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Evaluating Green Fiscal Policy and Regional Trade: A dynamic Computable General Equilibrium Application to Morocco under African Continental Free Trade Area (AfCFTA)

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Abstract:

This article evaluates the combined effects of carbon taxation and regional trade liberalization in Morocco using a dynamic Computable General Equilibrium (CGE) model. Calibrated to a 2019 Social Accounting Matrix enriched with trade and emissions data, the model simulates progressive carbon pricing alongside tariff reductions under AfCFTA. The study compares alternative fiscal recycling schemes, including income tax cuts, wage cost reductions, and investment support, to assess their macroeconomic, social, and environmental outcomes. Results show that certain recycling designs can simultaneously promote trade competitiveness, ensure fiscal sustainability, and reduce CO_2 emissions. These findings offer insights for policymakers designing integrated green fiscal strategies in developing countries undergoing trade reforms.

Keywords: carbon tax; CGE model; Morocco; AfCFTA; fiscal policy; trade integration; environmental economics.

JEL Classification: C68; F15; H23; Q52; Q58; O55.

Introduction

In an era defined by shifting trade alliances and escalating environmental pressures, the intersection of regional economic integration and green fiscal policy has become a critical area of inquiry for emerging economies. Morocco, situated at the crossroads of Europe and Africa, embodies this dual transformation through its reintegration into the African Union and its active participation in the African Continental Free Trade Area (AfCFTA), alongside growing commitments to climate mitigation, notably through the prospective introduction of a national carbon tax.

This study investigates the extent to which these policy trajectories can be reconciled within a unified analytical framework. While the literature has extensively examined the effects of trade reforms or environmental taxation in isolation, few studies assess their combined impact within a single macroeconomic model calibrated to a middle-income, energy-dependent economy like Morocco. This paper fills that gap by employing a dynamic Computable General Equilibrium (CGE) model specifically tailored to Morocco's structural features, calibrated to an extended 2019 Social Accounting Matrix (SAM) with trade and emissions disaggregation. By simulating AfCFTA tariff dismantling alongside carbon tax scenarios over the 2024–2030 horizon, the study explores various fiscal recycling mechanisms, including household transfers, payroll tax reductions, and green investment incentives, and assesses their macroeconomic, trade, and environmental effects. The findings provide empirical insights on the synergies and trade-offs between competitiveness, equity, and decarbonization. In doing so, the paper contributes to the applied policy debate on how developing economies can align regional integration with environmental sustainability through coordinated fiscal strategy.

1. Literature Review

The relationship between trade policy and environmental regulation is increasingly scrutinized in economic research, particularly in the context of low- and middle-income economies striving for balanced development. Classical trade theories, such as those of Ricardo and Heckscher-Ohlin, emphasized comparative advantages and factor endowments (Copeland & Taylor, 2003), but largely neglected environmental externalities. In contrast, new trade theories developed by Helpman & Krugman (1985) introduced imperfect competition and economies of scale, which allow for more nuanced analyses of how trade liberalization interacts with environmental outcomes.

On the environmental side, policy frameworks have evolved from Pigouvian approaches correcting market failures to more dynamic perspectives centered on ecological efficiency, carbon pricing, and sustainable governance (Baumol & Oates, 1988). The Environmental Kuznets Curve (EKC) proposed by Grossman & Krueger (1995) suggests a nonlinear relationship between income and pollution, though empirical evidence remains mixed (Cole, 2004). Meanwhile, the Porter & al. (1995) hypothesis contends that well-designed environmental regulation can foster innovation and competitiveness rather than hinder growth, thereby linking sustainability with industrial upgrading.

Research on the trade–environment nexus increasingly employs Computable General Equilibrium (CGE) models to jointly assess the effects of carbon pricing and trade reforms on growth, distribution, and emissions. Complementing traditional frameworks, recent CGE studies demonstrate that revenue recycling mechanisms are decisive for both efficiency and equity. Dynamic multi-regional analyses reveal that progressive redistribution schemes directed toward labour or production taxes can reduce inequality and macroeconomic costs while maintaining mitigation effectiveness (Zhao & al., 2022; Timilsina & al., 2023). These findings justify the explicit integration of recycling channels into policy simulations.

From an empirical perspective, evidence from Africa and the MENA region underscores these dynamics. In South Africa, carbon taxation has produced mixed economic outcomes but consistent mitigation gains, highlighting the importance of fiscal recycling (Chitiga & al., 2017). In Tunisia, Ben Sassi (2022) applies microsimulation-CGE techniques to assess household-level impacts of green fiscal reform. For Morocco, the evidence remains thin: few studies, such as El Malki & Haddou (2018), investigate macroeconomic consequences without spatial or partner-region disaggregation. This gap contrasts with the country's ambitious low-carbon strategies and AfCFTA commitments.

In the African context, a large and growing body of literature modelling the AfCFTA, primarily through ex-ante CGE analyses, documents sizable intra-African trade and welfare gains from tariff dismantling and trade facilitation. Nevertheless, results differ by country depending on heterogeneity and implementation paths. Recent studies have traced the reconfiguration of value-added and agri-food chains, while GTAP-based forward-looking work explores customs-union scenarios and common external tariffs. This emphasizes the importance of representing partner regions in a granular manner when conducting national-level modelling exercises.

For Morocco and the MENA region, peer-reviewed CGE-based contributions remain limited in evaluating the joint effects of AfCFTA liberalization and domestic carbon taxation. Existing Moroccan CGE exercises, including World Bank macro-CGE work, have primarily addressed renewable energy and energy transition pathways. Although recent reviews synthesize the national low-carbon strategy, most policy assessments continue to rely on reduced-form tools such as CPAT or simplified frameworks without dynamic carbon-pricing blocks and explicit recycling channels (Black et al., 2023). Morocco-specific AfCFTA studies focus mostly on tariff removal and trade creation without integrating carbon pricing (Raouf et al., 2021; Bouët et al., 2021). This evidences a clear methodological gap: the lack of a Morocco-calibrated dynamic CGE that simultaneously embeds AfCFTA tariff reduction schedules and a carbon tax-and-recycling architecture.

Beyond Africa, in the broader developing-country literature, recent research confirms that recycling carbon tax revenues by cutting pre-existing distortionary taxes (e.g., VAT, payroll, or production taxes) can deliver a "double dividend." Well-targeted schemes also mitigate adverse distributional impacts (Nong & Tiezzi, 2021). Such insights are especially relevant for MENA economies characterized by high informality and narrow fiscal space (examples include Côte d'Ivoire and multi-regional studies on China). They strengthen the case for experimenting with multiple recycling channels, social, economic, and sectoral, within national CGE applications.

From a modelling standpoint, dynamic CGE frameworks are increasingly adopted to capture intertemporal trade-offs and spatial heterogeneity in emissions and trade flows (Devarajan et al., 2011). Several contributions in Regional Science and Urban Economics reinforce this methodological choice. Meade and Roe (2005) demonstrated how multi-region CGE models reveal spatial asymmetries of joint trade, environmental policies. Nong and Tiezzi (2021) further confirmed that revenue recycling is essential to mitigate inequality in the context of carbon taxation.

Against this backdrop, the present contribution advances the frontier along four Morocco-specific dimensions. First, it employs a recursive dynamic CGE calibrated to a 2019 Morocco SAM, enriched with trade partner disaggregation (Africa, Europe, Rest of World), aligning tariff-cut geometries with AfCFTA schedules and extending the framework with an environmental module linking energy use to CO_2 emissions. Second, it operationalizes AfCFTA tariff dismantling through weighted annual schedules consistent with List A commitments, aligning with continental evidence while capturing Morocco's bilateral exposure. Third, it endogenizes a carbon tax block and tests a portfolio of revenue recycling instruments, social (labour/households), economic (investment/export-promotion), and combined (aggregate/sectoral). Fourth, it situates Morocco's results within the broader policy context (AfCFTA progress; CBAM-related export risks), ensuring alignment with recent high-impact work on trade–climate interactions while filling a Morocco-specific gap.

Finally, comparable CGE applications in other African countries, particularly South Africa and Tunisia, corroborate the importance of policy packaging that combines carbon pricing with reforms in subsidies and investment. They also demonstrate that fiscal recycling choices materially shape macroeconomic, sectoral, and equity outcomes. This cross-country evidence, drawn from reputable peer-reviewed and institutional sources, reinforces the external validity of the scenario design and aids in interpreting Morocco's differentiated outcomes across labour-, income-, and export-focused recycling schemes.

2. Model Description and Data

The present study relies on a dynamic Computable General Equilibrium (CGE) model specifically adapted from the PEP-1-t (Decaluwé et al., 2013) framework to capture the interaction between carbon taxation and regional trade integration in Morocco. The model is calibrated to a detailed 2019 Moroccan Social Accounting Matrix (SAM), constructed by the High-Commission of Planning (HCP, 2022) and extended to account for trade partners (Africa, Europe, RoW), carbon emissions by activity and final demand, and fiscal instruments such as a carbon tax. This extended SAM provides the accounting backbone of the model, enabling both macroeconomic consistency and a disaggregated analysis of sectoral and institutional responses. Table 1 presents the main accounts, while Appendix

10 offers an aggregated version[1], organized by branches, products, and taxes and duties (net of subsidies), with figures in millions of dirhams.

Table 1. Key accounts of the Social Accounting Matrix (SAM), Morocco 2019

Block	Description / aggregation	Role in the model
Activities (Industries)	Sectoral production accounts (author's 28-branch aggregation). See full list in Appendix 1	Produce via nested CES (value-added) over Leontief (intermediates).
Commodities	Goods and services; explicit energy vectors among commodities (e.g., Coal, Natural gas, Gasoline, Diesel fuel, Fuel, Butane). See full list in Appendix 2	Armington aggregation of domestic vs. imported sources.
Factors	Primary factors of production (Labour, Capital).	Receive factor incomes that accrue to institutions.
Institutions	Domestic institutions (MEN: households, ENT: firms, GOV: government).	Receive/transfer income; pay taxes; save/consume.
Rest of the world	External accounts disaggregated by three partner groups (Africa, Europe, rest of world).	Trade flows, transfers, current account balance.
Tax accounts	Customs duties (TM), Household income tax (IRO), Corporate income tax (ISO), Value added tax (TXTVA), Other product taxes (including excise taxes) (TXAIP), Consumption subsidy (TXSUBC), Sectoral production tax (TAXXO), Sectoral production subsidy (SUBPO).	Government revenue; price wedges; basis for recycling.
Saving–Investment	Accounting for savings and investments, with a public and private breakdown, and changes in inventories.	Macro equilibrium between total saving and investment.

Source: Author's calculations based on the 2019 SAM (national data and author's aggregation).

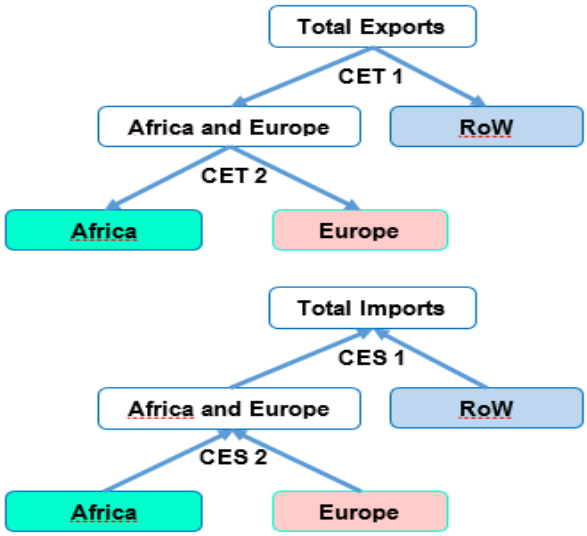
Production is represented through a nested structure with constant returns to scale. Each activity combines capital and labour within a constant elasticity of substitution (CES) function, which in turn is embedded in a Leontief aggregator of intermediate inputs. Firms behave competitively, acting as price-takers in both input and output markets, and minimize their unit costs subject to technological constraints. On the demand side, households' behaviour is modelled using a Stone–Geary (Linear Expenditure System, LES) utility function, which accounts for subsistence consumption thresholds. Minimum-consumption parameters ensure that low-income households allocate resources first to essential goods, while marginal budget shares are estimated from Moroccan household survey microdata. Government and enterprise consumption are treated as fixed budget shares across composite goods, consistent with the accounting categories of the SAM.

The model explicitly integrates spatial and regional trade structuring. Imports are represented through an Armington specification (Figure 1), where domestic and foreign varieties are imperfect substitutes. The Armington nest follows a two-tier design: the first level distinguishes between an aggregate of African and European partners versus the Rest of the World, while the second level disaggregates the Africa–Europe block into its two regional components. Similarly, exports are allocated between domestic and foreign markets through a Constant Elasticity of Transformation (CET) structure. The CET also follows a two-level hierarchy, first separating domestic versus international sales, and then distributing exports between Africa, Europe, and the Rest of the World. This nested Armington–CET setup allows the model to trace region-specific effects of AfCFTA liberalization, while simultaneously capturing trade shifts induced by carbon pricing. World prices are treated as exogenous in foreign currency under the small-country hypothesis, and domestic border prices equal international prices multiplied by the fixed nominal exchange rate, adjusted for tariffs and trade margins. The elasticities of substitution and

[1] The detailed version of the 2019 Social Accounting Matrix (SAM), covering 28 sectors and 36 commodities and expressed in millions of dirhams, can be obtained from the author upon request.

transformation underlying the Armington and CET functions are empirically calibrated using Moroccan trade data spanning the period 2010–2023, ensuring that the model's trade block reflects actual behavioural responses.

Figure 1: Distribution of trading partners within the model



Source: Figure compiled by the authors

Markets are assumed to operate under perfect competition with constant returns to scale. Producer and consumer prices are linked through a system of indirect taxes, distribution margins, and trade wedges. The numeraire of the system is the nominal exchange rate, which is fixed to maintain price normalization and to provide a transparent interpretation of domestic relative prices.

Labour supply is treated as exogenous and evolves according to demographic projections over the short- and medium-term horizon. While private-sector wages adjust endogenously to clear the labour market, ensuring full employment of the aggregate labour force, wages in public administration and social services are treated as institutionally rigid. Labour is assumed to be perfectly mobile across domestic sectors but internationally immobile, consistent with the absence of large-scale labour migration in Morocco.

Capital dynamics follow a recursive mechanism. The stock of capital accumulates over time as new investment adds to the existing stock net of economic depreciation. New private investment is distributed across sectors in fixed shares, reflecting the base-year investment composition. Public capital follows an exogenous growth path proportional to demographic expansion, while changes in inventories remain fixed at base-year levels. The recursive dynamic closure links savings, investment, and capital accumulation, thereby capturing the medium-run trajectory of growth.

The fiscal block incorporates a wide array of tax instruments, including indirect taxes (VAT, excises, import tariffs, export taxes), direct taxes (personal and corporate income), and subsidies. Real public consumption is treated as exogenous, growing in line with population, while tax rates remain constant. Government saving adjusts residually within the saving-driven macroeconomic closure. Public transfers are indexed to the consumer price index (CPI) and population, ensuring that redistribution remains constant in real per capita terms. External balance is governed by a fixed current-account ratio, expressed as a share of GDP, which serves as the external anchor of the model. Given the fixed nominal exchange rate and exogenous world prices, domestic absorption adjusts endogenously to satisfy the current account balance constraint. The savings–investment closure is saving-driven: institutional saving rates are exogenous, and aggregate investment adjusts to match the availability of both domestic and foreign savings.

The environmental block introduces explicit carbon accounting. CO_2 emissions are computed from intermediate energy use by production activities, final household demand, and government consumption, using product- and agent-specific emission coefficients derived from Morocco's energy balance. Emissions are then aggregated across activities and institutions to provide economy-wide totals. In implementation, the carbon tax is expressed as ad valorem–equivalent wedge applied to commodities, ensuring consistency with existing tax and trade instruments. Carbon revenues are disaggregated by source, activities, household, and government, and recycled through alternative fiscal scenarios. These recycling schemes include social transfers, payroll tax reductions, corporate tax cuts, export subsidies, and green investment support, thereby enabling a comparative evaluation of their economic, distributional, and environmental consequences.

Altogether, the model combines a rigorous structural specification with empirically grounded calibration, offering a reliable platform for ex ante policy evaluation. Its recursive dynamic nature links investment, capital accumulation, and demographic changes, while its extended trade and environmental modules allow for an integrated assessment of Morocco's dual policy challenge: advancing regional trade integration under AfCFTA while pursuing a credible pathway to decarbonization.

3. Scenario Design and Policy Framework

To assess the interplay between environmental taxation and regional trade liberalization in Morocco, this study develops a suite of integrated policy scenarios combining carbon pricing and AfCFTA implementation. The central objective is to evaluate the macroeconomic, environmental, and social implications of different fiscal recycling mechanisms applied to carbon tax revenues, under a context of gradually reduced tariffs on African trade flows.

The baseline scenario (BAU) assumes a continuation of existing trade policies and no carbon tax implementation. Alternative scenarios introduce a progressive carbon tax ranging from 5 to 20 dollars per ton of CO_2 over the period 2024–2030, aligned with Morocco's strategic low-carbon development trajectory (Ait Faraji & Zaoujal, 2025). Simultaneously, AfCFTA-driven tariff reductions are modelled through a linear dismantling of import duties on intra-African trade, starting in 2024 and phased over six years.

Six core and four combined recycling configurations are simulated to assess the impact of alternative fiscal uses of carbon revenues:

Table 2. Fiscal Policy Scenarios Simulated in the Model

Scenario Code	Policy Description
RE1	Public investment in productive sectors
RE2	Export subsidies targeting African destinations
RE3	Corporate tax reductions
RS1	Payroll and production tax reductions
RS2	Households' income tax cuts
RS3	Direct cash transfers to households
CA1	Combined aggregate recycling scheme blending social and economic support
CA2	Aggregate combination of payroll and production tax reductions by sector, coupled with uniform export subsidies for all products across all regions
CS1	Sector-specific combination targeting the industrial sector through payroll tax reductions and export subsidies for industrial goods directed toward African markets
CS2	Sector-specific combination targeting agriculture and light industry with wage support and trade incentives

Source: Compiled by the authors

This policy framework is structured to assess alternative fiscal recycling schemes that balance climate mitigation with macroeconomic stability and social equity. The ten scenarios (RE1–RE3, RS1–RS3, CA1–CA2, CS1–CS2) encompass economic, social, and combined policy designs, ranging from public investment, tax reductions, and direct transfers to aggregate and sector-specific hybrid approaches. Each configuration is simulated using a dynamic computable general equilibrium (CGE) model calibrated to a detailed 2019 Moroccan Social Accounting Matrix, extended to incorporate regional trade flows and activity-based CO_2 emissions. The simulation horizon covers 2024–2030, aligning with Morocco's AfCFTA implementation timeline and its medium-term climate policy commitments, thereby ensuring that interactions between fiscal recycling, trade liberalization, and decarbonization are captured in a consistent analytical framework.

4. Results and Discussion

This section presents the core results of the dynamic CGE simulations comparing the economic, environmental, and trade impacts of carbon taxation combined with AfCFTA liberalization under different fiscal recycling schemes in Morocco. The analysis is structured around four outcome categories: macroeconomic aggregates, emissions mitigation, export reconfiguration, and fiscal trade-offs. While Appendices 3 to 9 present the full annual results for 2025–2030, this section focuses on average outcomes for 2025–2029 in order to highlight the medium-term structural implications.

Table 3. Real GDP and household consumption under core scenarios

Scenario	Real GDP (% change, average outcomes for 2025–2029)	Households Consumption (% change, average outcomes for 2025–2029)
RE 1	-0.38	-1.82
RE 2	0.19	-0.78
RE 3	-0.59	-1.36
RS 1	-0.39	-1.40
RS 2	-0.80	0.46
RS 3	-0.56	-0.82
CA 1	0.00	-0.60
CA 2	0.17	-0.01
CS 1	-0.14	-0.94
CS 2	-0.24	-1.53

Source: authors' calculations

Table 3 reports the simulated effects on real GDP and households' consumption, expressed as average outcomes for 2025–2029. In the social recycling scenarios (RS1–RS3), household welfare improvements remain limited and heterogeneous. RS2 continues to provide a modest positive effect on household consumption (+0.46%), while RS1 (–1.40%) and RS3 (–0.82%) still exhibit declines. At the macroeconomic level, GDP contracts in all three cases, with losses ranging from –0.39% to –0.80%, suggesting that social recycling alone does not suffice to neutralize adjustment costs. In the environmental recycling block (RE1–RE3), results again diverge. RE2 stands out with the most favourable balance, producing a slight GDP gain (+0.19%) and a moderate consumption reduction (–0.78%). By contrast, RE1 and RE3 still show contractions (–0.38% and –0.59% in GDP; –1.82% and –1.36% in consumption, respectively). The competitiveness-oriented strategies (CA1–CA2) perform relatively well. CA1 preserves GDP at baseline (0.00%) while limiting consumption loss to –0.60%. CA2 even records a mild GDP increase (+0.17%) with almost neutral effects on household consumption (–0.01%).

Finally, the composite approaches (CS1–CS2) generate mixed outcomes. CS1 produces only a minor contraction (–0.14% GDP; –0.94% consumption), whereas CS2 performs less favourably, with somewhat larger losses (–0.24% GDP; –1.53% consumption). Overall, these findings confirm the trade-offs among recycling designs: measures that protect household purchasing power, such as RS2, carry macroeconomic costs, while strategies prioritizing GDP stabilization, such as RE2 and CA2, achieve efficiency gains but only limited welfare improvements. The results underscore the need for a carefully calibrated carbon tax design that reconciles both equity and efficiency objectives.

Table 4. CO_2 emissions reduction by scenario

Scenario	CO_2 Emissions Reduction (%,average outcomes for 2025–2029)
RE 1	-7.89
RE 2	-7.55
RE 3	-7.75
RS 1	-7.63
RS 2	-7.04
RS 3	-7.53
CA 1	-7.25
CA 2	-6.88
CS 1	-7.59
CS 2	-7.83

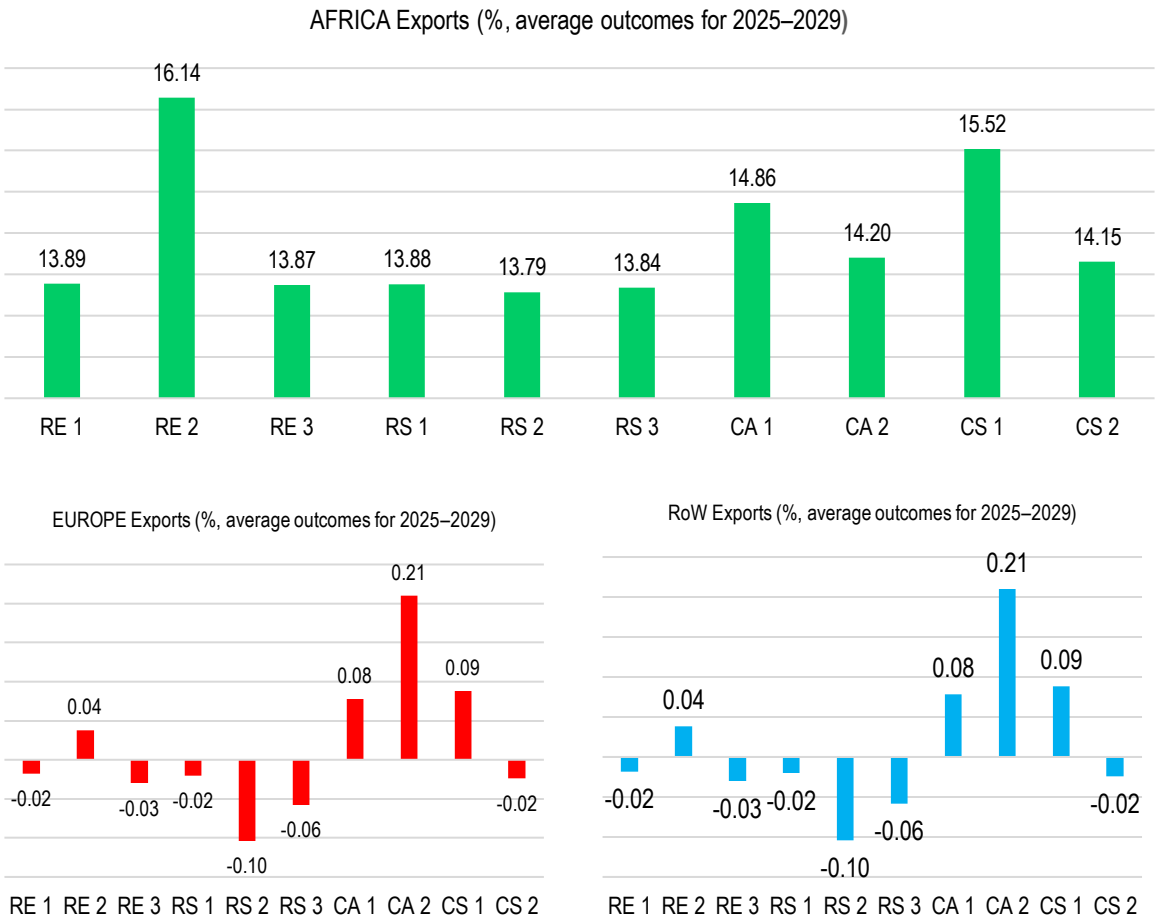
Source: authors' results

Table 4 reports the average reductions in CO_2 emissions across alternative scenarios for the period 2025–2029. All policy configurations confirm the effectiveness of the carbon tax, with reductions ranging from –6.88% to –7.89%. The strongest abatement is achieved under RE1 (green public investment) at –7.89% and CS2 (sectoral wage and export support) at –7.83%, underscoring the critical role of environmentally oriented investment strategies and targeted production incentives in driving emissions down. RE3 (technology and energy efficiency promotion) and RS1 (labour and production tax relief) also deliver robust outcomes (–7.75% and –7.63%, respectively), indicating that both technological upgrading and fiscal easing of production costs can reinforce mitigation effects. By contrast, CA2 (combined recycling with household orientation) yields the lowest reduction (–6.88%), followed by RS2 (direct household income transfers, –7.04%), reflecting that socially progressive redistribution, while improving household welfare, tends to channel expenditures into less emission-sensitive consumption, thereby limiting its mitigation potential.

Figure 2 illustrates the reconfiguration of Morocco's export flows by destination region under the alternative AfCFTA, carbon tax scenarios. In all scenarios, exports to Africa increase relative to the baseline, reaffirming the strong intra-African trade spill overs generated by continental integration. The most pronounced gains are recorded under RE2 (+16.84%), followed by CA1 (+15.42%) and CS1 (+14.97%), where the combination of revenue recycling and competitiveness-enhancing policies reinforces Morocco's penetration in regional markets.

By contrast, exports to Europe and the Rest of the World (RoW) remain relatively modest. Positive though limited effects are observed under CA1 (+0.31% Europe; +0.42% RoW) and RE2 (+0.12% Europe; +0.35% RoW), while socially oriented recycling schemes generate slight declines in extra-African exports. In particular, RS2 (–0.11% Europe; –0.21% RoW) and RS3 (–0.05% Europe; –0.09% RoW) exhibit marginal contractions, reflecting weaker competitiveness in energy-intensive industries when fiscal revenues are directed toward social transfers.

Figure 2. Export flows to Africa, Europe, and RoW by scenario



Source: authors' results

Taken together, these findings confirm that AfCFTA-related regional gains are robust across all policy configurations, whereas the orientation of carbon tax recycling critically shapes Morocco's competitiveness in global markets. This evidence underscores the need for complementary industrial upgrading and productivity-enhancing measures to consolidate regional trade advantages while mitigating potential erosion in Europe and RoW.

Table 5: Fiscal recycling effectiveness

Scenario	Net Fiscal Cost (% of GDP)	Household Income Gain (%, average outcomes for 2025–2029)	Budget Balance Effect
RE1	-1.44	0.04	Deficit
RE2	-1.05	0.82	Deficit
RE3	-0.14	0.72	Neutral–Mild Deficit
RS1	-1.15	0.51	Deficit
RS2	0.07	3.76	Neutral
RS3	-0.80	1.68	Deficit
CA1	-0.86	1.23	Deficit
CA2	-0.56	1.94	Deficit
CS1	-0.95	0.73	Deficit
CS2	-1.32	0.19	Deficit

Source: authors' results

Table 5 expands the evaluation of fiscal effectiveness and distributive outcomes by integrating the ten recycling scenarios, based on average outcomes for 2025–2029.

The purely economic options (RE1–RE3) display contrasting performances. RE1 (public investment) and RE2 (export subsidies to African destinations) both deteriorate the fiscal balance (–1.44% and –1.05% of GDP, respectively) while generating only modest household income improvements (+0.04% and +0.82%). By comparison, RE3 (corporate tax reductions) entails a neutral–mild deficit (–0.14% of GDP) but delivers relatively stronger distributive effects (+0.72%).

The socially oriented scenarios highlight more substantial household welfare gains, yet with persistent fiscal pressures. RS1 results in a deficit (–1.15%) despite producing moderate distributive benefits (+0.51%). RS2 emerges as the most effective social measure: it delivers a significant increase in household income (+3.76%) while maintaining fiscal neutrality (+0.07% of GDP). RS3 (direct transfers) combines a moderate-income gain (+1.68%) with a sizeable fiscal shortfall (–0.80%). These outcomes reveal the recurring tension between income redistribution and budgetary sustainability.

The hybrid schemes (CA1 and CA2) remain intermediate solutions. CA1 produces a household income gain of +1.23% but at the cost of a –0.86% deficit, while CA2 shows stronger distributive results (+1.94%) with a milder deficit (–0.56%). These findings confirm the relative attractiveness of hybrid strategies compared to purely economic or strictly social designs.

The sector-specific approaches (CS1 and CS2) prove less effective in balancing objectives. CS1 generates a moderate-income increase (+0.73%) but coincides with a deficit of –0.95%, whereas CS2 produces only marginal distributive benefits (+0.19%) and the deepest fiscal imbalance among all scenarios (–1.32%).

Overall, the updated results reinforce the difficulty of securing a “double dividend” through carbon taxation in emerging economies. While purely economic schemes provide limited distributive impacts and strong fiscal costs, targeted social mechanisms, particularly RS2, achieve meaningful welfare improvements without undermining fiscal sustainability. Hybrid measures (CA1, CA2) remain promising compromises, as they combine acceptable distributive effects with moderate fiscal costs. The Moroccan case thus illustrates that the design of recycling mechanisms must be carefully calibrated within a broader framework of fiscal discipline and regional trade integration in order to reconcile inclusiveness with low-carbon development.

5. Policy Implications

The findings of this study offer several key policy insights for designing effective green fiscal strategies in developing economies undergoing trade reforms. Consistent with the arguments advanced by Devarajan, Go, and Robinson (2011), the analysis confirms that carbon pricing alone, although environmentally beneficial, may generate contractionary effects on macroeconomic activity and welfare unless it is complemented by well-targeted fiscal measures. The Moroccan case illustrates this dynamic, showing that the intersection of carbon taxation and trade liberalization requires careful calibration to avoid unintended socio-economic consequences.

Firstly, the effectiveness of revenue recycling mechanisms emerges as a decisive factor in shaping the overall outcomes of green fiscal reform. Simulation results indicate that RS2, direct household income transfers, achieves the strongest welfare improvement (+3.76% in household income) while maintaining fiscal neutrality (+0.07% of GDP). However, other social recycling options such as RS1 and RS3, though generating moderate distributive benefits (+0.51% and +1.68%), still produce fiscal deficits (–1.15% and –0.80%). At the same time, GDP contracts in all social recycling cases (from –0.39% to –0.80%), highlighting the trade-off between household protection and macroeconomic stability.

These results echo previous findings by Chitiga, Devarajan & Mabugu (2017) for South Africa and Ben Sassi (2022) for Tunisia, where similar tensions between equity and fiscal sustainability were observed. In contrast, RE2 and CA2 stand out as more balanced solutions: RE2 (export subsidies to African markets) delivers a slight GDP gain (+0.19%) and meaningful income increase (+0.82%), while CA2 (hybrid scheme) combines a mild GDP improvement (+0.17%) with stronger distributive effects (+1.94%). These findings reinforce the “double dividend”

hypothesis as empirically confirmed by Nong and Tiezzi (2021) and van der Ploeg and Rezai (2020), provided that revenue is recycled efficiently.

Secondly, the study highlights the critical role of trade spatial reallocation. The AfCFTA's implementation significantly boosts Moroccan exports to Africa across all scenarios, with the strongest gains observed under RE2 (+16.84%), CA1 (+15.42%), and CS1 (+14.97%). These results align with the conclusions of Costantini & Martini (2010), who argued that trade integration can act as a catalyst for environmental reform when accompanied by supportive industrial and fiscal policies. Nevertheless, the decline in exports to Europe and the Rest of the World under socially focused scenarios (e.g., RS2 at –0.11% for Europe and –0.21% for RoW) underscores the vulnerability of carbon-intensive sectors to competitiveness erosion. This suggests the need for complementary measures such as green technology investment or sector-specific support to prevent adverse impacts on global market positioning.

Thirdly, the distributional outcomes of climate policy require spatial and sectoral differentiation. As Copeland & Taylor (2003) emphasize, uniform climate policies can inadvertently amplify regional disparities if not adapted to local economic structures. The mixed results of sector-specific approaches illustrate this point: CS1 delivers a moderate-income gain (+0.73%) but coincides with a fiscal deficit of –0.95%, while CS2 achieves significant emissions reduction (–7.83%) yet entails the deepest fiscal shortfall (–1.32%) and only marginal distributive benefits (+0.19%). These outcomes highlight that while targeted subsidies and wage support can drive environmental progress, they require careful design to ensure inclusiveness and fiscal sustainability.

Fourthly, the sequencing and institutional embedding of green fiscal reforms are essential. As Baumol & Oates (1988) noted, even theoretically efficient taxes may fail without robust administrative, institutional, and social support mechanisms. The Moroccan simulations confirm this proposition: hybrid strategies such as CA2 demonstrate that emissions reduction (–6.88%), fiscal moderation (–0.56%), and distributive gains (+1.94%) can be pursued simultaneously when reforms are well-sequenced and integrated into broader economic transformation strategies.

From a regional perspective, the policy implications resonate with comparable experiences across Africa and the broader MENA region. In South Africa, carbon taxation has delivered consistent environmental benefits but mixed macroeconomic outcomes, underscoring the critical importance of robust fiscal recycling (Chitiga et al., 2017). In Tunisia, microsimulation-CGE analyses confirm that targeted transfers safeguard welfare but strain fiscal balances (Ben Sassi, 2022). For Morocco, earlier contributions such as El Malki & Haddou (2018) examined macroeconomic effects without integrating AfCFTA or spatial heterogeneity. Against this backdrop, the present contribution fills a methodological gap by embedding AfCFTA liberalization and carbon taxation simultaneously within a dynamic CGE framework, thereby offering a comprehensive assessment of fiscal, trade, and environmental interactions.

Comparative findings across African CGE-based applications further confirm that AfCFTA implementation amplifies intra-African trade and welfare gains, although sectoral outcomes vary depending on national structures and sequencing. Studies focusing on agri-food value chains and industrial linkages highlight how tariff dismantling can reconfigure regional production networks, while GTAP-based analyses explore customs-union arrangements and common external tariffs. For Morocco, existing AfCFTA-related studies (Raouf et al., 2021; Bouët et al., 2021) remain limited to tariff removal without incorporating domestic climate instruments. This contrast underscores the originality of the present study, which jointly integrates climate and trade dimensions.

More broadly, lessons from the developing-country literature reinforce that recycling carbon tax revenues through reductions in distortionary taxes (e.g., VAT, payroll, or production levies) or through carefully designed hybrid schemes can secure a double dividend, simultaneously advancing efficiency and equity (Nong & Tiezzi, 2021). This is particularly relevant for MENA economies characterized by high informality, limited fiscal space, and constrained redistribution capacity. In such contexts, the design of recycling mechanisms, whether oriented toward

households, competitiveness, or investment promotion, becomes decisive for mitigating distributional risks while supporting sustainable growth.

In conclusion, this study demonstrates that the successful design of green fiscal policy in Morocco, and, by extension, in comparable African and MENA economies, requires more than the simple introduction of a carbon tax. A coherent strategy that integrates carbon taxation with AfCFTA liberalization, supported by context-sensitive recycling mechanisms, can simultaneously advance environmental sustainability (–6.88% to –7.89% emissions reduction), macroeconomic resilience (GDP impacts ranging from –0.80% to +0.19%), and social equity (household income gains up to +3.76%). Evidence from South Africa and Tunisia illustrates both the opportunities and trade-offs of fiscal recycling, while Morocco's case underscores the importance of embedding climate policy within a broader framework of structural transformation and trade integration. For policymakers in the Global South, the overarching lesson is clear: carbon taxation should not be treated as an isolated environmental instrument, but rather as a strategic lever for competitiveness, inclusive development, and long-term regional integration.

Conclusion

This study assessed the macroeconomic, environmental, and trade effects of carbon taxation combined with regional trade liberalization under the AfCFTA in Morocco, using a dynamic Computable General Equilibrium (CGE) model tailored to the country's structural characteristics. By simulating multiple policy scenarios involving progressive carbon pricing and fiscal revenue recycling schemes, the analysis contributes new insights into the complex interactions between green fiscal reform and trade integration in developing economies.

The findings confirm that the carbon tax is effective in reducing CO_2 emissions, with all scenarios achieving average reductions between –6.88% and –7.89% during 2025–2029. However, the macroeconomic and distributive impacts vary significantly depending on how fiscal revenues are recycled. Among the social recycling scenarios, only RS2 delivers a modest improvement in household consumption (+0.46%), while RS1 (–1.40%) and RS3 (–0.82%) still record declines. Moreover, all three social options are associated with contractions in real GDP (–0.39% to –0.80%), underscoring their limited ability to neutralize adjustment costs. By contrast, economic and hybrid configurations, particularly RE2 (export subsidies) and CA2 (combined recycling), generate favourable outcomes. RE2 delivers a slight GDP gain (+0.19%) and a meaningful household income increase (+0.82%), while CA2 combines a mild GDP improvement (+0.17%) with stronger distributive effects (+1.94%). These findings support the "double dividend" hypothesis, provided that recycling mechanisms are carefully designed.

From a trade perspective, the simulations show that AfCFTA liberalization consistently boosts Morocco's exports to African markets. The largest gains are achieved under RE2 (+16.84%), CA1 (+15.42%), and CS1 (+14.97%), where competitiveness-enhancing measures reinforce regional integration. However, socially focused schemes (RS2, RS3) result in slight declines in exports to Europe and the Rest of the World, reflecting competitiveness pressures in carbon-intensive sectors. These results suggest that complementary industrial upgrading and technology investment are required to safeguard extra-African market shares while maximizing AfCFTA-driven opportunities.

The analysis also underscores the importance of spatial and sectoral targeting in climate policy. Scenario CS2, which combines wage support with agro-export incentives, illustrates how sector-specific fiscal designs can achieve strong mitigation effects (–7.83%). Nevertheless, distributive impacts remain modest (+0.19%) and fiscal costs high (–1.32% of GDP), highlighting the persistent trade-off between inclusivity, efficiency, and budgetary discipline.

Overall, the study reinforces that carbon taxation, when integrated with regional trade liberalization and supported by carefully calibrated revenue recycling, can become a strategic lever for green structural transformation in the Global South. For Morocco and similar emerging economies, the design of green fiscal policy should go beyond emissions pricing to encompass broader institutional, trade, and equity dimensions of sustainable development.

Credit Authorship Contribution Statement

Ait Faraji, S. was responsible for the conceptualization of the study, development of the methodology, data curation, formal analysis, software implementation, visualization, and drafting of the original manuscript. Zaoujal, N. provided supervision, validation, and resources, and contributed to the review and editing of the manuscript. Both authors approved the final version of the paper. We affirm that this article is original, that all sources have been properly cited, and no data were plagiarized or falsified. We guarantee respect for copyright and uphold the highest ethical standards in the publication process.

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Conflict of Interest Statement

The authors declare that they have no financial or personal conflicts of interest that could influence the results or interpretations presented in this article. No external funding sources were received for the conduct of this research.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Appendix

Appendix 1. Full list of SAM sectors

Code	Industry	Aggregated sectors
A00	Agriculture & forestry	Primary sector
A05	Fishing & aquaculture	
B00	Mining	
CA0	Manufacture of food products & beverages	Secondary or industrial sector
CB0	Manufacture of textiles, wearing apparel, leather & leather products	
CC0	Manufacture of wood & paper products; printing & reproduction of media	
CD0	Coking & manufacture of refined petroleum products	
CE0	Manufacture of chemical products	
CF0	Manufacture of basic pharmaceutical products & pharmaceutical preparations	
CG0	Manufacture of rubber & plastic products, & other non-metallic mineral products	
CH0	Manufacture of basic metals & fabricated metal products, except machinery & equipment	
CI0	Manufacture of computers, electronic & optical goods	
CJ0	Manufacture of electrical equipment	
CK0	Manufacture of machinery & equipment, n.e.c.	
CL0	Manufacture of transport equipment	
CM0	Other manufacturing (incl. furniture), repair & installation	
DE0	Electricity & gas supply, Water supply, sewerage, waste management	
F00	Construction	
G00	Wholesale & retail trade; repair of motor vehicles & motorcycles	Service sector
H00	Transportation & warehousing	
I00	Accommodation & food services	
J00	Information & communications	
K00	Financial & insurance activities	
L68	Real estate activities	
MN0	Research & development & business services	
O84	Public administration & compulsory social security	
PQ8	Education, human health & social work activities	
RS0	Other services	

Source: Compiled by the authors

Appendix 2. Full list of SAM commodities

Code	Commodities: goods and services	Aggregated Commodities
A00	Agriculture and forestry	Primary Commodities
A05	Fishing and aquaculture	
CHARBON	Coal	
GAZNATUREL	Natural gas	
AUTREC00	Other mining Commodities	
CA0	Manufacture of food and beverages	Secondary/industrial Commodities
CB0	Manufacture of textiles and clothing, leather and leather goods	
CC0	Wood and paper industry Printing and media reproduction	
ESSENCE	Gasoline	
GASOIL	Diesel	
FUEL	Fuel	
BUTANE	Butane	
AUTREPP	Other refined petroleum Commodities	
CE0	Manufacture of chemicals	
CF0	Manufacture of basic pharmaceutical Commodities and pharmaceutical preparations	
CG0	Manufacture of rubber and plastic Commodities and other non-metallic mineral Commodities	
CH0	Metallurgy and metalworking, except for machinery and equipment	
CI0	Manufacture of computer, electronic, and optical equipment	
CJ0	Manufacture of electrical equipment	
CK0	Manufacture of machinery and equipment n.e.c.	
CL0	Manufacture of transport equipment	
CM0	Other manufacturing activities (including furniture) Repair and installation	
DE0	Electricity and gas supply Water supply Sanitation Waste management	
F00	Construction	
G00	Wholesale and retail trade Repair of motor vehicles and motorcycles	Tertiary Commodities
H00	Transportation and warehousing	
I00	Accommodation and food services	
J00	Information and communications	
K00	Financial and insurance activities	
L68	Real estate activities	
MN0	Research and development and business services	
O84	Public administration and compulsory social security	
PQ8	Education, human health, and social work activities	
RS0	Other services	

Source: Compiled by the authors

Appendix 3. Change in real GDP in % over the entire period 2025-2030

Year	Economic recycling			Social recycling			Combined recycling			
	RE 1	RE 2	RE 3	RS 1	RS 2	RS 3	CA 1	CA 2	CS 1	CS 2
2025	-0.12	0.16	-0.25	-0.13	-0.41	-0.26	-0.02	0.45	0.02	-0.06
2026	-0.23	0.19	-0.40	-0.24	-0.59	-0.39	-0.01	0.33	-0.04	-0.13
2027	-0.36	0.21	-0.57	-0.36	-0.78	-0.54	0.01	0.19	-0.11	-0.21
2028	-0.50	0.22	-0.75	-0.50	-0.98	-0.70	0.03	0.04	-0.21	-0.31
2029	-0.71	0.15	-0.99	-0.70	-1.25	-0.92	0.01	-0.18	-0.38	-0.47
2030	-1.04	-0.07	-1.35	-1.02	-1.64	-1.27	-0.12	-0.52	-0.70	-0.77

Source: authors' results

Appendix 4. Change in total actual household consumption in % over the entire period 2025-2030

Year	Economic recycling			Social recycling			Combined recycling			
	RE 1	RE 2	RE 3	RS 1	RS 2	RS 3	CA 1	CA 2	CS 1	CS 2
2025	-1.07	-0.61	-0.82	-0.85	0.18	-0.41	-0.43	0.77	-0.63	-0.93
2026	-1.45	-0.72	-1.07	-1.12	0.38	-0.60	-0.50	0.38	-0.78	-1.23
2027	-1.81	-0.80	-1.34	-1.39	0.52	-0.80	-0.59	0.00	-0.93	-1.52
2028	-2.18	-0.85	-1.61	-1.66	0.61	-1.01	-0.68	-0.38	-1.08	-1.81
2029	-2.59	-0.93	-1.95	-1.99	0.60	-1.29	-0.80	-0.80	-1.30	-2.15
2030	-3.08	-1.15	-2.38	-2.41	0.45	-1.67	-0.99	-1.31	-1.66	-2.60

Source: authors' results

Appendix 5. Change in total CO2 emissions in % over the entire period 2025-2030

Year	Economic recycling			Social recycling			Combined recycling			
	RE 1	RE 2	RE 3	RS 1	RS 2	RS 3	CA 1	CA 2	CS 1	CS 2
2025	-5.14	-4.98	-5.04	-5.00	-4.59	-4.86	-4.72	-4.08	-4.98	-5.11
2026	-6.62	-6.37	-6.48	-6.41	-5.86	-6.28	-6.05	-5.58	-6.38	-6.57
2027	-7.98	-7.65	-7.83	-7.71	-7.08	-7.60	-7.31	-6.97	-7.67	-7.92
2028	-9.25	-8.82	-9.09	-8.93	-8.25	-8.85	-8.51	-8.27	-8.87	-9.18
2029	-10.47	-9.94	-10.31	-10.10	-9.40	-10.05	-9.66	-9.51	-10.03	-10.39
2030	-11.68	-11.07	-11.54	-11.27	-10.59	-11.25	-10.82	-10.74	-11.21	-11.60

Source: authors' results

Appendix 6. Change in exports to Africa in % over the entire period 2025-2030

Year	Economic recycling			Social recycling			Combined recycling			
	RE 1	RE 2	RE 3	RS 1	RS 2	RS 3	CA 1	CA 2	CS 1	CS 2
2025	7.44	8.42	7.44	7.43	7.40	7.41	7.60	7.71	8.21	7.57
2026	11.04	12.60	11.03	11.03	10.98	11.00	11.48	11.34	12.23	11.24
2027	14.57	16.77	14.55	14.56	14.47	14.52	15.40	14.89	16.20	14.84
2028	18.02	20.94	18.00	18.02	17.89	17.96	19.40	18.36	20.11	18.36
2029	18.37	21.96	18.34	18.36	18.19	18.29	20.43	18.71	20.86	18.76
2030	13.12	17.23	13.08	13.11	12.91	13.03	15.95	13.44	15.86	13.54

Source: authors' results

Appendix 7. Change in exports to Europe in % over the entire period 2025-2030

Year	Economic recycling			Social recycling			Combined recycling			
	RE 1	RE 2	RE 3	RS 1	RS 2	RS 3	CA 1	CA 2	CS 1	CS 2
2025	-0.04	-0.01	-0.04	-0.04	-0.07	-0.06	-0.01	0.18	0.02	-0.04
2026	-0.03	0.01	-0.04	-0.03	-0.09	-0.06	0.02	0.20	0.05	-0.04
2027	-0.02	0.03	-0.03	-0.03	-0.11	-0.06	0.06	0.21	0.08	-0.03
2028	-0.01	0.06	-0.03	-0.01	-0.12	-0.06	0.12	0.22	0.12	-0.02
2029	0.01	0.10	-0.01	0.01	-0.13	-0.05	0.20	0.24	0.17	0.01
2030	0.05	0.15	0.01	0.04	-0.13	-0.03	0.29	0.28	0.22	0.04

Source: authors' results

Appendix 8. Change in exports to the rest of the world in % over the entire period 2025-2030

Year	Economic recycling			Social recycling			Combined recycling			
	RE 1	RE 2	RE 3	RS 1	RS 2	RS 3	CA 1	CA 2	CS 1	CS 2
2025	-0.05	0.02	-0.05	-0.04	-0.09	-0.07	-0.01	0.17	0.00	-0.05
2026	-0.06	0.06	-0.06	-0.05	-0.12	-0.09	0.03	0.17	0.02	-0.06
2027	-0.06	0.12	-0.07	-0.05	-0.14	-0.10	0.08	0.17	0.05	-0.06
2028	-0.05	0.19	-0.07	-0.04	-0.17	-0.10	0.15	0.18	0.08	-0.06
2029	-0.03	0.28	-0.06	-0.02	-0.18	-0.10	0.24	0.20	0.13	-0.05
2030	0.01	0.38	-0.03	0.02	-0.19	-0.08	0.38	0.23	0.19	-0.01

Source: authors' results

Appendix 9. Change in Household Income in % over the entire period 2025-2030

Year	Economic			Social			COMBINES			
	RE 1	RE 2	RE 3	RS 1	RS 2	RS 3	CA 1	CA 2	CS 1	CS 2
2024	0,16	0,16	0,16	0,16	0,16	0,87	0,16	0,16	0,16	0,16
2025	0,19	0,52	0,53	0,44	2,16	1,24	0,83	2,03	0,50	0,26
2026	0,17	0,69	0,68	0,54	3,07	1,53	1,11	2,03	0,66	0,28
2027	0,11	0,85	0,79	0,59	3,87	1,76	1,31	2,00	0,79	0,25
2028	0,00	1,01	0,85	0,59	4,60	1,94	1,46	1,94	0,89	0,19
2029	-0,28	1,03	0,73	0,40	5,12	1,92	1,45	1,71	0,82	-0,05
2030	-0,88	0,71	0,29	-0,12	5,26	1,59	1,16	1,15	0,39	-0,61

Source: authors' results

Appendix 10. Moroccan aggregate social accounting matrix, 2019, in millions of dirhams

		Sectors	Commodities	Exports	Production Factors		Taxes & Subsidies	Economic Agents						Savings - Investment			TOTAL
					TRA	CAP		Firm	Gvt	Men	Africa	Europe	Row	Vstk	Invpriv	Invpub	
Sectors		0	1634700	417163	0	0	0	0	0	0	0	0	0	0	0	0	2051863
Commodities		941336	0	0	0	0	0	0	225389	731976	0	0	0	42182	271235	65910	2278028
Exports		0	0	0	0	0	0	0	0	0	21758	224287	171118	0	0	0	417163
Production Factors	TRA	352169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	352169
	CAP	692083	0	0	0	0	0	0	0	0	0	0	0	0	0	0	692083
Taxes & Subsidies		8772	129309	0	0	0	0	63048	0	36872	0	0	0	0	0	0	238001
Economic Agents	Firm	0	0	0	0	331450	0	75381	25734	33271	583	4777	466	0	0	0	471662
	Gvt	57503	0	0	0	26947	238001	28887	69157	19915	3201	1994	52	0	0	0	445657
	Men	0	0	0	352169	333686	0	95999	77623	17309	0	64590	11398	0	0	0	952774
	Africa	0	20843	0	0	0	0	3807	239	72	0	0	0	0	0	0	24961
	Europe	0	323631	0	0	0	0	3359	957	306	0	0	0	0	0	0	328252
	ROW	0	169545	0	0	0	0	15228	3589	5066	0	0	0	0	0	0	193428
Savings - Investment	Vstk	0	0	0	0	0	0	0	0	0	0	0	0	0	24921	17261	42182
	Private Saving	0	0	0	0	0	0	185953	0	107987	-30	1703	543	0	0	0	296156
	Public Saving	0	0	0	0	0	0	0	42969	0	-550	30901	9851	0	0	0	83171
TOTAL		2051863	2278028	417163	352169	692083	238001	471662	445657	952774	24961	328252	193428	42182	296156	83171	

Source: Compiled by the authors