the power of the correlation coefficient. Notice that the year 1 error is the same as before, but correlation compounds errors, so that the valuation error of a 30-year zero-coupon bond becomes 3.341%.

It takes a very high degree of autocorrelation to approach the results of Table 1. We obtain the following when the correlation coefficient is 0.99:

Table 4. Alternative certainty equivalent discount factors and rates, coefficient of autocorrelation = 0.99

T	$\frac{1}{E[\prod(1+r)]}$	r**	$E\left[\frac{1}{\prod(1+r)}\right]$	r*	Error
1	0.9709	3.00%	0.9712	2.96%	0.038%
10	0.7318	3.17%	0.7594	2.79%	3.775%
20	0.5177	3.35%	0.5978	2.61%	15.47%
30	0.3553	3.51%	0.4851	2.44%	36.52%

The term structures display the same characteristics as were seen for the perfect correlation case, and the 30-year bond valuation error is now 36.52%.

It is clear from the preceding examples that the degree of autocorrelation is a key determinant of the magnitude of the error that results from using the wrong certainty equivalent discount factor calculation. The error rates observed above pertain to the posited very simple didactic example, however, the purpose of which was primarily expository, so they might not be indicative of the errors that would be encountered in real life. To gauge the error incurred in a more realistic case, Monte Carlo simulations were conducted of a short-term interest rate model of the Cox, Ingersoll & Ross (CIR) type, with parameters that were calibrated by Yajie Zhao and Boru Wang (2017) with reference to a monthly data series of US three-month Treasury Bill rates spanning the period 1992 to 2017.

In this case we simulated monthly interest rates, so we had as many variables as there are months in the ten-year period simulated. These were generated by the CIR process, but only every third one was used in the calculation, as we assumed quarterly compounding. The rates are expressed on a per-annum basis, but the calculation uses the effective annual equivalent quarterly rates. The results obtained from 10,000 Monte Carlo simulations are as follows. In this table the expected values of the interest rates simulated for each year are shown as well.

Table 5. Alternative certainty equivalent discount factors and rates with interest rate probabilities generated by a CIR type model - annual data

t	E[r]	$\frac{1}{E[\prod(1+r)]}$	r**	$E\left[\frac{1}{\prod(1+r)}\right]$	r*	Error
1	4.31%	0.9577	4.42%	0.9586	4.31%	0.103%
2	4.31%	0.9163	4.47%	0.9199	4.26%	0.399%
3	4.32%	0.8758	4.52%	0.8835	4.22%	0.878%
4	4.32%	0.8363	4.57%	0.8490	4.18%	1.523%

t	E[r]	$\frac{1}{E[\prod(1+r)]}$	r**	$E\left[\frac{1}{\prod(1+r)}\right]$	r*	Error
5	4.32%	0.7980	4.62%	0.8165	4.14%	2.324%
6	4.32%	0.7609	4.66%	0.7858	4.10%	3.267%
7	4.32%	0.7250	4.70%	0.7566	4.07%	4.347%
8	4.31%	0.6905	4.74%	0.7288	4.03%	5.552%
9	4.31%	0.6573	4.77%	0.7025	4.00%	6.876%
10	4.30%	0.6253	4.81%	0.6773	3.97%	8.313%

The errors measured are not insignificant, and they grow appreciably with time. This is because the average autocorrelation coefficient of the simulated interest rates was 0.957, which is not too far from the coefficient observed in the dataset used by Zhao and Wang (2017), which is 0.996.

The errors corresponding to the perfect autocorrelation and the no autocorrelation cases were calculated for this example as well. Perfect autocorrelation was mimicked by using the interest rate simulated for the first month in all subsequent months of the analysis. In that case the error observed for the 10-year time horizon was 10.864%, slightly higher than the Table 5 value due to the increased autocorrelation. The no autocorrelation case was mimicked by repeating in each period the generation of the first period interest rate, but always using a new random seed. In that case the error observed for the 10-year time horizon was only 0.26%. As expected, this value is much lower due to the lack of autocorrelation, but it is still not zero.

In summary, the above examples show that the magnitude of the error produced by probability weighting scenario specific discount factors depends greatly on the degree of autocorrelation of interest rates. It should be noted that all errors reported are due to fact that probability weighting discount factors is wrong, and not to any Monte Carlo sampling error, because in all simulations the same interest rates were used for both the correct and the incorrect calculation methods.

The reason why errors grow with autocorrelation is that when autocorrelation is high, the likelihood of a high rate being followed by another high rate is high, which induces an acceleration effect that associates higher future values to higher interest rates, thus skewing their certainty equivalent upwards. When a high rate is followed by a low rate, however, the acceleration is partially revered, hence the lower the correlation the more subdued the acceleration effect. When autocorrelation is low, or zero, the frequency of compounding also matters, because the size of the error, which is always present, is lower over a shorter period. When autocorrelation is zero, it is plausible to expect the error to vanish when compounding frequency becomes instantaneous. In that case $r^{**} = E[r]$, and EPVs can be computed as if r were deterministic, with a value of $E[r]$. Then discounting and time reversed negative compounding will be equivalent.

It is interesting to notice that in expressions (1), (2), (14), (15) discounting and compounding is done by certainty equivalent discount or compound factors that are not stochastic. The discrepancy observed by Pazner and Razin (1975) between (1) and (2) was therefore not due to combining discounting with interest rate uncertainty, but rather to calculating the wrong certainty equivalent discount factors. The error is theoretically always there, but as we have seen its magnitude is fundamentally dependent on the autocorrelation of interest rates and (other than in the case of perfect autocorrelation) on the frequency of compounding.

It would be recommendable to review many commonly used expressions for EPV in the light of the foregoing. In some applications the errors committed might be small. But why not exclude the possibility of errors in the first place?

Conclusions

In formulating the conclusions of this paper, it is worth recalling that the entire analysis has been carried out from the point of view of risk neutral investors facing investment decisions under uncertainty described by real probabilities. The conclusions of this paper are as follows:

1. the intuitively appealing and widely held belief that the certainty equivalent discount factor is the probability weighted expectation of scenario specific discount factors is wrong because the EPVs thereby calculated will not compound to the corresponding EFVs, in defiance of the definition of present value;
2. the inconsistency between the EPV and EFV criteria observed by Pazner and Razin (1975) is due to their incorrect specification of *EPV*, expression (1) above. Likewise, the "Weitzman-Gollier Puzzle" was caused by Weitzman's (1998) incorrect specification of certainty equivalent discount factor *A*, expression (16) above. Using the correct EPV calculation the discrepancy vanishes, and the puzzle is solved;
3. the argument has been made in the literature of social discounting that long term discount rates should be declining functions of time because probability weighted expected discount factors are declining. The latter

are, assuming a high enough degree of autocorrelation of interest rates, but they are not the correct risk neutral certainty equivalent discount factors. Consequently, as seen in Table 1, the opposite conclusion follows from the underlying assumptions;

4. the order of magnitude of the error that results from using the wrong EPV calculation depends crucially on the degree of autocorrelation of interest rates and, when autocorrelation is less than perfect, on the frequency of compounding. For some common specifications, the right and wrong computational formulas are shown in the following table. Subscripts of *r* are omitted for simplicity, as in Pazner and Razin (1975). Some of the incorrect formulations in the right-hand column are quite often used. It would be worthwhile to revise them;
5. notice that neither the usual formulations nor the correct ones proposed in Table 6 allow for the specification of the degree of autocorrelation of interest rates, which, as was shown here, does affect the results. Consequently, strictly speaking, none will give correct results if market interest rates show a high enough degree of autocorrelation. Under such circumstances only numerical methods will provide accurate results.

Table 6. Correct and incorrect formulations of the value of a zero-coupon bond to a risk neutral investor

Case	Expressions defining *EPV*, the expected present value of 1 due at time *t*	Correct certainty equivalent discount factor *D*, derived from the definition EPV	Incorrect certainty equivalent discount factor *A*, based on probability weighting of scenario specific discount factors
Discrete time, constant stochastic *r*	$EPV\ \mathrm{E}[(1+r)^t] \equiv 1$	$D = \frac{1}{\mathrm{E}[(1+r)^t]}$	$A = \mathrm{E}\left[\frac{1}{(1+r)^t}\right]$
Discrete time, variable stochastic *r(s), s = 1* to *t*	$EPV\ \mathrm{E}\left[\prod (1+r(s))\right] \equiv 1$	$D = \frac{1}{\mathrm{E}[\prod(1+r(s))]}$	$A = \mathrm{E}\left[\frac{1}{\prod(1+r(s))}\right]$
Continuous time, constant stochastic *r*	$EPV\ \mathrm{E}[e^{rt}] \equiv 1$	$D = \frac{1}{\mathrm{E}[e^{rt}]}$	$A = \mathrm{E}[e^{-rt}]$
Continuous time, variable stochastic *r(s)*	$EPV\ \mathrm{E}\left[\exp\left(\int_0^t r(s)ds\right)\right] \equiv 1$	$D = \frac{1}{\mathrm{E}\left[exp\left(\int_0^t r(s)ds\right)\right]}$	$A = \mathrm{E}\left[exp\left(-\int_0^t r(s)ds\right)\right]$

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APPENDIX

To show that expressions (14) and (15) are congruent, we will first consider the EPV and EFV of any B_t and show how they are related. Subsequently, we will extend the result to all B_t, and then show that the EPV and EFV values of the entire benefit flow only differ from one another by a factor. Consequently, they will always be either both positive, both negative, or both zero.

Before proceeding, however, we will have to re-index expressions (14) and (15) because they are not coherently formulated. This is because Pazner and Razin (1975) assign an interest rate r_i to all time periods $i = 0, T$ in both (1) and (2)[7]. Calculating EPVs, it is natural to assume that benefits B_t are received at the end of the periods to which interest rates r_t pertain, because they can then be discounted with the interest rate corresponding to that period. Calculating EFVs, on the other hand, it is natural to assume that the B_t are received at the beginning of the periods for which the interest rates are given, as that rate can be used to compound the benefit of the period. This is what Pazner and Razin (1975) do separately in (1) and (2), but that is why these expressions are not coherent when they are looked at simultaneously. Notice also that, as in their formulation B_0 is discounted, *EPV* must lie in period $t = -1$. Similarly, as B_T is compounded, *EFV* must be in period $T + 1$.

To simultaneously calculate both *EPV* and *EFV*, with all the interest rates given, we will use interest rates r_t to compound values B_t, and r_{t-1} it to discount them. Therefore, we need an additional interest rate for $t = -1$, which was not contemplated in Pazner and Razin (1975). We also need to change the indexes in (14) to ensure congruence of the measures. To avoid negative indexes, we re-index benefits $\{B_t\}$, so that $t = 1, T$.

To clarify which interest rate applies to which benefit in which calculation, the following table shows how these concepts are related.

Table 7. Interest rates used to compound and discount benefit stream $\{B_t\}$

Periods *t*	0	1	2		t		T	T+1
Interest rates r_t	r_0	r_1	r_2		r_t		r_T	
Amounts	*EPV*	B_1	B_2		B_t		B_T	*EFV*
Compounded by	r_0	r_1	r_2		r_t		r_T	
Discounted by		r_0	r_1		r_{t-1}		r_{T-1}	r_T

With this re-indexing, the EPV of B_t is valued at time $t = 0$, and its EFV at time $t = T + 1$. The EPV of any B_t is then:

$$EPV(B_t) = \frac{B_t}{\mathrm{E}\left[\prod_{i=1}^{t}(1+r_{i-1})\right]} \tag{20}$$

Expression (20) is summation term *t* of the re-indexed expression (14). Let's define the certainty equivalent discount factor used in (20) as follows:

$$D_0^t = \frac{1}{\mathrm{E}\left[\prod_{i=1}^{t}(1+r_{i-1})\right]} \tag{21}$$

Subscript 0 means that discounting is done to period 0, superscript *t* means that it discounts the value in period *t*.

Similarly, we can compute the EFV of B_t:

$$EFV(B_t) = \mathrm{E}\left[\prod_{i=t}^{T}(1+r_i)\right]B_t \tag{22}$$

Expression (22) is summation term *t* of the re-indexed expression (15). Let's define the certainty equivalent compound factor used in (22) as follows:

$$C_t^{T+1} = \mathrm{E}\left[\prod_{i=t}^{T}(1+r_i)\right] \tag{23}$$

which compounds *Bt* to period T + 1. Subscript t means that compounding is done for the value in period *t*, superscript T + 1 means that compounding is done to period T + 1. Notice that the last interest rate to be used in computing C_t^{T+1} is *rT*. We can use C_t^{T+1} (23) to compound EPV(Bt) (20) back to time *t*, thus obtaining again *Bt*.

$$C_0^t\, EPV(B_t) = \mathrm{E}\left[\prod_{i=0}^{t-1}(1+r_i)\right]\frac{B_t}{\mathrm{E}\left[\prod_{i=1}^{t}(1+r_{i-1})\right]} = B_t \tag{24}$$

[7] Indexes *i* and *t* both refer to time from 0 to *T*.

This shows the congruence between correct discounting and compounding. The certainty equivalent compound factor (C_0^t) and discount factor (D_0^t), being each other's reciprocals, cancel out. This is so because both span the same time period 0 to *t*. Notice that in (24) the r_i range from 0 to *t* -1 in both products of factors $(1+r_i)$.

We can also make an alternative computation of $EFV(B_t)$ by first compounding $EPV(B_t)$ to period *t*, thereby reaching the value B_t, as already done in (24), and then compounding that further by C_t^{T+1}:

$$EFV[EPV(B_t)] = C_0^t\ EPV(B_t)\ C_t^{T+1} = \ EFV(B_t) \tag{25}$$

Noticing that:

$$C_0^t C_t^{T+1} = \ \mathrm{E}\left[\prod_{i=0}^{t-1}(1+r_i)\right] \mathrm{E}\left[\prod_{i=t}^{T}(1+r_i)\right] = \mathrm{E}\left[\prod_{i=0}^{T}(1+r_i)\right] = C_0^{T+1} \tag{26}$$

we can state that:

$$EPV(B_t)\ C_0^{T+1} = \ EFV(B_t) \tag{27}$$

which means that compounding $EPV(B_t)$ by the certainty equivalent compound factor C_t^{T+1} yields $EFV(B_t)$, in compliance with the definition of present value. As this is true for all B_t, it follows that the total EFV of benefit flow $\{B_t\}$ will be its EPV times the constant C_t^{T+1}. Consequently, *EPV* and *EFV* will always be either both positive, both negative, or both zero. There is no discrepancy in the rankings given by the EPV and EFV criteria, provided that *EPV* is correctly calculated, as in (14).

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