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Identifying Optimal City Size for Sustainable Urban Development and Resource Allocation

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Abstract

Identifying the optimal population size at which cities maximize economic benefits while minimizing congestion and pollution is a challenge. This research explores the optimal city size by examining the relationship between population and economic performance, measured by city GDP. Using data from OECD regions for about 562 cities, the analysis employs a quadratic regression model to test an inverse U-shaped relationship between city population and GDP in 2020. The empirical results show that cities initially experience economic growth as populations increase. However, after a certain point (8.85 million), the benefits diminish due to congestion and pollution in the short run. However, the optimum city population size may increase to 15.2 million in the long run. The study concludes that an optimal city size exists, balancing the advantages of agglomeration with the costs of urban expansion.

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Additionally, population density, territorial fragmentation, working-age population, and built-up area positively affect city GDP, whereas air pollution negatively impacts it. Finally, several policies are recommended for sustainable urban development and efficient resource allocation.

Keywords: urban growth, sustainable urban development, optimal city size, population size, cities.

JEL Classification: R10; R11; R12; O10; O20; O40.

Introduction

Identifying the population size at which a city maximizes the benefits of urban living while minimizing associated costs is a key challenge in urban economics. Identifying this optimal city size is vital for sustainable urban development and resource allocations. An optimal city size is rooted in the idea that a city reaches its most efficient population level when the costs and benefits of urban living are balanced. Alonso (1971) and Richardson (1978) tried to define optimal city size based on cost-benefit analysis, but empirical evidence remains inconclusive.

The concept of optimal city size has been explored through various models and theories. Traditionally, optimal city size is measured by total population. The Alonso-Richardson model suggests that as a city grows, it benefits from agglomeration economies, such as lower transportation costs and better knowledge sharing. However, it also faces disadvantages like increased traffic and pollution. The optimal city size is where these opposing forces balance out, maximizing the city's contribution to national income.

Three primary approaches to defining optimal city size have emerged: minimum average cost, maximum net benefit, and long-run maximum profit. The minimum average cost approach identifies the city size where the average cost of providing services is minimized. The maximum net benefit approach seeks to maximize the difference between agglomeration benefits and the costs associated with a larger population. The long-run maximum profit approach identifies the city size where economic profit is zero, suggesting that cities can benefit from economies of scale even after reaching the net benefit peak (Brueckner, 1987; Henderson, 1974). Each method offers a unique perspective on balancing urban growth with economic efficiency.

Empirical studies have attempted to pinpoint this optimal size, with varying conclusions depending on the methodologies and datasets used. The Henry George Theorem (HGT) provides additional insight. It suggests that optimal city size is achieved when land rents cover the costs of public goods, balancing the benefits of agglomeration with the costs of congestion. Similarly, studies have highlighted how cities can experience significant economic gains from high population density due to improved efficiency and innovation. However, these benefits are countered by pollution and territorial fragmentation challenges, which can undermine overall economic performance.

The debate over optimal city size has gained renewed interest due to modern urban challenges. This research aims to contribute to the ongoing discussion on optimal city size by examining the relationship between city population and economic performance using data from OECD regions and cities. The study employs a quadratic model to explore whether the relationship between population size and GDP exhibits an inverse U-shape, where initial increases in population drive economic growth, but further increases lead to diminishing returns. By analysing various economic and demographic factors, this research provides valuable insights for urban planners and policymakers to better balance city size with economic and social benefits.

1. Literature Review

Henderson (1974) and Fisch (1977) discussed the equilibrium city size that balanced welfare and quality of life. They found a positive relationship between population size and urban benefits, supporting the idea that larger populations often lead to increased economic opportunities and services. Glaeser et al. (1992) found that increased population density in urban areas leads to higher economic output due to the concentration of resources and talents. These studies suggest that as cities grow, they can harness economies of scale, leading to increased GDP. Bloom and Canning (2008) further emphasized the role of urbanization in economic development, noting that urban areas typically exhibit higher productivity levels, contributing to national economic growth. Building on this, Nguyen & Nguyen (2017), who studied ASEAN countries from 1993 to 2014, found that urbanization positively contributes to economic growth, although this relationship becomes negative beyond a certain threshold (around 68–70%). Similar conclusions were drawn by Wu et al. (2017) and Sun et al. (2018), who identified an optimal city population of around 4.2 million in Chinese cities for maintaining a balance between economic performance and quality of life.

High population density offers economic advantages such as efficient service delivery and municipal cost up to a threshold (De Duren & Compeán, 2015; Ahlfeldt & Pietrostefani, 2019), innovation, and increased productivity (Brunt & García-Peñalosa, 2021) through agglomeration economies. Glaeser et al. (1992) and Henderson et al. (2006) found that denser cities support better collaboration and economic output, though migration restrictions can limit urban growth, particularly in Chinese cities. Territorial fragmentation, on the other hand, is associated with hampering growth by creating inefficiencies and duplicating services (Alesina & Spolaore, 2005; Capello & Camagni, 2000). While high population density can drive innovation and productivity, it can also lead to congestion and pollution, which may offset some of the benefits (Guo et al., 2023). Furthermore, in very high-density cities, the increase in population density does not significantly impact innovation output, suggesting diminishing returns beyond a certain point (Shukai et al., 2021). De Duren & Compeán (2015) examined the relationship between urban population density and per capita municipal spending on public services in municipalities across Brazil, Chile, Ecuador, and Mexico and found a strong, non-linear correlation, with optimal spending efficiency at around 9,000 residents per square kilometre, where per capita costs are minimized.

Demographics also matter. Bloom and Canning (2000) highlighted that a higher working-age population boosts urban productivity and economic expansion. However, unregulated growth can result in oversized cities plagued by pollution and congestion. Henderson (1974) stressed the need for optimal city size policies to internalize such externalities. Air pollution, for instance, reduces output, productivity (Greenstone & Hanna, 2004; Chang et al., 2019) and hinders innovations and future productivity (Bracht & Verhoeven, 2025).

Built-up area expansion, when well-planned, enhances urban functionality and land value (Camagni, 2002; Arnott, 2004). Models like Yang (2020) and the SOUDY framework highlight the balance between agglomeration benefits and congestion costs in determining optimal city size. While larger cities typically perform better economically, studies like Petrikovičová et al. (2022) suggest that smaller cities may offer a higher quality of life. Agglomeration benefits, such as lower transport costs, shared infrastructure, and knowledge spillovers, must be weighed against diseconomies like pollution and congestion (Rosenthal & Strange, 2004; Duranton & Puga, 2004).

Recent empirical studies have expanded this discussion by incorporating environmental, spatial, and social dimensions into the concept of optimal city size. Pflüger (2021) highlighted how local governments may permit excessive urban growth when national environmental policies are weak, leading to pollution and inefficiencies, while overly strict regulations can prevent cities from realizing agglomeration economies. Mitra and Tripathi (2025) find that even in developed countries, cities have not reached population saturation, and growth continues due to productivity advantages in agglomerated areas. Supporting this, Zhang et al. (2023) demonstrated that spatial functional division within urban agglomerations can mitigate urban externalities by promoting specialization and inter-city coordination. Wang et al. (2021) emphasized the significance of land use optimization and green infrastructure in managing emissions and accommodating urban populations efficiently. Alderete (2021) adds a critical social perspective by showing that citizen awareness, demographic factors, and ICT use significantly influence engagement in smart city initiatives, particularly in mid-sized cities like Bahía Blanca, Argentina. Due to their manageable scale, the study suggests that such cities may be well-positioned to implement targeted, citizen-centric sustainability practices provided investments are made in digital infrastructure and awareness programs to bridge existing divides. Together, these recent studies make it known that optimal city size is context-dependent and must balance economic benefits, environmental constraints, and citizen participation.

This study aims to contribute to this body of literature by exploring the optimal city size through a comprehensive analysis of cities worldwide. Utilizing a dataset from the OECD Regions and Cities Atlas, this research examines the impact of various economic and demographic factors on GDP, a proxy for the benefits of urban living. The analysis employs a quadratic model to capture the potential non-linear relationship between city population and GDP, following the hypothesis that this relationship may exhibit an inverse U-shape. This hypothesis aligns with the notion that while initial increases in population can drive economic growth through agglomeration economies and increased productivity (Rosenthal & Strange, 2004), further increases may lead to diminishing returns due to congestion and pollution (Duranton & Puga, 2004).

The study analyses several key variables to test this hypothesis, as outlined in Table 1. A larger population is expected to positively influence economic growth by expanding the labour force, market size, and consumption. Higher population density is anticipated to increase economic efficiency through agglomeration economies. Greater territorial fragmentation is predicted to negatively impact economic growth due to inefficiencies and administrative complexities. An increased working-age population is expected to support economic growth by providing a productive labour force. Higher air pollution levels are anticipated to reduce economic benefits by affecting health and productivity. Expanding built-up areas will likely positively impact economic growth by improving infrastructure and supporting development. Table 1 outlines these expected relationships, providing a framework for analysing how these factors interact to determine the optimal city size. The findings from this study aim to offer valuable insights for emphasizing the need to balance city size to optimize economic benefits while addressing potential challenges.

Table 1: Expected effects of variables on optimal city size

Variables	Expected sign
Population	Positive
Population density	Positive
Territorial Fragmentation	Negative
Working-Age Population	Positive
Air Pollution	Negative
Built-Up Area	Positive

Source: Authors' compilation

2. Research Methodology

This study utilizes data from the OECD Regions and Cities Atlas for 2020 to explore the optimal city size and its effects on economic benefits. The analysis focuses on city Gross Domestic Product (GDP) as the dependent variable, which serves as a proxy for the benefits of urban living and reflects overall economic activity within cities. Independent variables include population, population density, territorial fragmentation, working-age population, air pollution, and built-up area, each selected for its theoretical impact on economic growth and urban development.

The primary goal is to identify the optimal city size, defined as the population level that maximizes the benefits of urban living, represented by GDP. To achieve this, ordinary least squares (OLS) regression analysis is employed. This method examines how different urban factors affect GDP and determines if there is a specific city size that optimizes economic benefits. Both linear regression models and a U-test are used in the analysis. The U-test helps assess whether the relationship between city size and GDP follows an inverse U- shape, suggesting that while initial increases in population enhance economic growth through economies of scale, further increases may lead to diminishing returns due to congestion and pollution. The dataset comprises between 358 and 363 observations, depending on the specific model used. A quadratic model is applied to capture the potential non-linear relationship between population and GDP, as follows:

$$GDP = \beta_0 + \beta_1\, population + \beta_2\, population^2 + \beta_3\, population\ density + \beta_4\, territorial\ fragmentation + \beta_5\, working\ age\ population + \beta_6\, air\ pollution + \beta_7\, built\ up\ area + \epsilon \quad (1)$$

In this model, GDP represents Gross Domestic Product, while population indicates the total number of residents in the city. *Population2* captures potential non-linear effects of population on GDP. Population density refers to the number of people per unit area within the city, and territorial fragmentation measures the extent of administrative and political fragmentation within the urban area. Working age population denotes the proportion of the population that is of working age, air pollution encompasses the levels of pollutants in the city's atmosphere, and built-up area represents the extent of developed land within the city. The error term, denoted by ϵ, accounts for any unexplained variability in GDP. Including quadratic terms for population allows for testing an inverse U-shaped relationship, where economic benefits are maximized at a certain city size before diminishing returns set in.

3. Empirical Results

3.1 Cross-Sectional Study

Table 2 presents the summary statistics for the variables used in this analysis. The correlation matrix indicates several important relationships among key variables (Table 3). GDP shows a strong positive correlation with both population (0.946) and the working-age population (0.908), suggesting that cities with larger and more productive labor forces tend to exhibit higher economic output (Glaeser et al., 1992). Additionally, GDP is positively correlated with built-up area (0.709), reflecting the role of infrastructure in supporting economic growth (Duranton & Turner, 2012). In contrast, territorial fragmentation has a weak negative correlation with GDP (-0.049), implying that the division of urban areas minimally impacts economic performance. Population density also positively correlates with GDP (0.358) and population (0.438), suggesting that higher density can contribute to economic activity. However, the effect is less pronounced than the overall population size (Glaeser, 2008). On the other hand, air pollution has a minimal positive correlation with GDP (0.010), indicating that its direct impact on economic output is negligible (Greenstone & Gallagher, 2008).

Table 2. Summary statistics

Variables	N	Mean	SD	CV	Min	Max
GDP	363	4.255e+10	8.618e+10	2.026	1.425e+09	9.322e+11
Population	562	1,119,604.7	2,551,168.2	2.279	200,455	34,589,501
Population density	562	1,432.367	2,029.761	1.417	10.532	24,401.441
Territorial fragmentation	539	2.479	5.499	2.218	0	43.1
Working age population	556	731,976.6	1,696,391.3	2.318	119,886	21,956,397
Air pollution	562	12.164	5.469	0.45	4.2	36.5
Built up area	562	247.811	532.406	2.148	1	6249

Source: Authors' calculation

Table 3. Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) GDP	1.00						
(2) Population	0.95	1.00					
(3) Population density	0.36	0.44	1.00				
(4) Territorial fragmentation	-0.05	-0.08	0.14	1.00			
(5) Working age population	0.91	0.96	0.26	-0.08	1.00		
(6) Air pollution	0.01	0.12	0.11	-0.09	0.15	1.00	
(7) Built up area	0.71	0.56	-0.05	-0.10	0.56	-0.21	1.00

Source: Authors' calculation

Table 4 presents the regression results with the log of GDP as the dependent variable across three models, using robust standard errors to address heteroskedasticity. Population shows a positive and statistically significant impact on GDP in Models 2 and 3, with coefficients of 0.0591 and 0.0719, indicating that larger populations boost economic output due to a larger labor force and increased economic activity (Glaeser et al., 1992).

However, the negative and significant coefficients for population squared in both models (-3.34e-09 and -3.71e-09) reveal diminishing returns, suggesting the positive effect of population on GDP weakens at higher population levels. Territorial fragmentation has a positive and significant effect in Models 1 and 3, indicating that some fragmentation might enhance economic performance, possibly by fostering competition and specialization (Duranton & Puga, 2004). The working-age population has a consistent, positive impact across all models, supporting the idea that a larger working-age demographic drives economic output (Glaeser et al., 1992). In contrast, air pollution has a significant negative effect on GDP in all models, coefficients ranging from -0.0181 to -0.0318, reflecting the detrimental impact of pollution on productivity. Population density and built-up area show small but significant positive effects in Model 3, suggesting that urbanization and population concentration can contribute to economic growth, though their impact is less pronounced. The R-squared values range from 0.593 to 0.701, indicating that the models explain between 59.3% and 70.1% of the variation in GDP, with additional variables improving the models' explanatory power.

Table 4: Regression output: Relationship between GDP and population

VARIABLES	Dependent variable		
	Log of city GDP		
	Model 1	Model 2	Model 3
City population size	0.0591***		0.0719***
	(0.00886)		(0.00456)
Squared of city population size	-3.34e-09***		-3.71e-09***
	(4.73e-10)		(4.30e-10)
Population density	3.61e-05	0.000133***	
	(2.76e-05)	(1.88e-05)	
Territorial fragmentation	0.00825*		0.00877**
	(0.00430)		(0.00406)
Working age population	3.39e-07***	3.36e-07***	3.08e-07***
	(8.62e-08)	(1.10e-07)	(4.82e-08)
Air pollution	-0.0272***	-0.0181**	-0.0318***
	(0.00612)	(0.00746)	(0.00522)
Built up area	0.000315	0.00112***	
	(0.000261)	(0.000331)	
Constant	23.28***	23.34***	23.36***
	(0.0975)	(0.121)	(0.0771)
Observations	358	358	358
R-squared	0.701	0.593	0.696

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

To ensure the robustness of our findings, we conducted a series of statistical tests and diagnostics. Initially, a heterogeneity test with robust standard errors was performed to address potential heteroskedasticity in the data, ensuring that coefficient estimates remain reliable despite variations in error variance. The Variance Inflation Factor (VIF) was computed for all variables to assess multicollinearity. Although the VIF for population was within acceptable limits, the VIF for population squared was notably high, indicating potential multicollinearity issues and necessitating cautious interpretation of the results for population squared. We verified the expected signs of the coefficients and included control variables significant at the 1% level to enhance the model's explanatory power. This approach helps mitigate omitted variable bias and model misspecification, ensuring the robustness of our results.

To test the hypothesis of an inverse U-shaped relationship between population size and GDP, we employed a U-test. The hypothesis framework was: H1 posits an inverse U-shaped relationship, while H0 suggests a monotonic or U-shaped relationship. The U-test, using the specification $f(x) = x^2$, revealed an extreme point at a population level of 8,854,469. The p-value for the test was below 0.05, leading to the rejection of the null hypothesis in favour of the alternative, confirming that the relationship between population and GDP is indeed inverse U-shaped.

Table 5: U-test

	Lower Bound	Upper Bound
Interval	200455	3.46e+07
Slope	0.000	-0.000
t-value	6.617	-6.276
P>t	0.000	0.000

Source: Authors' calculation

Table 5 presents the U-test results, with the extreme point identified at 8,854,469, and bounds ranging from 200,455 to 34,600,000. The slope at these bounds was approximately 0.000 for the lower bound and -0.000 for the upper bound, with t-values of 6.617 and -6.276, respectively. The overall t-value for the test was 6.28, and the p-value was 5.14e-10, supporting the presence of an inverse U-shaped relationship. The combination of robust regression analysis and U-test results highlights an optimal population size for maximizing GDP. Overall test of presence of an inverse U shape: t-value = 6.28, P>t = 5.14e-10.

3.2 Panel Data Analysis

Given an inverse U-shaped relationship between city GDP and population size in the cross-sectional study, it is important to investigate the relationship in the long run by estimating the panel data model. We consider data from 2000 to 2024 to run the panel data model. The data is available primarily for city GDP and population size; other variables have fewer observations. Most importantly, minimal data are available for territorial fragmentation and air pollution variables to run the panel data model. To choose the appropriate model, we perform the Hausman test and choose the fixed effect model. Table 6 presents the regression results of the fixed effect panel data model. The results are consistent with the regression results obtained in Table 4. City population size, density, and working age population have a positive and statistically significant effect on the city GDP. The squared city population size negatively affects the city GDP.

Table 6: Relationship between city GDP and population: panel data analysis

Variables	Dependent variable		
	Log of city GDP		
	Model 4	Model 5	Model 6
City population size	0.00776***		
	(0.00102)		
Squared of city population size	-1.80e-10***		
	(0.000)		
Population density	7.084***	6.785***	
	(1.016)	(1.968)	
Working age population		-0.000426	0.00891***
		(0.00423)	(0.00328)
Built up area		43.64***	32.96**
		(13.28)	(13.05)
Constant	26,056***	30,605***	35,849***
	(890.0)	(1,848)	(1,060)
Observations	4,397	760	760
R-squared	0.075	0.080	0.060
Number of cities	249	220	220

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Again, we performed a U-test to test the hypothesis of an inverse U-shaped relationship between population size and GDP. The results are presented in Table 7. The U-test suggests an extreme point at a population level of 15,200,000, bounds ranging from 1,05,469 to 200,00,000. The p-values confirm that the relationship between city population and GDP is inverse U-shaped. The overall t-value for the test was 9.53, and the p-value was 1.33e-21. The findings of the U-test indicate the optimum number of people for maximizing city GDP.

Table 7: U-test: panel data analysis

	Lower Bound	Upper Bound
Interval	105469	2.00e+07
Slope	0.000	-0.000
t-value	43.276	-9.527
P>t	0.000	0.000

Source: Authors' calculation

Conclusion

This study provides critical insights into the intricate relationship between city size and economic performance, contributing valuable knowledge for urban planning and policy-making. Our findings confirm that larger cities generally enhance economic output; however, they also identify an optimal city size of approximately 8.85 million people in the short run and up to 15.2 million in the long run. Beyond this size, the economic benefits of further expansion tend to decline due to negative factors such as congestion and pollution. This supports the hypothesis of an inverse U-shaped relationship between population size and GDP. Initially, increases in population are beneficial for economic growth, but further expansion may lead to diminishing returns, reflecting an optimal balance between the benefits of agglomeration and the drawbacks of excessive urban size.

These results are consistent with the broader literature on urban economics. The findings are notably aligned with Brülhart et al. (2009) and Shukai et al. (2021), who argue that while agglomeration benefits are significant at lower levels of economic development, they diminish as the economy grows beyond a certain threshold. This mirrors our observation that the economic advantages of city growth wane once the population surpasses the optimal size. Our study also aligns with the broader economic concept that spatial concentration and urban expansion yield diminishing returns after reaching a critical level of development. Air pollution emerged as a significant factor negatively affecting GDP. Pollution imposes health-related externalities that reduce labour productivity (Lin et al., 2023), increase healthcare costs, and discourage investment. Chronic exposure to pollutants such as particulate matter (PM2.5) and Nitrogen oxides (NOx) can lead to respiratory illnesses, cardiovascular diseases, and even cognitive decline, which lowers human capital accumulation (Bracht & Verhoeven, 2023). Empirical studies support this link, with research showing regions with high pollution tend to experience slower productivity growth and declining work efficiency (Dechezleprêtre, 2025). In knowledge-driven urban economies, where human capital is a primary engine of growth, such productivity losses have a direct and measurable impact on GDP. Interestingly, while territorial fragmentation is typically associated with inefficiencies and duplicated services, our results show a positive association. This may reflect the benefits of moderate decentralization, which can enhance local accountability and allow customization of policies to local needs (Polishchuk, 2018) and support higher regional GDP growth when accompanied by high-quality regional governance (Rodríguez-Pose & Muštra, 2022).

The 8.85 million (15.2 million in long run) figure reflects conditions specific to high-income OECD cities, where relatively strong institutions, advanced infrastructure, and service delivery systems enable economies of scale up to that point and may not be a one-size-fits-all figure. In developing countries, where governance capacity, infrastructure resilience, and social equity mechanisms may be weaker, the optimal size may be considerably lower due to the quicker onset of congestion costs or inadequate urban services. Another key result is the shift in optimal city size from 8.85 million in the short run to 15.2 million in the long run (from panel data analysis). In the short term, infrastructure and institutions may lag behind population growth, creating bottlenecks.

However, in the long run, proper planning, productive investments in mass transit, green technologies, housing, and digital infrastructure can raise the optimality threshold, allowing cities to sustain larger populations without experiencing proportional increases in congestion or pollution (Henao et al., 2015; Wang et al., 2024). This increase from the short-run to the long-run threshold suggests that cities can "grow into" higher optimal sizes if supported by sustained investment, governance reforms, and adaptive capacity. This finding has great policy relevance. City planners should prepare for long-term growth by designing infrastructure, transport, and housing systems that are scalable and resilient.

Additionally, our research highlights several gaps in the existing body of knowledge. Many previous studies focus on specific regions or countries and often employ static models that do not account for rapid changes in urban conditions, technological advancements, or evolving infrastructure. There is a clear need for more dynamic and region-specific models that integrate a broader range of variables, including technological innovations, social equity, and infrastructure development. While this study focuses on economic output (GDP), congestion, and pollution, key indicators in assessing optimal city size, it does not account for important social dimensions such as equity, access to services, quality of life, or cultural vibrancy due to data limitations. Future research should aim to incorporate these broader social indicators to provide a more holistic understanding of what constitutes a sustainable and truly optimal urban size. By addressing these gaps, future research can offer a more comprehensive understanding of the interplay between city size, economic performance, and quality of life.

The findings of this study underscore the need for targeted policy interventions to balance the economic benefits of urban population growth with the adverse effects of over-expansion, congestion, and pollution. First, strategic urban planning should focus on accommodating population growth by investing in infrastructure, housing, and public services that enhance productivity without overstressing urban systems. These efforts can help cities reap the benefits of agglomeration economies while ensuring sustainable growth (Ahrend et al., 2017).

Second, recognizing the diminishing returns from population beyond the optimal size (8.85 million in this study), policymakers should implement measures to manage urban sprawl and control congestion and pollution. This can be achieved by promoting satellite cities, expanding public transportation networks, and implementing congestion pricing, as recommended by Duranton & Puga (2020). Furthermore, high-density, compact urban designs should be prioritized to maximize land use efficiency and reduce urban sprawl.

Additionally, addressing adverse effects of territorial fragmentation requires fostering regional cooperation and integration among neighbouring municipalities to streamline governance and enhance resource sharing. Promoting inter-municipal collaboration can mitigate the negative effects of fragmented urban regions and improve overall economic performance (OECD, 2019). Moreover, investments in the working-age population through education, skills development, and labour market policies are critical to sustaining economic growth. Enhancing the human capital of the workforce is essential for maintaining competitiveness in an increasingly knowledge-based economy (Moretti, 2012; Mohmed et al., 2021). Finally, stringent environmental regulations and the promotion of green technologies are necessary to combat the negative impact of air pollution associated with large urban populations. The adoption of clean energy technologies and emission control measures will not only improve air quality but also contribute to long-term economic sustainability (Melhim & Isaifan, 2025). By adopting these integrated strategies, cities can optimize their population size and economic outcomes while ensuring a sustainable urban future.

Furthermore, future studies should explore the effects of emerging trends and technologies on urban dynamics. Comparative analyses across different global contexts could provide insights into how varying socio-economic conditions and policy environments influence the optimal city size and its impact on economic performance. Developing more sophisticated models that consider the interactions between economic, social, and environmental factors will be crucial for understanding how cities can grow sustainably while maximizing economic and social benefits.

Credit Authorship Contribution Statement

S.T. and A. K. contributed to the overall conceptualization of the study and led the design of the research framework. A.K, S.T., and K. M. were primarily responsible for developing the methodology, formulating the core arguments, and drafting the original version of the manuscript. A. K, S. T., and K. M. conducted an extensive literature review.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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