

The Marginal Cost of Public Funds in Morocco: An Estimation Using a Computable General Equilibrium Model

NABIL EL BAOUCHARI

elbaoucharinabil@gmail.com

Mohammed V University

Research Article

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Abstract:

This article assesses the marginal cost of public funds (MCPF) in Morocco using a computable general equilibrium (CGE) model, by estimating the economic burden borne by households for each additional dirham of tax revenue. Two complementary experiments are simulated for five fiscal instruments (direct tax, production tax, import duties, consumption tax, and their combination): a 1% marginal increase in each tax rate with the additional revenue accruing to public savings, and the same shocks with the revenue redistributed to households as a lump-sum transfer. Under the savings closure, direct taxes show the lowest MCPF (1.44), owing to their progressivity and a negligible impact on GDP (−0.0001%), while import and production taxes generate substantially higher economic costs (up to 3.16). Redistributing the additional revenue as a lump-sum transfer lowers the MCPF of every instrument by 27–57%, moving direct and production taxes below the efficiency benchmark of a non-distorting lump-sum tax ($MCPF < 1$), while import and consumption taxes remain cost-positive under both closures. A comprehensive sensitivity analysis further shows that these findings are robust to substitution-elasticity uncertainty and to the capital-mobility closure, but that the ranking of import relative to consumption tax is reversed under a flexible exchange-rate regime, and that the treatment of tax revenue is the single most consequential assumption tested. These findings argue in favour of prioritizing direct taxation — particularly when paired with revenue redistribution — exercising caution with import and consumption taxes regardless of how their revenue is used, and explicitly stating the intended use of additional tax revenue as part of any tax-reform proposal.

Keywords: Marginal Cost of Public Funds (MCPF), Social Welfare, Tax Revenue, Computable General Equilibrium (CGE), Revenue Recycling, Robustness Analysis, Morocco.

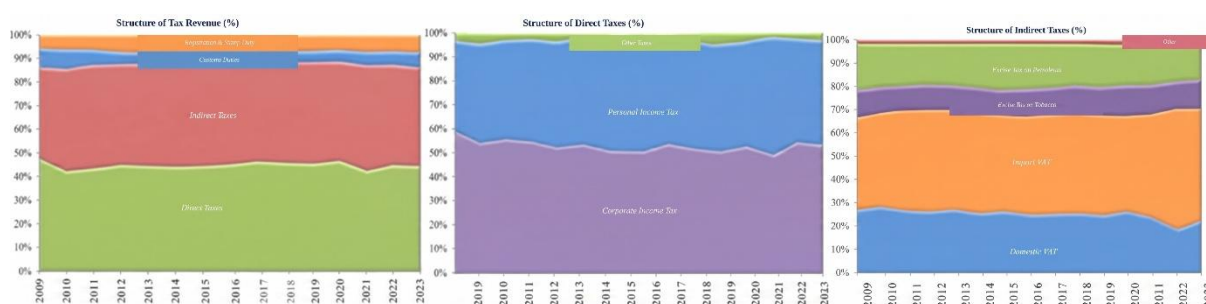
JEL classification: D43, H25, H26, H32, H60, C63, C68.

1. Introduction

The tax system plays a central role in financing public policies and promoting economic development. It serves as the primary lever for mobilizing the state's financial resources while directly impacting economic activity and the behaviour of economic agents.

In Morocco, the tax system, structured around direct taxes (corporate tax, income tax), indirect taxes (VAT), and registration duties, constitutes a central pillar for funding public policies and socio-economic investments. With tax revenues representing nearly 30% of GDP, Morocco ranks among the African countries most dependent on this resource, placing the country second in Africa, behind Tunisia. In contrast, non-tax revenues amounted to only 2.9% of GDP, relegating Morocco to 25th place. However, this dependence comes with a significant public funds cost, linked to structural inefficiencies and distortions inherent to the current fiscal model (OECD, 2024).

Figure 1. Evolution and structure of tax revenues in Morocco 2009-2023



Source: Ministry of Economy and Finance (MEF), Public Finance Dashboard (2024). Translated into English by the author; the original figure is in French.

Several challenges hinder the optimization of this system. First, the extreme concentration of tax contributions: 80% of corporate income tax (CIT) revenue comes from only 2% of companies, while 70% of companies report losses or zero profits. This situation reflects a narrow tax base, exacerbated by an informal sector that accounts for 12.6% of GDP and largely escapes taxation. Second, tax expenditures (exemptions, reduced rates) generate an annual revenue shortfall of 3% of GDP, limiting the government's ability to mobilize resources without resorting to costly coercive measures. Finally, the low elasticity of tax revenues relative to GDP (0.73 in the short term and 1.02 in the long term) (Kissami et al., 2023) reveals the system's insufficient responsiveness to economic growth, forcing the government to compensate through administrative efforts or rate increases, which are sources of additional distortions.

These factors amplify the marginal cost of public funds, defined as the economic and administrative cost associated with collecting an additional unit of tax revenue. For example, broadening the tax base requires investment in tax enforcement, where taxpayer coverage remains below 2%, while combating fraud and informality requires costly institutional reforms. Furthermore, sectoral exemptions, although motivated by specific sectoral development objectives, reduce revenues without guaranteeing proportional incentive effects, thereby increasing the tax burden on a limited number of taxpayers.

The concept of the cost of public funds, firmly rooted in the theoretical foundations of welfare economics (Pigou, 1947), optimal taxation theory (Ramsey, 1927) and public monopoly pricing (Boiteux, 1956), is an analytical pillar in the evaluation of public policies. This concept, represented by the parameter λ , reflects the fact that the collection of one monetary unit by the government generates a total cost of $1 + \lambda$ monetary units for the economy, due to the distortions introduced by taxation.

To measure the effect of the cost of public funds, an indicator called the marginal cost of public funds (MCPF) is often used, which assesses the change in social welfare caused by a marginal increase in tax revenue. Consequently, a public project must produce marginal benefits greater than the MCPF in order to improve welfare. By keeping public revenues constant, welfare can be improved by reducing taxes with the highest MCPF and increasing those with the lowest MCPF. Thus, MCPF estimates provide guidelines for tax structure reform and help determine the most efficient ways to finance public projects (Chisari & Cicowiez, 2010).

Indeed, a better understanding and control of the MCPF makes it possible to guide tax reforms in such a way as to minimize the distortions that are most detrimental to employment and competitiveness (Artus et al., 1980). Furthermore, in a context marked by pressing social needs — combating unemployment, strengthening health and education systems — optimizing the MCPF offers a means of increasing the impact of public spending. By reducing the economic cost of resource mobilization, the government can free up more budgetary margins to finance structural social programs without compromising macroeconomic stability (Davis et al., 2010; El Baouchari & Raouf, 2024b).

In this context, this article aims to empirically estimate the marginal cost of public funds (MCPF) in Morocco, combining the theoretical foundations of welfare economics and computable general equilibrium modelling. Beyond estimating point values of the MCPF for Morocco's main fiscal instruments, the paper makes three further contributions that go beyond a standard single-country CGE application. First, it estimates the MCPF under two distinct, policy-relevant closures for the use of additional tax revenue — accrual to public savings and redistribution as a lump-sum transfer — and shows that this assumption is quantitatively as important as the choice of tax instrument itself. Second, it subjects the resulting estimates to a systematic sensitivity analysis with respect to substitution and trade elasticities, capital mobility, and the exchange-rate closure, identifying which conclusions are robust and which are conditional on specific modelling choices. Third, it derives policy recommendations that are explicitly conditioned on both the tax instrument and the intended use of its revenue, rather than treating the two as independent choices.

We use a static computable general equilibrium model (CGE), calibrated using Morocco's 2019 Social Accounting Matrix (SAM). The main results can be summarized as follows. Under the baseline closure, in which the additional revenue accrues to public savings, the marginal cost of public funds differs markedly across instruments: it is lowest for the direct tax (1.44) and highest for the import tax (3.16), with the production tax (1.97), the consumption tax (1.805) and the combined four-tax package (1.72) falling in between. Redistributing the same revenue to households as a lump-sum transfer lowers the MCPF of every instrument by between 27% and 57%, and is enough to bring the direct tax (0.622) and the production tax (0.993) below the $MCPF = 1$ benchmark of a non-distorting lump-sum tax, while the import tax (2.307) and the consumption tax (1.152) remain cost-positive. A battery of 59 additional simulations confirms that the ordering of instruments is robust to substitution-elasticity uncertainty and to the capital-mobility closure, but shows that the import-tax estimate is highly sensitive to the Armington elasticity and that its ranking relative to the consumption tax reverses under a flexible exchange-rate closure.

The remainder of the paper is organized as follows. Section 2 sets out the theoretical framework and reviews the empirical literature on the MCPF, situating our contribution within it. Section 3 describes the model, the data and the methodology. Section 4 presents the two simulation experiments and their results, and compares them directly. Section 5 subjects the resulting MCPF estimates to a comprehensive robustness and sensitivity analysis. Section 6 discusses the results in light of the international literature and derives evidence-based policy recommendations. Section 7 concludes.

2. Theoretical Framework

The first theorem of welfare economics (Arrow, 1951) posits that, in a competitive environment, resource allocation is optimal in the absence of government intervention. However, the introduction of taxation artificially alters relative prices and causes economic distortions. These distortions result in an excess burden, representing the difference between the loss of collective welfare caused by taxation and the tax revenue collected. Consequently, tax revenue and the excess burden together constitute the total social cost of public funds. In addition, the marginal cost of public funds is defined as the marginal social cost borne by the community following a marginal increase in tax revenues. In this section, we present the main theoretical contributions needed to measure the marginal cost of public funds.

2.1 Excess Burden

Historically, the concept of excess burden (EB) was first mentioned by Dupuit (1844) and Jenkin (1872), then formalized by Hotelling (1938), Boiteux (1951) and Debreu (1951, 1954). However, it was the work of Harberger (1964a, 1964b) that led to the widespread dissemination of the concept, in particular through the Harberger triangle, used to estimate the efficiency losses associated with labour and capital taxes in the United States.

The excess burden (EB) is defined as the difference between the variation in surplus (VS) due to the introduction of the tax and the tax revenue collected by that tax.

$$EB = VS - R, \text{ where } R \text{ represents tax revenue.} \quad (1)$$

Economic literature identifies various methods for measuring EB. Auerbach and Rosen (1980) identified seven approaches, which differ in terms of the monetization of the change in surplus and the method used to calculate tax revenues. However, the most relevant method is that of equivalent variation (EV), defined by Mohring (1971). Formally, the EB is obtained by:

$$EB = EV - R, \text{ where } R \text{ represents tax revenue.} \quad (2)$$

Equivalent variation of income (EV) is a monetary estimate of the loss of utility caused by the tax. It can be interpreted as the amount each consumer is willing to pay to cancel the tax. For a complete formal analysis of this measure, see Beaud et al. (2013, pp. 23–25).

However, EB allows for comparison of the efficiency of different tax systems that collect the same level of public revenue. The optimal system is therefore the one that minimizes EB. In theory, a more efficient system could replace the existing system, but radical reform is complex to implement. In practice, policymakers tend to seek to adjust the existing tax system in order to increase revenue or reduce economic distortions. So how can we measure the change in distortions caused by taxation following a reform? The following subsection introduces two key concepts: the Marginal Excess Burden (MEB) and the Marginal Cost of Public Funds (MCPF).

2.2 Marginal Excess Burden and Marginal Cost of Public Funds

One of the first contributions to this issue is that of Browning (1976), who extends Harberger's analysis by developing an analytical formulation of the marginal excess burden (MEB). MEB is defined as the change in EB following a change in tax revenue. It is expressed by the following formula:

$$MEB = \frac{\Delta EB}{\Delta R} = \frac{\Delta VS - \Delta R}{\Delta R} = \frac{\Delta VS}{\Delta R} - 1 \quad (3)$$

To our knowledge, the term “Marginal Cost of Public Funds” first appeared in the work of Browning (1976). He defines MCPF as the ratio between the change in surplus and the change in tax revenue following a tax reform. According to equations (1) and (2):

$$MCPF = \Delta VS / \Delta R = (\Delta EB + \Delta R) / \Delta R = 1 + MEB \quad (4)$$

Since MEB is based on EB, there are as many possible measures of MEB as there are possible measures of EB. Therefore, Browning’s measure of MCPF is only one particular measure, specifically when MEB is based on the variation in Marshallian surplus. In our analytical framework, we are interested in finding the MCPF based on the equivalent variation EV:

$$MCPF = 1 + EV_{\Delta t} / \Delta R \quad (5)$$

where $EV_{\Delta t}$ is the equivalent variation associated with the price change due to the change in the tax rate Δt .

However, the MEB based on EV is obtained using a different formula. The EV-based MEB is given by $1 + \Delta VE / \Delta R$, where ΔVE represents the VE associated with the new tax rate minus that associated with the old tax rate. In this case, it is clear that $MCPF \neq 1 + MEB$; this inequality is the result of the non-additivity of VE.

In general, MCPF is defined as the change in social welfare associated with collecting an additional unit of tax revenue using a particular tax instrument. The difference between the various existing approaches lies in the multitude of methods used to monetize the change in social welfare.

2.3 Empirical Review

The existing literature presents a wide range of estimates of the marginal cost of public funds (MCPF), which vary according to the methodology used, the tax categories analysed, and the country or region studied. A direct comparison of results between studies is rather complex, as definitions, underlying theoretical frameworks, and measurement methods differ from one study to another. Nevertheless, there are two main methodological approaches to estimating this cost: econometric models, which rely on historical data to identify causalities, and computable general equilibrium (CGE) models, which simulate interactions between sectors and economic agents in a structural framework. This empirical review focuses on studies using CGE models.

International studies on the marginal cost of public funds (MCPF) highlight its importance in assessing the effectiveness of fiscal and regulatory policies. In the Argentine context, marked by structural challenges and a heterogeneous regulatory framework, Chisari and Cicowiez (2010) enrich this literature by integrating the impact of regulatory regimes (price-cap vs. cost-plus) on the MCPF, a dimension that is often overlooked. Using a computable general equilibrium (CGE) model, the authors demonstrate that the MCPF varies significantly depending on the mode of regulation of public services, corroborating previous work on the sensitivity of the MCPF to economic distortions. Their results also reveal that labour supply elasticity, capital mobility, the existence of unemployment, and exempt goods amplify these variations, highlighting the interdependence of public policies. In particular, the authors observe that the price-cap regime, by limiting tariff adjustments, reduces the propensity to finance public projects compared to the cost-plus regime, reflecting differentiated incentives for economic actors.

Honkatukia et al. (2011) assess the marginal cost of public funds (MCPF) for the tax increase measures adopted by the Finnish government in the wake of the global financial crisis, estimating that this cost could reach up to 1.5 in the long term.

Subsequently, international comparative studies (Auriol & Warlters, 2012) made it possible to place MCPF estimates in a global context. The studies reviewed reveal significant variation in values depending on the tax instruments and regions. For non-African countries, MCPF estimates generally vary within moderate ranges. Taxes on labour typically have a cost of between 1.08 and 1.55, while taxes on capital are most often between 1.15 and 1.51. Consumption (sales) taxes show greater variability, with values ranging from 0.95 in some developing countries to over 2.30 in others, with import taxes sometimes reaching levels above 2.15.

This heterogeneity is confirmed across the African continent, where estimates from a computable general equilibrium model (Auriol & Warlters, 2012) reveal distinct cost structures. Taxes on domestic production have the lowest MCPF, with values generally ranging between 1.02 and 1.20. Taxes on imports have a moderate cost, most often between 1.00 and 1.23. On the other hand, taxes on production factors — capital and labour in the formal sector — generate the most significant distortions, with frequently high MCPFs ranging from 1.20 to 2.03 and 1.05 to 2.01, respectively. The total MCPF for African countries is mostly between 1.08 and 1.33, although some economies have particularly low total marginal costs, such as Botswana (1.05), or, conversely, higher costs, exceeding 1.25. These disparities highlight the influence of national economic structures, the degree of informality, and the specificities of tax systems on the marginal efficiency of public fund collection.

Based on this empirical review and existing estimates for African countries, our study makes four main contributions: first, it is, to our knowledge, the first attempt to estimate the marginal cost of public funds in Morocco using a computable general equilibrium model; second, it places Morocco in the context of developing countries in terms of the cost of public funds; third, unlike most of the studies reviewed above, which report a single point estimate per instrument under a single, implicit assumption about the use of tax revenue, it explicitly compares two revenue-treatment closures and shows that this assumption is quantitatively decisive; and fourth, it subjects the resulting estimates to a systematic, multi-dimensional sensitivity analysis (substitution elasticities, capital mobility, exchange-rate closure), a form of robustness reporting that remains uncommon in the single-country CGE-MCPF literature.

3. Methodology: Model and Data

3.1 Accounting Framework of the Model: Social Accounting Matrix (SAM)

The Social Accounting Matrix (SAM) is a consistent accounting framework, structured in the form of a square table, which organizes the interactions between national accounts (resources, uses, income) in order to ensure balance between expenditures (columns) and revenues (rows). Built from the TRU (Table of Resources and Uses) and TIEA (Table of Integrated Economic Accounts) tables, it forms the basis of the Computable General Equilibrium (CGE) models used to assess the impact of economic shocks.

The SAM-PEP-2019 was constructed in several stages (Raouf et al., 2021; El Baouchari & Raouf, 2024a): the national accounts were first aggregated into four economic agents and twenty sectors, then the Territorial Adjustment Account (TRO) was removed to avoid any bias in the consumption of residents and non-residents, before specific disaggregations were carried out, in particular:

- The breakdown of the labour factor into three skill levels (unskilled, highly skilled, moderately skilled) using a method combining Mincer's equation and Heckman's correction.
- The disaggregation of the Education-Health-Social Action account into three sub-accounts (non-market education, market education, health/social action).
- Three groups of households (poor, middle-income, rich) according to their expenditure, based on the National Survey on Household Consumption and Expenditure (ENCDM-2014, HCP).

The matrix also takes transfers (taxes, social security contributions, property income) into account and adjusts the data for pension funds. Its main sources are the TRU 2019, the SAM-HCP (2013 and 2015), the HCP employment survey (2015), and the ENCDM-2014. Figures 2, 3 and 4 illustrate certain statistics on income structure, consumption, savings, and transfers between households.

After disaggregating the matrix and introducing external data, we proceed to rebalance it, which was achieved by using the accumulation/savings account, assumed to be exogenous in the SAM.

Figure 3. Household savings

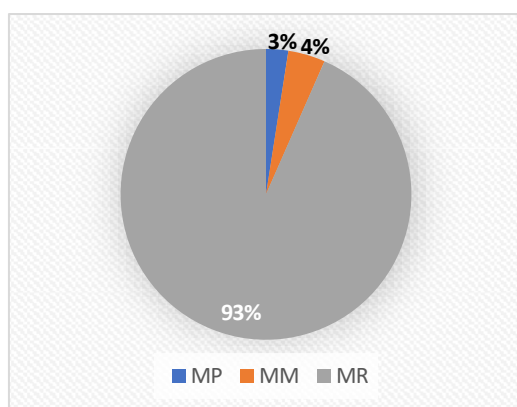
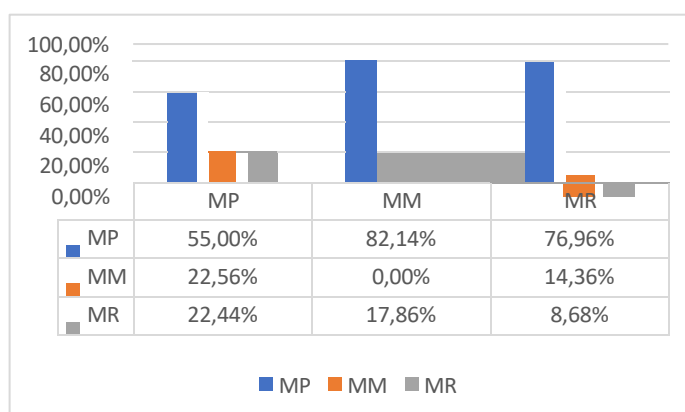
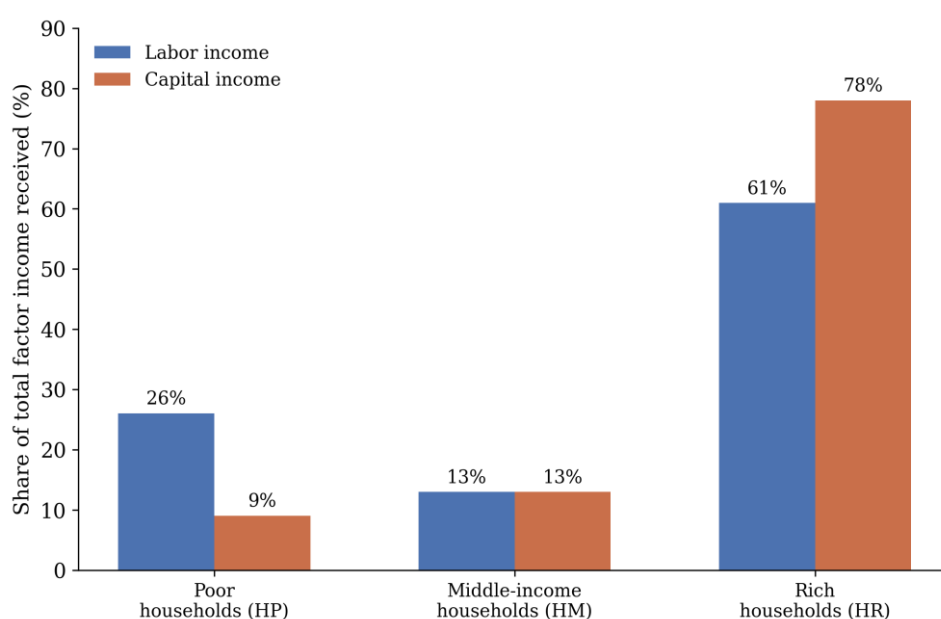


Figure 2. Household transfer



Source: Authors, based on data from the SAM-PEP-2019.

Figure 4. Reward for production factors among households.



Source: Authors, based on data from the SAM-PEP-2019.

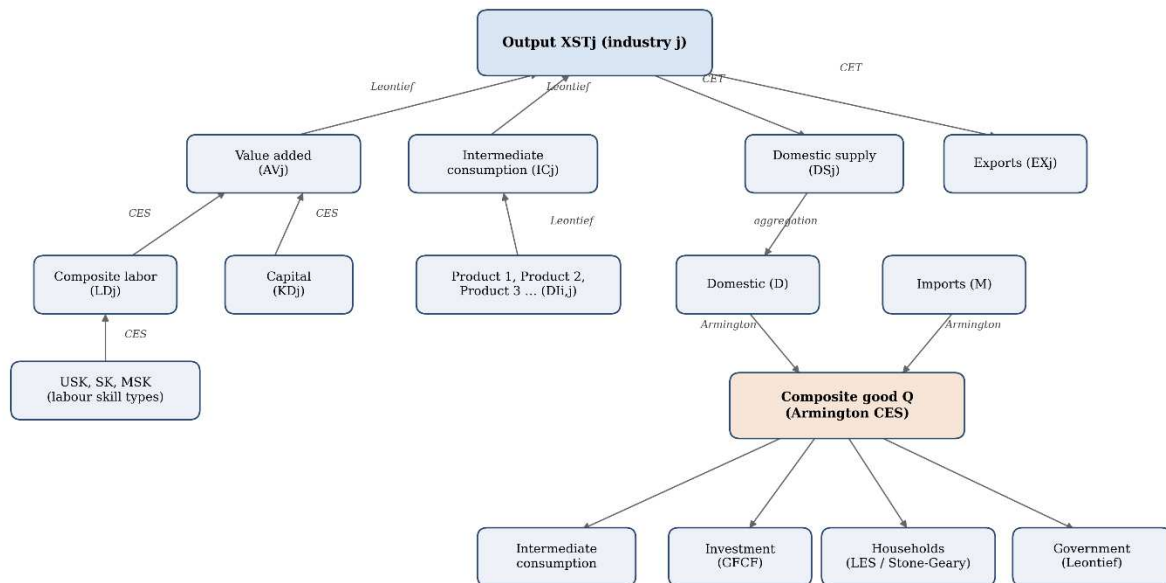
Figure 4 shows the distribution of labour and capital income across the three household groups. Capital income is markedly more concentrated among rich households (78% of total capital income) than labour income (61%), while poor households receive a comparatively larger share of labour income (26%) than of capital income (9%). This concentration of capital income among rich households is a structural feature of the SAM that helps explain, later in the paper, why taxes and transfers that operate through capital returns have more redistributive bite than those operating through labour income.

The final PEP1.1 2019 matrix has 81×81 accounts, structured into seven distinct categories. It includes four factors of production: unskilled labour (USK), skilled labour (SK), medium-skilled labour (MSK), and capital (Cap). The six economic agents included are poor households (HP), middle-income households (HM), rich households (HR), firms, government, and the rest of the world (ROW). Three types of taxes are included: income and corporate taxes (TD), indirect taxes and subsidies (TI), and customs duties (TM). The matrix also includes twenty-two branches of activity and twenty-two distinct products. Accumulation and savings accounts are divided between changes in inventories (VSTK) and gross fixed capital formation (INV). Finally, twenty-two specific accounts are dedicated to products intended for export.

3.2 The PEP 1.1 Model

To estimate the marginal cost of public funds in Morocco, we adopt a static computable general equilibrium model based on the standard model of the “Partnership for Economic Policy” (PEP-1-1). This model represents the economy in a neoclassical structure, through a set of blocks of equations describing the process of production and value-added formation, household behaviour, public demand, imports and exports, as well as the conditions of the raw materials and production factors markets. The supply and demand equations for firms and households are derived from optimization programs, where agents are assumed to be price takers in a competitive market. The model treats the rest of the world as a single region and considers the country as a small open economy. For more details, see Decaluwé et al. (2013). Figure 5 shows the general structure of the modified PEP-1.1 model.

Figure 5. General overview of the PEP 1.1 model.



Source: Authors, adapted from Decaluwé et al. (2013).

The determination of supply and demand by agents in the model is based on optimization programs with constraints specific to each category of agents. Markets operate in a situation of pure and perfect competition (PPC), where equilibrium is ensured by the adjustment of relative prices. The model considers the economy to be small and open, with no impact on world prices, and the exchange rate is defined as the numéraire.

In terms of production structure, there is perfect Leontief complementarity between intermediate consumption (IC) and value added (AV), and imperfect substitutability between the two factors of production (capital and labour), with technology represented by a constant elasticity of substitution (CES) function. International trade is modelled according to the Armington (1969) hypothesis, where the distribution of local supply between the domestic market and exports is determined by relative prices, reflecting optimization under constraints. On the demand side, consumers arbitrate between domestic and foreign products according to a CES function. Finally, households maximize a Stone-Geary type utility function, represented by a linear expenditure system (LES), under budget constraints.

In order to better meet the objectives of this study, we have made modifications to the basic PEP 1.1 model. First, to take into account unemployment in the Moroccan labour market, we introduced the wage curve from Blanchflower and Oswald (1995), given by equation (6), which assumes a negative relationship between the unemployment rate and the wage rate in each segment of the labour market.

$$\omega(l) = A(l) \cdot U(l)^{\sigma(l)} \cdot PIXCON \quad (6)$$

where: l is the labour category; $PIXCON$ is the consumer price index; $U(l)$ is the unemployment rate; $A(l)$ is a scale parameter; $\omega(l)$ is the wage rate; and $\sigma(l)$ is the elasticity of wages with respect to unemployment, assumed to be negative and equal to -0.1 , following Blanchflower and Oswald (1995).

To integrate the wage curve into the model, the labour market equilibrium was modified. Labour supply (LS) and wages (W) are therefore expressed as a function of the unemployment rate. For calibration, we used data published by the HCP. The unemployment rate in 2019 by qualification is presented in Table 1.

Table 1. Unemployment rate in 2019, by qualification

Labour category	Unemployment rate
Unskilled work (USK)	3.10%
Medium-skilled work (MSK)	12.40%
Skilled work (SK)	21.90%

Source: Haut-Commissariat au Plan (HCP), 2019.

In addition, we use Equivalent Variation (EV) as a measure of changes in household well-being. In our model, EV, associated with the Stone-Geary function (LES) that formalizes household consumption (Figure 5), is expressed by equation (7) (Mukoko & Blaise, 2016, pp. 21–23):

$$VE = \prod_{i=1}^I \left(\frac{P_i^0}{P_i^1} \right)^{\beta_i} \left(Y^1 - \sum_{i=1}^I \gamma_i P_i^1 \right) - \left(Y^0 - \sum_{i=1}^I \gamma_i P_i^0 \right) \quad (7)$$

with: P_i^0 the price of good i at the initial period (before the change); P_i^1 the price of good i at the final period (after the change); β_i the budget elasticity, or marginal importance of good i in the indirect utility function; Y^1 nominal income or consumer budget after the change (new situation); Y^0 nominal income or consumer budget before the change (initial situation); and γ_i a coefficient representing the minimum consumption, or incompressible quantity, of good i .

Economic welfare improves when the equivalent variation (EV) is positive ($EV > 0$). In other words, an EV greater than zero indicates that economic agents would be willing to pay to achieve the new situation resulting from the change in question, thus revealing a net gain in welfare.

In this study, this measure is also used to calculate the Marginal Cost of Public Funds (MCPF), according to the formula proposed by Chisari and Cicowiez (2010), given by equation (8):

$$MCPF = - \left[\frac{\sum_h VE_h - (TREV - TREV^0)}{TREV - TREV^0} \right] \quad (8)$$

where: MCPF is the Marginal Cost of Public Funds; VE_h is the equivalent variation for household class h , capturing the monetary change in welfare associated with a tax increase; $TREV$ is the counterfactual tax revenue after the tax increase; $TREV^0$ is the initial tax revenue before the tax increase; $(TREV - TREV^0)$ is the increase in tax revenue due to the change in fiscal policy, and forms the denominator of the equation; and the numerator, $\sum_h VE_h - (TREV - TREV^0)$, represents the net welfare loss due to the tax increase. The increase in tax revenue is subtracted from the sum of equivalent variations because it represents a transfer of resources from the private to the public sector, and not a welfare loss per se; the subtraction isolates the welfare loss associated specifically with the distortions created by taxation (the deadweight loss).

Dividing the numerator by the denominator gives the cost per monetary unit of additional revenue collected. An MCPF greater than 1 indicates that raising an additional monetary unit costs more than one monetary unit in terms of social welfare; an MCPF below 1 indicates that the instrument, financed this way, costs society less than a hypothetical non-distorting lump-sum tax would.

3.3 Model Closure

When closing the model, it is sufficient to identify the exogenous variables in order to achieve equality between the number of equations and the number of endogenous variables, while adapting to the model's assumptions. In our model, the exchange rate is assumed to be the model's numéraire. International prices are therefore assumed to be fixed, since the national economy is a small open economy and cannot, as a result, influence world prices. In terms of production factors, the supply of labour is assumed to be fixed, while capital is assumed to be mobile across industries, so that its sectoral allocation adjusts endogenously to the shock; the alternative of sector-specific (immobile) capital is tested separately in Section 5.3 (KMOB0). Walras' law, which ensures equilibrium in the n th market if $(n - 1)$ markets are in equilibrium, is represented by the equilibrium between supply and demand for good A00. A non-zero value for the corresponding residual variable would indicate an error in the model.

This baseline closure — fixed exchange rate, inter-sectorally mobile capital, and (in Experiment 1) additional tax revenue accruing to public savings — is the reference closure used to produce the headline results in Section 4.1. Sections 4.2 and 5 relax, respectively, the assumption governing the use of additional tax revenue and each of the model's main behavioural and closure parameters in turn, to test the sensitivity of the resulting MCPF estimates.

4. Simulations and Results

This section reports two complementary simulation experiments. In the first (Section 4.1), the additional tax revenue generated by each shock accrues to public savings, isolating the pure efficiency cost of taxation. In the second (Section 4.2), the same shocks are re-simulated with the additional revenue redistributed to households as a lump-sum transfer. Section 4.3 compares the two experiments directly.

4.1 Experiment 1: Tax Increases with Revenue Accruing to Public Savings

4.1.1 Simulations

We calculated the MCPF associated with five separate shocks to tax rates. In the first four experiments, we increased each tax rate by 1% from its initial level, taken separately. In the fifth experiment, we increased all four tax rates simultaneously, each by 1%. In every case, the additional tax revenue accrues to public savings (SG), which adjusts endogenously.

Table 2. Presentation of the simulations used in the study

N. Simulation	Shock to the model
Simulation 1	Increase in direct income tax and corporate tax by 1% of the current rate: $ttdf1.fx(f) = ttdf1O(f) \times 1.01$; $ttdh1.fx(h) = ttdh1O(h) \times 1.01$;
Simulation 2	Increase in the tax rate on industrial production by 1% of the existing rate: $ttip.fx(j) = ttipO(j) \times 1.01$;
Simulation 3	Increase in the rate of taxes and duties on imports of product i by 1% of the existing rate: $ttim.fx(i) = ttimO(i) \times 1.01$;
Simulation 4	A marginal increase in indirect tax: a 1% increase in the consumption tax rate: $ttic.fx(j) = tticO(j) \times 1.01$;
Simulation 5	Raise all four tax rates simultaneously by 1% of the existing rate (Simulations 1–4 combined).

Source: Authors.

4.1.2 Presentation of Results

For each of the five simulations, Table 3 presents a summary of the main results, including key indicators such as GDP, consumption, and the estimated cost per simulation.

Table 3. Consolidated simulation results — Experiment 1 (revenue accrues to public savings)

Aggregate	Initial value	Sim. 1 (Direct tax)	Sim. 2 (Production tax)	Sim. 3 (Import tax)	Sim. 4 (Consumption tax)	Sim. 5 (Combined)
MCPF	—	1.44	1.97	3.16	1.805	1.72
Real GDP at basic prices	1,019,658.00	1,019,656.94 (−0.0001%)	1,019,655.44 (−0.0003%)	1,019,657.54 (−0.00004%)	1,019,657.13 (−0.00008%)	1,019,653.03 (−0.0005%)
Real GDP at market prices	1,152,806.00	1,152,846.56 (+0.0035%)	1,152,480.68 (−0.028%)	1,152,723.32 (−0.007%)	1,152,788.79 (−0.001%)	1,152,421.38 (−0.033%)
Household welfare (HP)	8,955.10	8,952.36 (−0.03%)	8,941.62 (−0.15%)	8,953.39 (−0.02%)	8,953.55 (−0.017%)	8,935.66 (−0.22%)
Household welfare (HM)	5,692.03	5,690.19 (−0.03%)	5,683.42 (−0.15%)	5,691.04 (−0.017%)	5,691.05 (−0.017%)	5,679.63 (−0.22%)
Household welfare (HR)	20,399.59	20,378.21 (−0.1%)	20,367.15 (−0.16%)	20,396.51 (−0.015%)	20,396.04 (−0.017%)	20,339.18 (−0.30%)
Total welfare (Σ)	35,046.71	35,020.77 (−0.07%)	34,992.18 (−0.16%)	35,040.94 (−0.016%)	35,040.64 (−0.017%)	34,954.47 (−0.26%)
Public savings	44,271.00	45,178.42 (+2.05%)	44,991.29 (+1.63%)	44,296.36 (+0.057%)	44,370.29 (+0.224%)	46,021.75 (+3.95%)
Government consumption	221,811.96	221,812.50 (+0.0002%)	221,977.80 (+0.07%)	221,832.40 (+0.010%)	221,827.79 (+0.010%)	222,014.86 (+0.09%)
Household consumption (HP)	133,811.23	133,784.29 (−0.020%)	133,680.25 (−0.10%)	133,795.40 (−0.012%)	133,796.16 (−0.011%)	133,622.48 (−0.14%)
Household consumption (HM)	96,626.77	96,606.18 (−0.021%)	96,533.11 (−0.10%)	96,616.59 (−0.011%)	96,615.90 (−0.011%)	96,491.54 (−0.14%)
Household consumption (HR)	416,012.36	415,725.51 (−0.069%)	415,597.35 (−0.10%)	415,975.49 (−0.009%)	415,964.89 (−0.011%)	415,226.68 (−0.19%)
Total consumption (Σ)	646,450.36	646,115.97 (−0.052%)	645,810.72 (−0.10%)	646,387.48 (−0.010%)	646,376.96 (−0.011%)	645,340.71 (−0.17%)

Aggregate	Initial value	Sim. 1 (Direct tax)	Sim. 2 (Production tax)	Sim. 3 (Import tax)	Sim. 4 (Consumption tax)	Sim. 5 (Combined)
Household savings (HP)	2,313.20	2,312.73 (−0.020%)	—	—	2,312.93 (−0.011%)	2,309.73 (−0.15%)
Household savings (HM)	3,872.86	3,872.03 (−0.021%)	—	—	3,872.41 (−0.011%)	3,867.13 (−0.15%)
Household savings (HR)	87,565.94	87,504.78 (−0.069%)	—	—	87,555.87 (−0.011%)	87,395.22 (−0.19%)
Total household savings (Σ)	93,752.00	93,689.54 (−0.067%)	—	—	93,741.21 (−0.011%)	93,572.08 (−0.19%)
Household income (HP)	151,890.50	151,866.97 (−0.015%)	—	—	—	151,670.13 (−0.15%)
Household income (HM)	112,877.05	112,865.41 (−0.010%)	—	—	—	112,722.72 (−0.14%)
Household income (HR)	653,664.45	653,531.95 (−0.020%)	—	—	—	652,713.68 (−0.15%)
Total household income (Σ)	918,432.00	918,264.33 (−0.018%)	—	—	—	917,106.53 (−0.14%)
Imports	563,942.00	—	—	563,694.66 (−0.04%)	—	563,095.42 (−0.15%)
Corporate savings	182,536.00	—	182,313.64 (−0.12%)	—	—	—

Note: percentages in parentheses indicate the rate of change relative to the initial value; HP: poor households; HM: middle-income households; HR: rich households; Σ: total. Source: Authors, based on simulations performed using GAMS software.

4.1.3 Discussion of Results

In the first simulation, direct income and corporate tax rates are increased by 1%. The MCPF stands at 1.44, indicating that for every dirham collected, households suffer an additional welfare loss of 0.44 dirhams. GDP at market prices increases slightly by 0.0035%, while GDP at basic prices remains virtually stable, with a variation of −0.0001%. Household welfare declines, with a more pronounced decline for rich households (−0.1%) than for poor and middle-income households (−0.03% each). Public savings increased by 2.05%, suggesting that the government retained a significant portion of the additional revenue. These results show that direct taxes have a moderate welfare cost and a redistributive effect, affecting high-income groups more.

The second simulation focuses on a 1% increase in production tax in a specific industry, generating an MCPF of 1.97, which is higher than that of direct taxes. GDP at market prices declines marginally by 0.028%, while GDP at basic prices declines slightly by −0.0003%. Welfare losses are distributed relatively evenly among households: −0.15% for poor and middle-income households, and −0.16% for rich households. Public savings increase by 1.63%. This higher MCPF reflects greater economic distortions, even though the impact on households remains uniform (Karim, 2013; Chtouki & Raouf, 2022).

The third simulation increases taxes and import duties by 1%, resulting in an MCPF of 3.16, the highest among individual taxes. GDP at market prices decreases slightly by −0.007%, while GDP at basic prices remains almost unchanged (−0.00004%). Household welfare losses are small: −0.02% for poor households, −0.017% for middle-income households, and −0.015% for rich households. Imports fall by only −0.04%, signaling low elasticity to these tax changes. Public savings increase modestly by 0.057%. This high MCPF reflects a notable inefficiency of import taxes, linked to the inelasticity of imports, which increases the welfare cost relative to the revenue generated (World Bank, 2019).

In the fourth simulation, the consumption tax increases by 1%, with an MCPF of 1.805. GDP at market prices and at basic prices decrease slightly, by -0.001% and -0.00008% respectively. All households suffer an identical welfare loss of -0.017% . Public savings increase by 0.224% . These results, comparable to those of previous simulations, indicate a moderate impact, balancing revenue and welfare losses (Agueny et al., 2025; Ed-daoudi & Oubejja, 2024).

The fifth simulation combines a 1% increase in all four tax rates, resulting in an overall MCPF of 1.72. GDP declines by -0.033% at market prices and -0.0005% at basic prices. Welfare losses are more pronounced, particularly for rich households (-0.30%), followed by poor and middle-income households (-0.22% each). Public savings jump by 3.95% , reflecting the cumulative effect on revenues. This overall MCPF is a weighted average of fiscal instruments, influenced by the predominance of direct and consumption taxes in the Moroccan tax system.

A comparative analysis of MCPFs reveals disparities in the effectiveness of fiscal instruments. Direct taxes, with an MCPF of 1.44, appear to be the most effective in minimizing welfare losses per dirham collected. Consumption taxes (1.805) and production taxes (1.97) have moderate MCPFs, reflecting greater but still manageable distortions. Import taxes (3.16) are the least effective, due to the inelasticity of imports, which increases the welfare cost relative to the revenue generated. The overall MCPF of 1.72 reflects a tax system that relies on direct and consumption taxes, which offset the higher costs of taxes on production and imports.

These differences are due to several factors. First, broad-based taxes, such as income tax or VAT, spread the tax burden and limit distortions, resulting in a relatively low MCPF. Second, taxes on goods with low elasticity, such as essential imports (energy, food), generate a higher MCPF, as consumption remains virtually unchanged despite the tax, accentuating welfare losses. Finally, the size of the informal sector and dependence on imports, characteristics of developing economies, weigh heavily on this indicator. These findings are consistent with the analyses of Dahlby (2008) and Auriol and Warlters (2012), which show how the extent of tax distortions and informality influence the MCPF.

4.2 Experiment 2: Tax Increases with Lump-Sum Transfer of Revenue

4.2.1 Simulations

In Experiment 1, the additional tax revenue generated by each 1% rate increase was assumed to accrue entirely to public savings, isolating the pure efficiency cost of taxation from any assumption about how the government subsequently uses the proceeds. This closure, however, is only one of several plausible treatments of additional tax revenue. Experiment 2 re-simulates the same five 1% tax-rate shocks described in Table 2 under an alternative closure: the additional revenue, $\Delta R = \text{TREV} - \text{TREV}_0$, is redistributed to households as an aggregate lump-sum transfer (the model variable LUMPSUM), while government savings (SG) is held fixed at its baseline level instead of adjusting endogenously.

Because households now receive the transfer directly, their post-shock income — and hence their computed equivalent variation, $\text{EV}(h)$ — reflects both the direct cost of the tax increase and the direct income benefit of the transfer. Left uncorrected, this would conflate the efficiency cost of taxation with the redistributive benefit of public spending, and would understate the true marginal cost of raising the tax. Equation (8) already addresses this by construction: the numerator of the MCPF subtracts the change in tax revenue, ΔR (which, under this closure, is paid out to households almost in full as LUMPSUM), from the sum of household equivalent variations, $\sum h \text{EV}_h$, before dividing by ΔR . The additional transfer received by consumers is therefore netted out of the welfare measure before the MCPF is computed, because the MCPF is designed to measure the cost of taxation, not the benefit of

the public spending — here, a transfer — that the revenue finances. This keeps the indicator conceptually identical to Experiment 1 and directly comparable across the two experiments; only the closure describing what happens to ΔR differs.

Table 4. Closure rules compared across the two experiments

Closure element	Experiment 1	Experiment 2
Additional tax revenue (ΔR)	Accrues to public savings	Redistributed as a lump-sum transfer to households
Government savings (SG)	Endogenous (absorbs ΔR)	Fixed at baseline level
Lump-sum transfer (LUMPSUM)	Fixed at 0	Endogenous ($\approx \Delta R$)

Source: Authors, based on the model's closure specification (variables SG and LUMPSUM).

4.2.2 Presentation of Results

Table 5 reports the consolidated results of the five simulations under the lump-sum-transfer closure, following the same layout as Table 3. Unlike Table 3, household consumption, savings and income are reported for every instrument.

Table 5. Consolidated results — Experiment 2 (tax increase with lump-sum transfer)

Aggregate	Initial value	Direct tax	Production tax	Import tax	Consumption tax	Combined
MCPF	—	0.622	0.993	2.307	1.152	0.907
Real GDP at basic prices	1,019,658.00	1,019,659.15 (+0.0001%)	1,019,657.37 (−0.0001%)	1,019,657.61 (−0.0000%)	1,019,657.19 (−0.0001%)	1,019,657.31 (−0.0001%)
Real GDP at market prices	1,152,806.00	1,152,759.06 (−0.0041%)	1,152,779.22 (−0.0023%)	1,152,720.88 (−0.0074%)	1,152,410.79 (−0.034%)	1,152,251.53 (−0.048%)
Household welfare (HP)	8,955.09	8,968.81 (+0.153%)	8,955.35 (+0.0029%)	8,953.85 (−0.014%)	8,954.66 (−0.0049%)	8,967.36 (+0.137%)
Household welfare (HM)	5,692.03	5,699.88 (+0.138%)	5,692.11 (+0.0014%)	5,691.32 (−0.013%)	5,691.10 (−0.016%)	5,698.30 (+0.110%)
Household welfare (HR)	20,399.59	20,408.65 (+0.044%)	20,399.37 (−0.0011%)	20,397.37 (−0.011%)	20,391.30 (−0.041%)	20,397.88 (−0.0084%)
Total welfare (Σ)	35,046.71	35,077.34 (+0.087%)	35,046.83 (+0.0003%)	35,042.53 (−0.012%)	35,037.06 (−0.028%)	35,063.54 (+0.048%)
Public savings	44,271.00	44,271.00 (+0.000%)	44,271.00 (+0.000%)	44,271.00 (+0.000%)	44,271.00 (+0.000%)	44,271.00 (+0.000%)
Government consumption	222,967.00	222,967.79 (+0.0004%)	222,982.89 (+0.0071%)	222,987.66 (+0.0093%)	223,133.21 (+0.075%)	223,170.57 (+0.091%)
Household consumption (HP)	144,212.01	144,359.41 (+0.102%)	144,214.48 (+0.0017%)	144,200.60 (−0.0079%)	144,198.44 (−0.0094%)	144,336.58 (+0.086%)
Household consumption (HM)	100,756.36	100,849.05 (+0.092%)	100,757.22 (+0.0009%)	100,748.63 (−0.0077%)	100,742.25 (−0.014%)	100,827.87 (+0.071%)
Household consumption (HR)	415,683.63	415,806.53 (+0.030%)	415,681.05 (−0.0006%)	415,650.83 (−0.0079%)	415,582.99 (−0.024%)	415,669.94 (−0.0033%)
Total consumption (Σ)	660,652.00	661,014.99 (+0.055%)	660,652.75 (+0.0001%)	660,600.07 (−0.0079%)	660,523.68 (−0.019%)	660,834.39 (+0.028%)
Household savings (HP)	2,313.20	2,315.57 (+0.102%)	2,313.24 (+0.0017%)	2,313.02 (−0.0079%)	2,312.98 (−0.0094%)	2,315.20 (+0.086%)
Household savings (HM)	3,872.86	3,876.42 (+0.092%)	3,872.89 (+0.0009%)	3,872.56 (−0.0077%)	3,872.32 (−0.014%)	3,875.61 (+0.071%)
Household savings (HR)	87,565.94	87,591.83 (+0.030%)	87,565.39 (−0.0006%)	87,559.03 (−0.0079%)	87,544.74 (−0.024%)	87,563.05 (−0.0033%)
Total household savings (Σ)	93,752.00	93,783.82 (+0.034%)	93,751.53 (−0.0005%)	93,744.61 (−0.0079%)	93,730.04 (−0.023%)	93,753.86 (+0.0020%)

Aggregate	Initial value	Direct tax	Production tax	Import tax	Consumption tax	Combined
Household income (HP)	151,890.50	152,053.14 (+0.107%)	151,893.10 (+0.0017%)	151,878.48 (−0.0079%)	151,876.21 (−0.0094%)	152,029.09 (+0.091%)
Household income (HM)	112,877.05	112,993.59 (+0.103%)	112,878.01 (+0.0009%)	112,868.39 (−0.0077%)	112,861.24 (−0.014%)	112,969.87 (+0.082%)
Household income (HR)	653,664.45	654,182.08 (+0.079%)	653,660.40 (−0.0006%)	653,612.88 (−0.0079%)	653,506.20 (−0.024%)	653,967.18 (+0.046%)
Total household income (Σ)	918,432.00	919,228.80 (+0.087%)	918,431.51 (−0.0001%)	918,359.75 (−0.0079%)	918,243.65 (−0.021%)	918,966.13 (+0.058%)
Imports	563,942.00	563,781.28 (−0.029%)	563,914.60 (−0.0049%)	563,686.05 (−0.045%)	562,944.37 (−0.177%)	562,500.83 (−0.256%)
Corporate savings	182,536.00	182,152.77 (−0.210%)	182,512.62 (−0.013%)	182,514.00 (−0.012%)	182,325.11 (−0.116%)	181,897.20 (−0.350%)

Note: percentages in parentheses indicate the rate of change relative to the initial value. HP: poor households; HM: middle-income households; HR: rich households; Σ: total. Source: Authors, based on simulations performed using GAMS software.

4.2.3 Discussion of Results

In the first simulation, direct income and corporate tax rates are increased by 1% and the proceeds are transferred back to households. The MCPF falls to 0.622, meaning each dirham collected now costs society only 0.62 dirhams — below the cost of a non-distorting lump-sum tax, whose MCPF would equal exactly 1. Household welfare rises for every group (EV of 147.2 for poor households, 92.6 for middle-income households, and 123.1 for rich households), and the increase is proportionally largest for poor households, whose welfare index rises by 0.153% against 0.044% for rich households — consistent with a transfer that is not scaled to pre-existing income and therefore represents a proportionally larger income gain for lower-income households. Real GDP at basic prices is essentially unchanged (+0.0001%), while real GDP at market prices falls slightly (−0.0041%), a modest reversal of the small increase recorded under the savings closure in Experiment 1 (+0.0035%); this follows from the composition of aggregate demand rather than from a change in productive capacity, since real gross fixed capital formation falls by 0.18% once household savings — rather than public savings — becomes the main channel absorbing the shock, leaving less of the additional revenue available to finance investment.

The second simulation raises the production tax by 1%. The MCPF falls to 0.993, essentially the break-even point, from 1.97 under the savings closure. Household-level effects are small and mixed in sign: poor and middle-income households register tiny welfare gains (EV of 2.8 and 1.0), while rich households register a small loss (EV of −3.0), so that the sum of equivalent variations before netting out the transfer is only marginally positive. Real GDP at basic prices is virtually unchanged (−0.0001%) and real GDP at market prices declines only slightly (−0.0023%). Because the tax falls on production rather than directly on household income, the lump-sum transfer here mainly offsets the indirect, price-mediated cost of the tax rather than adding a large direct income boost, which explains why the swing in the MCPF, while still substantial in relative terms (−49.6% versus Experiment 1), is smaller in absolute terms than for the direct tax.

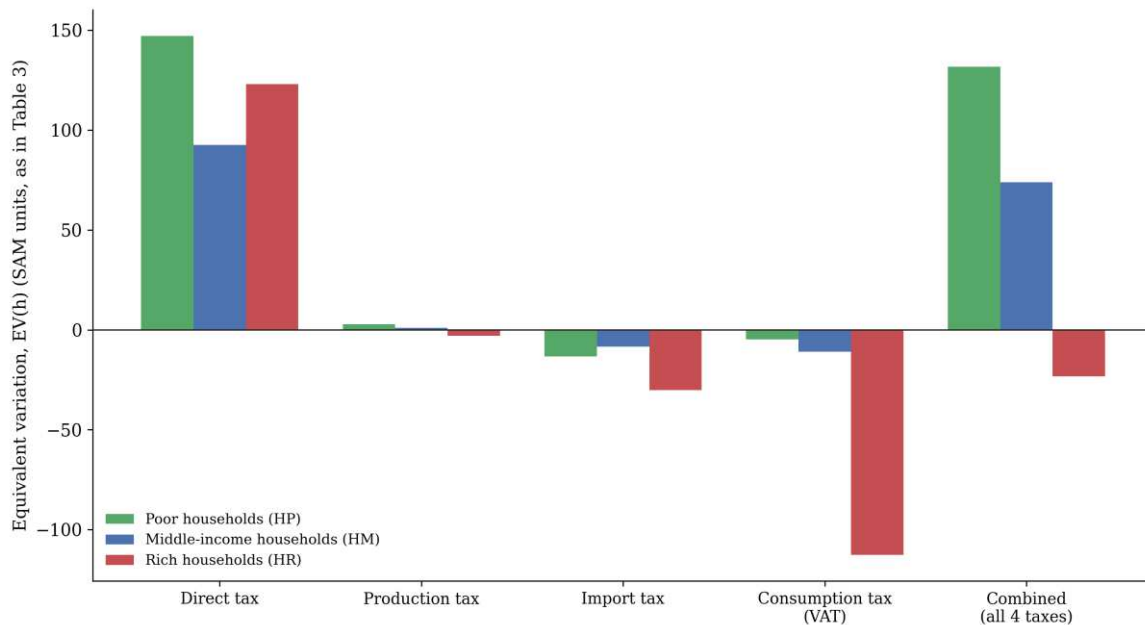
The third simulation increases import duties by 1%. The MCPF falls from 3.16 to 2.307, a reduction of 27.0%, but import tax remains by a wide margin the most expensive instrument even under the transfer closure. All three household groups experience a welfare loss (EV of −13.3, −8.4 and −30.2 for HP, HM and HR respectively), and imports fall slightly further than under Experiment 1 (−0.045% against −0.044%). This instrument's comparatively small response to the change in revenue treatment is consistent with a mechanism identified in the robustness analysis (Section 5): the import tax's cost is

driven mainly by the inelasticity of import demand and the trade-account channel, which the revenue-recycling closure does little to address, unlike the direct-income channel that dominates for the direct and production taxes.

The fourth simulation raises the consumption tax by 1%. The MCPF falls from 1.805 to 1.152, a reduction of 36.2%, but — like the import tax — remains above 1, so this instrument continues to impose a net welfare cost even once its revenue is returned to households. The welfare loss is concentrated on rich households (EV of -112.6 , against -4.7 for poor and -10.9 for middle-income households), reflecting the fact that rich households account for the largest share of aggregate consumption expenditure (415,683.6 out of 660,652.0 at baseline, or 63%) and therefore bear the largest share of the tax base, even though the transfer is redistributed without regard to income.

The fifth simulation combines all four tax increases. The MCPF falls from 1.72 to 0.907, moving from clearly cost-positive to marginally below the lump-sum-tax benchmark. The distributional pattern mirrors the direct tax result: poor and middle-income households gain (EV of 131.7 and 74.0), while rich households lose (EV of -23.2), so that the combined package becomes mildly progressive once revenue recycling is taken into account, in contrast to Experiment 1, where all three household groups lost welfare from the combined shock. Real GDP at market prices falls by 0.048%, the largest decline recorded in Experiment 2, consistent with the corresponding 0.80% fall in real investment once four revenue streams are simultaneously redirected from public and corporate savings towards household consumption.

Figure 6. Household-level equivalent variation, $EV(h)$, by tax instrument under the lump-sum-transfer closure (Experiment 2).



Source: Authors' calculations from the GAMS simulation outputs.

A comparative reading of Experiment 2 confirms the ranking established in Experiment 1 — direct tax cheapest, followed by production tax and the combined shock, then consumption tax, with import tax the most expensive — and shows that this ranking is unaffected by the revenue-recycling closure: only the level of the MCPF changes, not the order of the four elementary instruments. The results also reveal a threshold effect not visible in Experiment 1: two instruments — the direct tax and, marginally, the production tax — cross the MCPF = 1 benchmark once their revenue is transferred back to households, meaning that these two taxes, financed this way, cost society less than a hypothetical non-distorting

lump-sum tax would. Import and consumption taxes, by contrast, remain clearly cost-positive under either closure, indicating that their distortions are large enough that redistributing the revenue narrows, but does not eliminate, their net welfare cost.

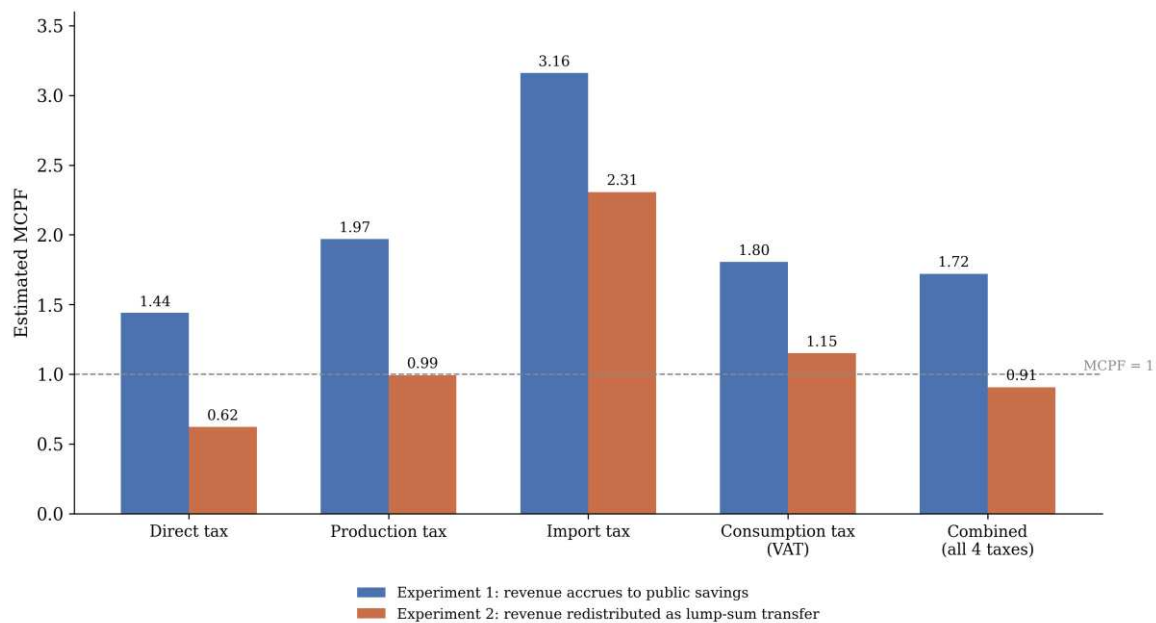
4.3 Comparison of the Two Experiments: The Effect of Revenue Recycling

Table 6. Estimated MCPF under the two revenue-treatment closures

Tax instrument	MCPF — Exp. 1 (savings)	MCPF — Exp. 2 (transfer)	Δ (points)	Δ (%)
Direct tax	1.440	0.622	−0.818	−56.8%
Production tax	1.970	0.993	−0.977	−49.6%
Import tax	3.160	2.307	−0.853	−27.0%
Consumption tax (VAT)	1.805	1.152	−0.653	−36.2%
Combined (all 4 taxes)	1.720	0.907	−0.813	−47.3%

Source: Authors' calculations. Experiment 1 values from Table 3; Experiment 2 values from Table 5.

Figure 7. Estimated MCPF by tax instrument under the two revenue-treatment closures.



Source: Authors' calculations.

Table 6 and Figure 7 make explicit what the sensitivity analysis in Section 5 identifies as the single most consequential assumption tested anywhere in this study: how the government uses the additional revenue matters as much as — and for two of the four instruments, more than — which tax is raised in the first place. Redistributing the revenue as a lump-sum transfer lowers the MCPF of every instrument by between 27.0% (import tax) and 56.8% (direct tax), and it is enough to move both the direct tax and the production tax below the MCPF = 1 threshold. This pattern is consistent with the broader CGE literature on revenue recycling, which finds that the channel through which additional public revenue is returned to the economy can be as consequential for aggregate welfare outcomes as the choice of the tax instrument that raised the revenue in the first place (Zhu et al., 2018): a transfer restores purchasing power directly to household budgets, disproportionately benefiting the poor and middle-income households whose marginal propensity to consume out of additional income is highest, whereas a public-savings closure leaves the revenue outside the household sector entirely, so that none of it offsets the initial welfare loss captured by the equivalent-variation measure.

The size of the effect, however, is not uniform across instruments, and the pattern is informative in its own right. The reduction is largest, in percentage-point terms, for the direct tax (-0.818) and the combined shock (-0.813), and smallest for the consumption tax (-0.653) and, in relative terms, the import tax (-27.0% , against -49 – 57% for the other three). Direct and production taxes fall most because their tax base is household and corporate income, so the lump-sum transfer offsets the distortion through the same channel — disposable income — that the tax itself operates through, producing a close to one-for-one cancellation at the margin. Import and consumption taxes, in contrast, distort relative prices in product markets (the price of imports relative to domestic goods, and the price of consumption relative to saving) rather than directly reducing household income; a lump-sum transfer restores income but does not correct the relative-price distortion that drives the excess burden of these two instruments, which is why their MCPF, although substantially reduced, remains above 1 under both closures.

Two points of interpretation should be attached to the Experiment-2 estimates. First, when the additional revenue is returned to households in full, no public expenditure is financed, so the quantity measured is the net welfare effect of a tax-and-transfer package rather than the cost of mobilizing funds for a public project. The Experiment-2 figures are therefore best read as the efficiency cost of each instrument net of the distributional gain from redistributing its proceeds, and only the Experiment-1 estimates should be used as the value of λ to be applied in a cost-benefit test of public spending. Second, the finding that this net cost can fall below unity is not a mechanical consequence of the transfer: it obtains only for instruments whose distortion operates through the same disposable-income channel that the transfer restores, which is why the import and consumption taxes remain above 1 even when their entire yield is rebated to households.

5. Robustness and Sensitivity Analysis of the MCPF Estimates

5.1 Rationale and Design of the Robustness Analysis

Point estimates produced by computable general equilibrium models are conditional on a specific set of behavioural parameters and closure rules chosen by the modeller, and this conditionality is not a minor technical caveat. Schürenberg-Frosch (2015) re-simulated fifty published CGE policy experiments a thousand times each under randomized Armington elasticities and found that the choice of elasticity altered the results — in some cases qualitatively — in more than half of the models tested. More recently, Oliveira and Cordeiro (2023) show for Brazil that revising the Armington elasticities used in a standard trade-and-tax CGE model materially changes the estimated welfare impact of a tariff reform. The economic-incidence literature has, independently, long established that the assumed degree of capital mobility is itself a first-order determinant of who ultimately bears the burden of a tax (Fullerton & Metcalf, 2002), and the treatment of the revenue generated by a tax reform — whether it accrues to public savings, finances a lump-sum transfer, or reduces another distortionary tax — shifts the magnitude, and sometimes the sign, of the resulting welfare and output effects (Zhu et al., 2018). Because the headline MCPF estimates in Table 3 rest on a single central specification of these parameters, this section tests how far they can be pushed by defensible alternative assumptions, and — more importantly — whether the paper’s qualitative conclusions and policy ranking survive that scrutiny.

For each of the five Experiment-1 shocks (direct tax, production tax, import tax, consumption tax, and the combined shock), eleven additional simulations were run — ten for the combined shock, for which the lump-sum-transfer variant was not re-run — each varying one parameter or closure rule at a time relative to that instrument’s own internal reference case. Together with the five reference runs, this gives the 59 simulations reported in Appendix C:

- Substitution and trade elasticities. The Armington import-substitution elasticity (σ_M), the capital–labour substitution elasticity (σ_{VA}), the CET export-domestic transformation elasticity (σ_{XT}), and the wage-curve elasticity (σ_{wage}) were each multiplied by 0.5 (“low”) and by 1.5 (“high”), one at a time, holding all other parameters at their central calibrated value.
- Capital-market closure (KMOB0). Capital is treated as sector-specific (immobile across the model’s twenty-two activities) instead of the baseline assumption of full inter-sectoral mobility.
- Exchange-rate / current-account closure (CABFLEX). The current account balance is fixed and the nominal exchange rate is allowed to float, instead of the baseline closure in which the exchange rate is the model’s numéraire and the current account absorbs the adjustment.
- Revenue-recycling closure. Additional government revenue is redistributed to households as a lump-sum transfer instead of accruing to public savings, for the direct, production, import and consumption tax experiments (this alternative was not run for the combined-shock experiment; the corresponding Experiment-2 value from Section 4.2, where available, is used instead).

In the absence of Morocco-specific econometric estimates of these elasticities for each of the model’s twenty-two sectors, the $\times 0.5/\times 1.5$ bracket follows standard applied-CGE practice of symmetrically perturbing the calibrated central values to span plausible short-run (lower) and long-run (higher) substitution responses, rather than constituting a re-estimation of Moroccan elasticities. A natural extension of this work, noted in the limitations below, would be to replace this generic bracket with econometrically estimated elasticities for Morocco as these become available. A related limitation concerns the central values themselves: the Armington elasticity is calibrated at a single value ($\sigma_M = 2.0$) for all twenty-two commodities, whereas import demand for primary commodities, manufactures and services is unlikely to respond identically. Since Section 5.2 identifies σ_M as the parameter to which the import-tax estimate is by far the most sensitive, sector-specific Armington values are the highest-priority refinement to this analysis.

Table 7. Parameters and closures tested in the robustness analysis

Parameter / closure	Baseline (central)	Alternative 1	Alternative 2
Armington elasticity (σ_M)	Central calibrated value	$\times 0.5$ (low)	$\times 1.5$ (high)
Capital–labour elasticity (σ_{VA})	Central calibrated value	$\times 0.5$ (low)	$\times 1.5$ (high)
CET elasticity (σ_{XT})	Central calibrated value	$\times 0.5$ (low)	$\times 1.5$ (high)
Wage-curve elasticity (σ_{wage})	Central calibrated value (-0.1)	$\times 0.5$ (low)	$\times 1.5$ (high)
Capital mobility	Mobile across sectors	—	Sector-specific (KMOB0)
Exchange-rate / CAB closure	Fixed exchange rate (numéraire)	—	Flexible exchange rate / fixed CAB (CABFLEX)
Revenue treatment	Accrues to public savings	—	Lump-sum transfer to households

Source: Authors, based on the GAMS scenario files underlying Table 3.

5.2 Sensitivity to Substitution and Trade Elasticities

Table 8. Sensitivity of the MCPF to substitution and trade elasticities, by tax instrument

Tax instrument	Elasticity tested	Low value MCPF (Δ)	Central MCPF	High value MCPF (Δ)
Direct tax	Armington elasticity (σ_M)	1.35 (+0.0%)	1.35	1.35 (+0.0%)
Direct tax	Capital–labour elasticity (σ_{VA})	1.34 (−0.7%)	1.35	1.35 (+0.0%)
Direct tax	CET elasticity (σ_{XT})	1.34 (−0.7%)	1.35	1.35 (+0.0%)
Direct tax	Wage-curve elasticity (σ_{wage})	1.35 (+0.0%)	1.35	1.35 (+0.0%)
Production tax	Armington elasticity (σ_M)	1.66 (+0.0%)	1.66	1.66 (+0.0%)

Tax instrument	Elasticity tested	Low value MCPF (Δ)	Central MCPF	High value MCPF (Δ)
Production tax	Capital-labour elasticity (σ_{VA})	1.64 (−1.2%)	1.66	1.67 (+0.6%)
Production tax	CET elasticity (σ_{XT})	1.64 (−1.2%)	1.66	1.67 (+0.6%)
Production tax	Wage-curve elasticity (σ_{wage})	1.66 (+0.0%)	1.66	1.66 (+0.0%)
Combined (all 4 taxes)	Armington elasticity (σ_M)	1.57 (−0.6%)	1.58	1.61 (+1.9%)
Combined (all 4 taxes)	Capital-labour elasticity (σ_{VA})	1.57 (−0.6%)	1.58	1.59 (+0.6%)
Combined (all 4 taxes)	CET elasticity (σ_{XT})	1.56 (−1.3%)	1.58	1.60 (+1.3%)
Combined (all 4 taxes)	Wage-curve elasticity (σ_{wage})	1.58 (+0.0%)	1.58	1.58 (+0.0%)
Consumption tax (VAT)	Armington elasticity (σ_M)	1.76 (−1.7%)	1.79	1.83 (+2.2%)
Consumption tax (VAT)	Capital-labour elasticity (σ_{VA})	1.77 (−1.1%)	1.79	1.80 (+0.6%)
Consumption tax (VAT)	CET elasticity (σ_{XT})	1.73 (−3.4%)	1.79	1.83 (+2.2%)
Consumption tax (VAT)	Wage-curve elasticity (σ_{wage})	1.79 (+0.0%)	1.79	1.79 (+0.0%)
Import tax	Armington elasticity (σ_M)	2.26 (−18.4%)	2.77	4.21 (+52.0%)
Import tax	Capital-labour elasticity (σ_{VA})	2.75 (−0.7%)	2.77	2.78 (+0.4%)
Import tax	CET elasticity (σ_{XT})	2.67 (−3.6%)	2.77	2.83 (+2.2%)
Import tax	Wage-curve elasticity (σ_{wage})	2.77 (+0.0%)	2.77	2.77 (+0.0%)

Note: Δ is the percentage deviation of the alternative-elasticity MCPF from the instrument's own central-case MCPF.
Source: Authors' calculations from the GAMS simulation outputs.

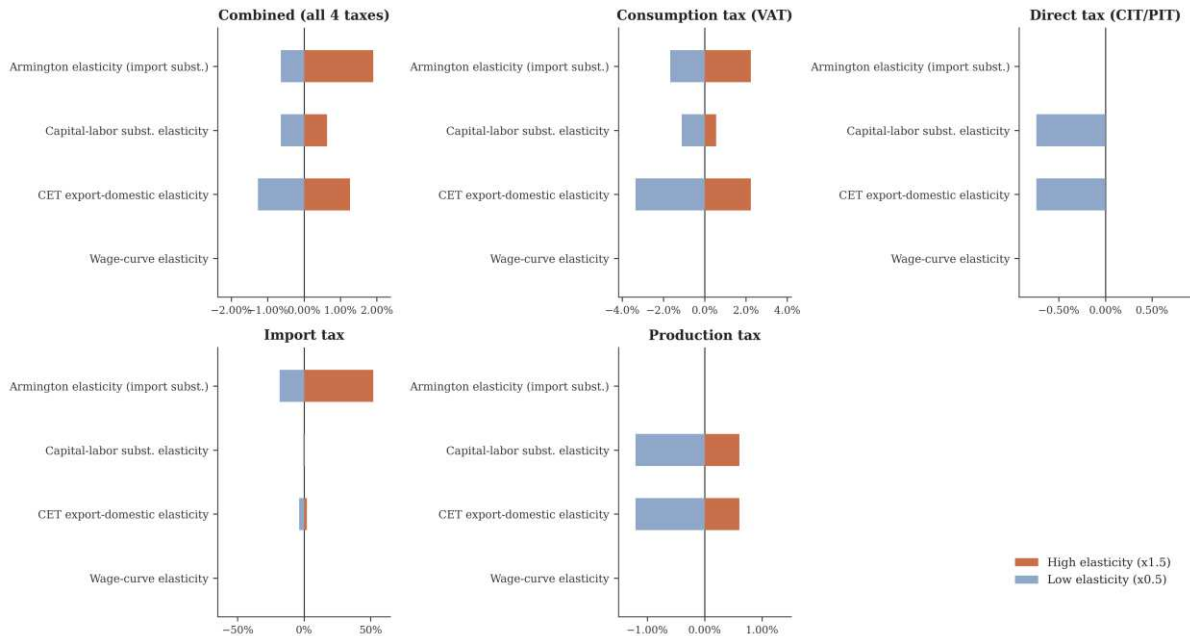


Figure 8. Sensitivity of the estimated MCPF to substitution and trade elasticities (% deviation from the central-case MCPF, by tax instrument).

Source: Authors' calculations.

Three patterns stand out. First, the wage-curve elasticity has a negligible effect on every instrument's MCPF (a deviation below the two-decimal reporting precision of the simulation outputs in every case). This is consistent with the mechanism through which σ_{wage} operates in the model: it governs how a labour-market shock is split between the wage rate and the unemployment rate (equation 6), which mainly redistributes the incidence of a shock within the labour market rather than altering the aggregate

tax wedge that the MCPF prices. Second, the capital–labour and CET elasticities have small, single-digit effects throughout (generally within $\pm 3.5\%$), somewhat larger for the consumption tax’s CET elasticity ($-3.4\%/+2.2\%$) and for the production tax ($\pm 1.2\%$), consistent with these two instruments operating mainly through the value-added and output side of the model rather than through the trade margin.

Third, and most importantly, the Armington (import-substitution) elasticity is by far the most influential parameter tested, and its effect is heavily concentrated on the import tax itself: raising σ_M by 50% increases the import tax’s MCPF by 52.0% (from 2.77 to 4.21), while halving it lowers the MCPF by 18.4% (to 2.26). The mechanism follows directly from the structure of the Armington nest: the baseline calibration assumes imported and domestically produced varieties are relatively imperfect substitutes, so a tax-induced rise in the relative price of imports is absorbed partly through a fall in import volumes and partly through continued (now more expensive) import consumption. A higher σ_M makes it easier for consumers to substitute towards the untaxed domestic variety, which erodes the tax base — and hence the revenue gain in the denominator of equation (8) — proportionally faster than it reduces the associated welfare loss in the numerator, since the imperfect (CES, not perfect) substitutability assumed by the Armington structure means switching consumers do not fully recover the lost consumer surplus. This is precisely the kind of elasticity-driven, trade-related sensitivity flagged as a general source of disagreement across CGE studies by Schürenberg-Frosch (2015): our finding that the single most policy-relevant instrument in this study — already the most expensive at the central calibration — is also the least robust to elasticity uncertainty echoes that broader meta-evidence and warrants particular caution when the import-tax result is used, on its own, to motivate policy.

5.3 Sensitivity to Model Closure and to the Treatment of Additional Tax Revenue

Table 9. Sensitivity of the MCPF to model closure and revenue treatment, by tax instrument

Tax instrument	Alternative closure / scenario	MCPF	Δ vs. central (pts)	Δ vs. central (%)
Direct tax	Flexible exchange rate (CABFLEX)	1.36	+0.01	+0.7%
Direct tax	Sector-specific capital (KMOB0)	1.25	−0.10	−7.4%
Direct tax	Lump-sum transfer to households	0.62	−0.73	−54.1%
Production tax	Flexible exchange rate (CABFLEX)	1.67	+0.01	+0.6%
Production tax	Sector-specific capital (KMOB0)	1.49	−0.17	−10.2%
Production tax	Lump-sum transfer to households	0.99	−0.67	−40.4%
Combined (all 4 taxes)	Flexible exchange rate (CABFLEX)	1.46	−0.12	−7.6%
Combined (all 4 taxes)	Sector-specific capital (KMOB0)	1.53	−0.05	−3.2%
Combined (all 4 taxes)	Lump-sum transfer to households	0.91*	−0.67*	−39.0%*
Consumption tax (VAT)	Flexible exchange rate (CABFLEX)	1.54	−0.25	−14.0%
Consumption tax (VAT)	Sector-specific capital (KMOB0)	1.77	−0.02	−1.1%
Consumption tax (VAT)	Lump-sum transfer to households	1.15	−0.64	−35.8%
Import tax	Flexible exchange rate (CABFLEX)	1.42	−1.35	−48.7%
Import tax	Sector-specific capital (KMOB0)	4.00	+1.23	+44.4%
Import tax	Lump-sum transfer to households	2.31	−0.46	−16.6%

Note: central case = internal reference (no-transfer) closure for each instrument. * The Combined/transfer row uses the Experiment-2 value from Section 4.2 (Table 5), since this scenario was not part of the 59-run stress-test battery; the Δ is computed against the same instrument’s internal reference case (1.58) for comparability with the other rows. Source: Authors’ calculations from the GAMS simulation outputs.

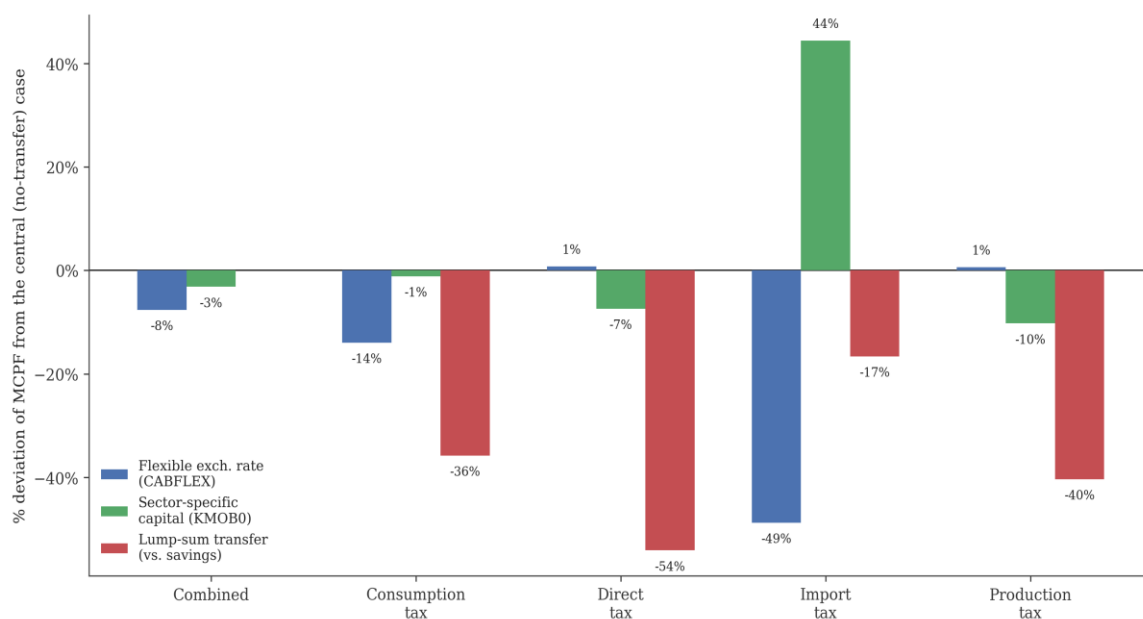


Figure 9. Sensitivity of the estimated MCPF to model closure and to the treatment of additional tax revenue, by tax instrument.

Source: Authors' calculations.

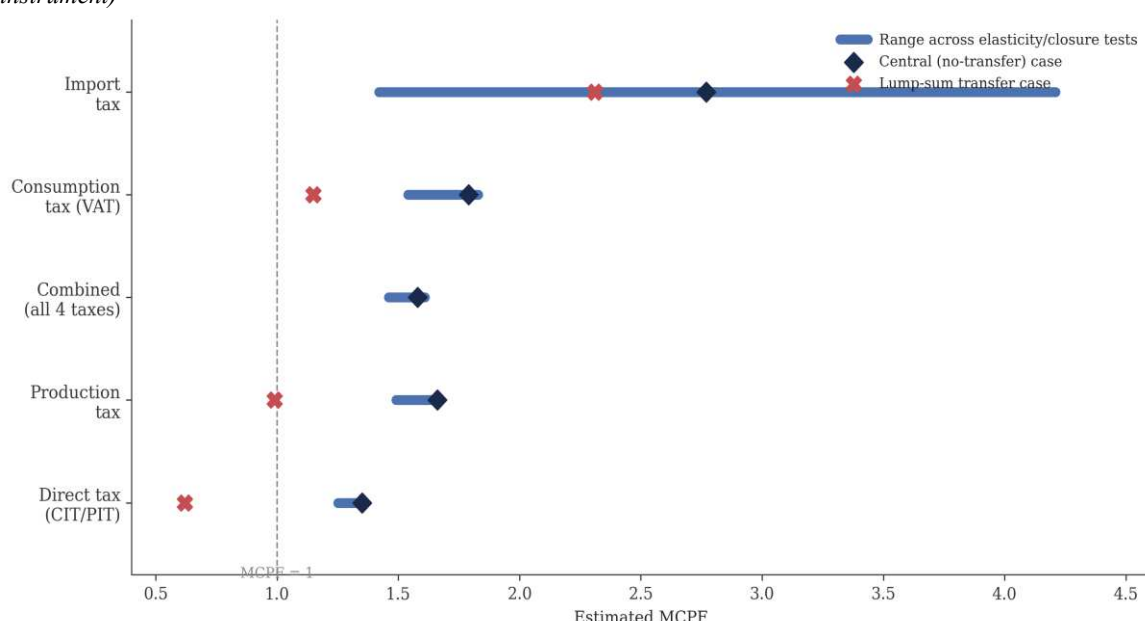
Closure sensitivity. The exchange-rate/current-account closure (CABFLEX) has a very uneven effect across instruments: it lowers the import tax's MCPF by 48.7% (2.77 to 1.42), the consumption tax's by 14.0%, and the combined shock's by 7.6%, while leaving the direct and production tax essentially unchanged (within $\pm 1\%$). Under the baseline fixed-exchange-rate closure, any deterioration of the trade balance triggered by the tax-induced fall in import volumes must be absorbed elsewhere in the economy; under CABFLEX, the nominal exchange rate is instead allowed to depreciate to keep the current account fixed, which mechanically lowers the domestic-currency price of exports and dampens the relative-price wedge that the import tax introduces on the traded-goods margin. Because import and (to a lesser extent) consumption taxes operate most directly on traded-goods prices, they are the instruments most exposed to this closure choice, while direct and production taxes — whose distortions concentrate on domestic factor and output markets — are structurally insulated from it.

The capital-mobility closure (KMOB0) produces the mirror-image result for the import tax: restricting capital to remain sector-specific raises its MCPF by 44.4% (2.77 to 4.00), the single largest deviation recorded in the elasticity/closure stress-test after the high-Armington-elasticity case. This is consistent with the standard tax-incidence result that when capital can reallocate away from an activity whose after-tax return has fallen, the burden of the tax is spread more thinly across the whole capital stock; when that adjustment margin is shut down, the loss is instead concentrated on the capital employed in the directly affected, import-competing activities (Fullerton & Metcalf, 2002). Interestingly, the direct and production taxes move in the opposite direction under KMOB0, with their MCPF falling by 7.4% and 10.2% respectively. A plausible general-equilibrium mechanism for this result is that, for taxes whose distortion falls mainly on household or corporate income rather than on a specific factor market, restricting capital mobility removes a secondary channel of reallocation-induced cost — the cross-sector Harberger-triangle effect that would otherwise compound with the direct tax's own distortion — without introducing a comparable new cost, since these instruments do not operate through the trade account. This counter-intuitive result is not central to the paper's conclusions and warrants further investigation.

Revenue treatment. Of every parameter and closure tested, the assumption governing what happens to the additional revenue collected has by far the largest effect on the estimated MCPF, and it is the only lever capable of changing the sign of the welfare judgement, as Section 4.3 already showed by direct comparison of the two full experiments. Recycling the additional revenue as a lump-sum transfer to households instead of allowing it to accrue to public savings lowers the direct tax's MCPF by 54.1% within the stress-test battery (and by 56.8% in the full Experiment-2 re-run of Section 4.2), crossing the $\text{MCPF} = 1$ threshold in both cases. The production and combined-shock instruments follow the same pattern, and the import tax's revenue-treatment sensitivity (-16.6% to -27.0% , depending on which run is used) is, again, the smallest of the four — consistent with the discussion in Section 4.3.

5.4 Robustness of the Policy Ranking Across Instruments

Figure 10. Robustness of the MCPF ranking across instruments (range across all elasticity and closure stress-tests, per instrument)



Source: Authors' calculations.

Figure 10 summarizes the full stress-test battery by plotting, for each instrument, the range of MCPF values obtained across all elasticity and capital-mobility/exchange-rate variants (blue bar), the internal central-case value (diamond marker), and the lump-sum-transfer value where tested (cross marker). Two conclusions follow. First, the ranking established in Table 3 — direct tax cheapest, followed by production tax and the combined shock, then consumption tax, with import tax the most expensive — is robust to elasticity perturbations and to the capital-mobility closure for every pair of instruments except production tax and the combined shock, whose ranges overlap slightly (1.49–1.67 and 1.46–1.61 respectively) and could in principle swap order under an unfavourable combination of assumptions.

Second, and more consequentially, the ranking is not robust to the exchange-rate closure. Under CABFLEX, the import tax's MCPF (1.42) falls below the consumption tax's MCPF under the same closure (1.54) — the opposite of their ordering under the baseline fixed-exchange-rate closure (2.77 versus 1.79) — and even below the combined shock's central-case estimate (1.58). In other words, the conclusion that import taxes are Morocco's most costly fiscal instrument, and the associated policy recommendation to reduce reliance on them, holds specifically under the model's baseline assumption of a fixed exchange rate; it is not a closure-free property of the tax itself. Because Morocco's exchange-

rate regime has itself evolved in recent years — Bank Al-Maghrib gradually widened the dirham’s fluctuation band after 2018 — this qualification is of direct practical relevance rather than a purely theoretical caveat, and is taken up further in Section 6.

5.5 Summary of Robustness Findings

- Substitution elasticities (capital–labour, CET, wage-curve) have only a marginal effect on the MCPF of every instrument (generally within $\pm 3.5\%$): the paper’s central estimates are robust to uncertainty about these parameters.
- The Armington elasticity is the single most influential behavioural parameter, and its effect is concentrated on the import tax, whose MCPF ranges from 2.26 to 4.21 depending on the assumed value — a nearly two-fold spread that should temper any policy conclusion that rests on the precise magnitude of the import-tax estimate, though not on its sign or its status as the most expensive instrument under the baseline closure.
- The capital-mobility closure matters mainly for the import tax (+44.4% under sector-specific capital) and, in the opposite direction, moderately for the direct and production taxes (–7.4% and –10.2%).
- The exchange-rate closure is decisive for the ranking of the import tax specifically: under a flexible exchange rate, its MCPF falls below that of the consumption tax, reversing their order under the baseline closure.
- The treatment of additional revenue, examined in full in Section 4.2–4.3, is the single most consequential assumption tested. It is the only lever that changes the sign of the welfare judgement, turning the direct tax and the production tax welfare-neutral or welfare-improving at the margin once their proceeds are transferred back to households.

Taken together, these results indicate that the paper’s central finding — that Morocco’s tax instruments differ substantially and consistently in their marginal cost — is robust to elasticity uncertainty and to the capital-mobility assumption, while the precise magnitude of that cost, its ranking relative to other instruments, and in two cases even its sign, are conditional on the exchange-rate regime and, above all, on how the resulting revenue is used. All of these results are, finally, local: they are derived from 1% perturbations around the 2019 calibration in a static model, and they characterize the marginal cost of the existing tax structure rather than the welfare consequences of a large discrete reform. Section 6 restates the paper’s policy recommendations in this conditional, evidence-based form.

6. Discussion and Policy Recommendations

6.1 Morocco in International Perspective

Under the baseline (savings) closure, our simulations produce MCPFs ranging from 1.44 for direct taxes to 3.16 for import taxes, above most of the ranges reported by Auriol and Warlters (2012) for developing and African economies — 1.02–1.20 for production taxes, 1.00–1.23 for import taxes, and 1.20–2.03 for capital and labour taxes — Only the direct-tax estimate (1.44) falls inside a band they report; the production-tax (1.97) and import-tax (3.16) estimates exceed the corresponding African ranges by wide margins, and the combined-shock estimate (1.72) sits above the 1.08–1.33 band they report for total African MCPFs. Morocco’s import-tax MCPF (3.16) is also above the upper bound Auriol and Warlters (2012) report for non-African developing countries (up to roughly 2.30 for consumption taxes, with

import taxes “sometimes reaching levels above 2.15”), and it is more than double the long-term MCPF of up to 1.5 that Honkatukia et al. (2011) report for Finland under a broader tax-increase package.

Part of this gap is likely to be definitional rather than structural, and the comparison should be read with that in mind. Auriol and Warlters (2012) derive their MCPF analytically from a compact general-equilibrium model with an explicit informal sector, evaluating welfare through a representative-agent money-metric measure; the estimates reported here are simulated from a twenty-two-sector CGE model and monetized through the sum of household-specific equivalent variations under a Stone-Geary demand system. The two constructions coincide only under restrictive conditions, and an EV-based measure will generally record larger welfare losses where the tax falls on goods with high minimum-consumption requirements, as import-intensive necessities do in the Moroccan calibration. The cross-country comparison in this section is therefore indicative of relative position rather than a like-for-like ranking, and the internal comparison across Morocco’s own instruments — which holds the welfare measure, the model and the calibration fixed — carries more weight.

Three non-mutually-exclusive mechanisms plausibly explain why Morocco’s import-tax MCPF sits at the upper end of the international distribution. First, broad-based taxes such as direct income tax or VAT spread the tax burden across a wide base and limit distortions per dirham collected, resulting in a comparatively low MCPF; Morocco’s direct-tax MCPF (1.44) falls within the international range reported above, though nearer its upper than its lower bound. Second, taxes on goods with low demand elasticity — including several import-intensive necessities — generate a higher MCPF because consumption barely responds to the tax, so the deadweight loss grows roughly in proportion to the (still collected) revenue; the robustness analysis in Section 5.2 confirms this mechanism directly: the import tax’s MCPF is, by a wide margin, the single most elasticity-sensitive estimate in the paper, and it is precisely the Armington (import-demand) elasticity that drives this sensitivity. Third, informality and import dependence, both documented as structural features of the Moroccan economy in Section 1 (a 12.6%-of-GDP informal sector, and tax-revenue dependence ranking second in Africa), plausibly narrow the effective tax base available to formal, broad-based instruments while leaving import flows — which are comparatively easy to observe and tax at the border — as an administratively convenient, but economically costly, revenue source. This combination of findings is consistent with the analyses of Dahlby (2008) and Auriol and Warlters (2012), which show how the extent of tax distortions and informality jointly shape a country’s MCPF profile.

Two further, Morocco-specific qualifications temper this comparison. First, the robustness analysis (Section 5.3) shows that the import tax’s ranking as the most expensive instrument is not closure-free: under a flexible exchange-rate regime, its MCPF falls to 1.42, below the consumption tax’s MCPF under the same closure (1.54). Since Bank Al-Maghrib has progressively widened the dirham’s fluctuation band since 2018, this closure-dependence is a live consideration for interpreting the headline ranking, not a purely theoretical one, and future work should re-estimate the model under the (now wider, though still managed) exchange-rate regime actually in place. Second, and more importantly for policy design, none of the international comparators cited above report MCPF estimates under more than one assumption about how the additional tax revenue is used; Section 4 shows that this single design choice moves Morocco’s MCPF estimates by 27% to 57%, which is larger than the entire cross-country dispersion Auriol and Warlters (2012) report for several tax categories. This suggests that part of the wide variation observed across countries in the existing MCPF literature may itself reflect differences in the (often unstated) revenue-treatment assumption embedded in each study’s CGE closure, rather than solely differences in underlying economic structure — a possibility that, to our knowledge, has not been previously quantified within a single-country study and that follows directly from presenting the two experiments side by side.

6.2 Evidence-Based Policy Recommendations

Consistent with the requirement that policy recommendations be directly justified by simulation results, each recommendation below is stated as: result → mechanism → policy implication, and is explicitly conditioned on the revenue-treatment assumption where the robustness analysis shows this to matter.

Recommendation 1 — Prioritize direct taxation, particularly where proceeds are redistributed.

Result: direct tax has the lowest MCPF under both closures (1.44 under the savings closure; 0.62, i.e. below the non-distorting benchmark, once revenue is transferred to households), and this ranking is robust to every elasticity and closure variant tested in Section 5. Mechanism: the direct-tax base is comparatively broad and its distortion operates through household and corporate disposable income, the same channel through which a lump-sum transfer restores purchasing power, producing an almost one-for-one offset when the two are combined (Section 4.3). Policy implication: revenue-neutral reforms that shift the tax mix towards direct taxation, especially when packaged with explicit redistribution of the proceeds (e.g., targeted transfers to poor and middle-income households), offer the most efficient available margin for raising revenue in the Moroccan tax system. This requires continued investment in tax administration to broaden effective coverage of direct taxation, particularly given that 80% of CIT revenue currently comes from only 2% of companies (Section 1).

Recommendation 2 — Exercise caution with import taxation, and recognize its cost is state-contingent.

Result: import tax has the highest MCPF under the baseline, fixed-exchange-rate closure (3.16, falling to 2.31 under transfer), but this ranking reverses under a flexible exchange-rate closure, where its MCPF (1.42) falls below the consumption tax's (1.54). Mechanism: the import tax's cost is driven by low import-demand elasticity and by the fixed-exchange-rate closure's inability to let relative prices adjust through the currency; a more flexible regime allows depreciation to absorb part of the shock (Section 5.3). Policy implication: a gradual reduction in reliance on import duties, offset by revenue from direct taxation or VAT, remains advisable under Morocco's prevailing, largely managed exchange-rate regime; but the magnitude of the efficiency gain from such a shift should be re-assessed if and when the dirham's exchange-rate band is widened further, since part of the current cost differential between import and consumption taxes is a closure artifact rather than an intrinsic property of the tax base.

Recommendation 3 — Broaden the consumption tax (VAT) base, but do not expect revenue recycling alone to make it cost-free.

Result: consumption tax MCPF falls from 1.805 to 1.152 when revenue is transferred to households, the smallest percentage-point reduction of the four elementary instruments, and it remains above the MCPF = 1 benchmark under every scenario tested. Mechanism: the consumption tax distorts the relative price of consumption versus saving rather than household income directly; a lump-sum transfer restores income but does not correct this relative-price distortion (Section 4.3). Policy implication: broadening the VAT base to a well-designed, uniform structure, as suggested by Auriol and Warlters (2012) for African countries, remains a viable way to stabilize revenue while limiting distortions, but should be paired with targeted protection for poor households — who bear a materially smaller absolute welfare loss than rich households under this tax (Section 4.2.3) but a larger loss relative to their income — rather than relying on generalized revenue recycling to neutralize the instrument's efficiency cost.

Recommendation 4 — Treat the use of tax revenue as a first-order element of reform design, not an implementation detail.

Result: for the combined four-tax package, the choice of revenue treatment alone moves the MCPF from 1.72 (clearly welfare-reducing) to 0.907 (marginally welfare-improving at the margin) — a larger swing than that produced by any single elasticity or closure parameter tested in the robustness analysis. Mechanism: revenue recycling operates through the same disposable-income channel as direct and production taxes, and its effect is large enough to change the qualitative welfare verdict on the reform package as a whole (Section 4.3). Policy implication: any comprehensive tax-reform proposal for Morocco should specify, and ideally quantify, the intended use of the additional revenue — debt reduction / public savings, targeted transfers, or a reduction in another distortionary tax — as an explicit design parameter, rather than leaving it implicit. Improving tax administration to reduce evasion and further integrating the informal sector into the tax system, while carefully assessing the associated administrative costs, would complement this approach by reducing the overall MCPF independently of the revenue-treatment choice.

Two caveats apply to all four recommendations. First, as Section 5 shows, the import tax's MCPF is highly sensitive to the assumed Armington elasticity (a range of 2.26 to 4.21); policy conclusions that hinge on its precise magnitude, rather than on its sign and approximate ranking, should be treated with corresponding caution. Second, all recommendations are derived from marginal (1%) tax-rate changes around the current structure; extrapolating them to large, non-marginal reforms would require re-simulating the model at the relevant scale, since MCPF is, by construction, a marginal concept.

7. Conclusion

This article estimates the marginal cost of public funds (MCPF) in Morocco using a computable general equilibrium model, to assess the economic cost to households of each additional dirham of tax revenue. Two complementary experiments were simulated for five fiscal shocks (a 1% marginal increase in direct tax, production tax, import duties, consumption tax, and their combination): one in which the additional revenue accrues to public savings, and one in which it is redistributed to households as a lump-sum transfer.

Under the savings closure, direct taxes have the lowest MCPF (1.44) due to their progressivity and low impact on GDP (−0.0001%), while import and production taxes entail substantially higher costs (up to 3.16), driven in the case of the import tax by the low elasticity of import demand and by the baseline fixed-exchange-rate closure. A combined approach across several taxes moderates these distortions, with an overall MCPF of 1.72. Redistributing the additional revenue as a lump-sum transfer lowers the MCPF of every instrument by 27–57%, moving direct and production taxes below the MCPF = 1 efficiency benchmark, while import and consumption taxes, though substantially cheaper, remain cost-positive under either closure.

A systematic robustness analysis, comprising 59 additional simulations, shows that the paper's central qualitative finding — that Morocco's tax instruments differ substantially and consistently in their marginal cost — is robust to uncertainty about substitution elasticities and to the capital-mobility closure. It also shows, however, that the precise magnitude of the import tax's cost is highly sensitive to the assumed Armington elasticity, that its ranking relative to the consumption tax reverses under a flexible exchange-rate closure, and that the treatment of additional tax revenue is, on its own, capable of changing the sign of the welfare judgement for two of the four instruments studied. These findings indicate that MCPF-based policy advice for Morocco should be conditioned jointly on the tax instrument, the prevailing exchange-rate regime, and the intended use of the revenue raised, rather than treating the tax instrument in isolation.

To improve tax efficiency in Morocco, an optimal tax strategy should prioritize direct taxation — particularly where its proceeds can be channelled back to households — exercise caution with import taxation under the current, largely fixed exchange-rate regime, broaden the VAT base while protecting vulnerable households, and treat the use of additional tax revenue as an explicit, first-order element of any reform proposal. These reforms, supported by a strengthened tax administration and further integration of the informal sector into the tax system, would maximize public revenues while minimizing welfare losses.

Certain limitations must be considered. MCPF estimates remain conditional on the CGE model's functional-form and calibration assumptions; although Section 5 shows these estimates to be reasonably robust along several dimensions, the elasticity brackets tested are generic ($\times 0.5/\times 1.5$ around the calibrated central value) rather than Morocco-specific econometric estimates, and future work should revisit this bracket as such estimates become available. Specific data on the Moroccan informal sector also warrant further analysis, and the administrative costs associated with taxing the informal sector would need to be carefully assessed so as not to increase the MCPF. Finally, all results are derived from marginal (1%) tax changes; extending the analysis to non-marginal reforms, to a dynamic (rather than static) version of the model, or to a wider set of closure rules — for example, alternative treatments of unemployment or of the current-account balance beyond those tested in Section 5 — constitute natural directions for future research.

References

- Agueny, F., Ragbi, A., Faraji, S. A., El Ouairi, Z., & Baouchari, N. E. (2025). The impact of indirect taxes on labor income and employment in Morocco: A dynamic CGE modeling. Paper presented at the 28th Annual Conference on Global Economic Analysis, Kigali, Rwanda. Global Trade Analysis Project (GTAP). https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=7509
- Armington, P. S. (1969). A theory of demand for products distinguished by place of production. *Staff Papers (International Monetary Fund)*, 16(1), 159–178. <https://www.jstor.org/stable/3866406>
- Arrow, K. J. (1951). An extension of the basic theorems of classical welfare economics. In J. Neyman (Ed.), *Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability* (pp. 507–532). University of California Press. <https://www.jstor.org/stable/1809093>
- Artus, P., Sterdyniak, H., & Villa, P. (1980). Investissement, emploi et fiscalité. *Économie et statistique*, 127(1), 115–127.
- Auerbach, A., & Rosen, H. (1980). *Will the real excess burden please stand up? (Or, seven measures in search of a concept)* (Working Paper No. 495). National Bureau of Economic Research. <https://econpapers.repec.org/paper/nbrnberwo/0495.htm>
- Auriol, E., & Warlters, M. (2012). The marginal cost of public funds and tax reform in Africa. *Journal of Development Economics*, 97(1), 58–72. <https://doi.org/10.1016/j.jdevco.2011.01.003>
- Beaud, M., Blayac, T., Bougette, P., Khoudmi, S., Mahenc, P., & Mussard, S. (2013). *Estimation du coût d'opportunité des fonds publics pour l'économie française* (Technical Report ES 2014–01). LAMETA, Université Montpellier 1.
- Blanchflower, D., & Oswald, A. (1995). *The wage curve*. MIT Press. <https://econpapers.repec.org/bookchap/mitptitles/026202375x.htm>
- Boiteux, M. (1951). La tarification au coût marginal et les demandes aléatoires. *Revue d'Économie Politique*, 61(2), 149–168. <https://www.jstor.org/stable/20075348>

- Boiteux, M. (1956). Sur la gestion des monopoles publics astreints à l'équilibre budgétaire. *Econometrica*, 24, 22–40.
- Browning, E. K. (1976). The marginal cost of public funds. *Journal of Political Economy*, 84(2), 283–298.
- Chisari, O. O., & Cicowiez, M. (2010). Marginal cost of public funds and regulatory regimes: Computable general equilibrium evaluation for Argentina. *Economic Analysis Review*, 25(1), 79–116.
- Chtouki, Z., & Raouf, R. (2022). Evaluation of the socioeconomic impact of income inequality in Morocco using a CGE model. *Statistika*, 103(1), 62–88. <https://doi.org/10.54694/stat.2022.31>
- Dahlby, B. (2008). *The marginal cost of public funds: Theory and applications*. MIT Press.
- Davis, J., Fouad, M., & Van Rijckeghem, C. (2010). *Fiscal adjustment for stability and growth*. International Monetary Fund.
- Debreu, G. (1951). The coefficient of resource utilization. *Econometrica*, 19(3), 273–292.
- Debreu, G. (1954). A classical tax-subsidy problem. *Econometrica*, 22, 14–22.
- Decaluwé, B., Lemelin, A., Robichaud, V., & Maisonnave, H. (2013). *PEP-1-1: The PEP standard single-country, static CGE model*. Partnership for Economic Policy.
- Dupuit, J. (1844). De la mesure de l'utilité des travaux publics. *Revue française d'économie*, 10(2), 55–94.
- Ed-daoudi, M. A., & Oubejja, K. (2024). The effect of a cap-and-trade policy on the economy, welfare and carbon intensity in Morocco: A dynamic computable general equilibrium approach. *African Scientific Journal*, 3(23), 655. <https://doi.org/10.5281/zenodo.11125035>
- El Baouchari, N., & Raouf, R. (2024a). Conditional cash transfer programs and poverty in Morocco: An ex-ante assessment. Paper presented at the 27th Annual Conference on Global Economic Analysis, Fort Collins, USA. Global Trade Analysis Project (GTAP). https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=7226
- El Baouchari, N., & Raouf, R. (2024b). Impact of health on labour productivity in Morocco: Insights from dynamic ARDL and KRLS techniques. *Journal of Global Sustainability and Development*, 1(1), 7–25. <https://doi.org/10.57017/jgsd.v1.i1.01>
- Fullerton, D., & Metcalf, G. E. (2002). Chapter 26: Tax incidence. In A. J. Auerbach & M. Feldstein (Eds.), *Handbook of public economics* (Vol. 4, pp. 1787–1872). Elsevier. [https://doi.org/10.1016/S1573-4420\(02\)80005-2](https://doi.org/10.1016/S1573-4420(02)80005-2)
- Harberger, A. C. (1964a). Taxation, resource allocation, and welfare. In *The role of direct and indirect taxes in the Federal Reserve System* (pp. 25–80). Princeton University Press. <https://doi.org/10.1515/9781400875931-003>
- Harberger, A. C. (1964b). The measurement of waste. *The American Economic Review*, 54(3), 58–76.
- Haut-Commissariat au Plan. (2014). *Enquête nationale sur la consommation et les dépenses des ménages (ENCDM) – 2014*. https://www.hcp.ma/Enquete-Nationale-sur-la-Consommation-et-les-Depenses-des-Menages-ENCDM-2014_a2946.html
- Haut-Commissariat au Plan. (2015). *Enquête nationale sur l'emploi 2015*. https://www.hcp.ma/Enquete-nationale-sur-l-emploi_a89.html
- Haut-Commissariat au Plan. (2020). *Comptes nationaux*. <https://applications-web.hcp.ma/DCN2022/Accueil.html>

- Honkatukia, J., Dixon, P., & Rimmer, M. (2011). *The marginal costs of funds in the VATTAGE model of Finland*. Paper presented at the 14th Annual Conference on Global Economic Analysis, Venice, Italy. Global Trade Analysis Project (GTAP). https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3582
- Hotelling, H. (1938). The general welfare in relation to problems of taxation and of railway and utility rates. *Econometrica*, 6(3), 242–269. <https://doi.org/10.2307/1907054>
- Jenkin, F. (1872). On the principles which regulate the incidence of taxes. *Proceedings of the Royal Society of Edinburgh*, 7, 618–631. <https://doi.org/10.1017/S0370164600042760>
- Karim, M. (2013). *Taxation of agricultural sector in Morocco: An analysis using a dynamic computable general equilibrium model* (MPRA Paper No. 45622). University Library of Munich. <https://mpra.ub.uni-muenchen.de/45622/>
- Kissami, R., Zbair, E. M., & Bali, R. (2023). Élasticité du système fiscal marocain. *International Journal of Economics and Management Research*, 4(6), Article 6.
- Mohring, H. (1971). Alternative welfare gain and loss measures. *Economic Inquiry*, 9(4), 349–368. <https://doi.org/10.1111/j.1465-7295.1971.tb01680.x>
- Mukoko, N., & Blaise, J. (2016). *Social investments and poverty in the D.R. Congo: A general equilibrium approach* (MPRA Paper No. 72662). <https://mpra.ub.uni-muenchen.de/72662/>
- OECD. (2024). *Revenue statistics in Africa 2024 — Morocco*. OECD Publishing. <https://www.oecd.org/content/dam/oecd/fr/topics/policy-sub-issues/recettes-fiscales-mondiales/statistiques-recettes-publiques-afrique-maroc.pdf>
- Oliveira, P. F., & Cordeiro, P. A. (2023). Trade policy analysis in Brazil: Assessing welfare impacts with revised Armington elasticities. *Economic Modelling*, 129, Article 106538. <https://doi.org/10.1016/j.econmod.2023.106538>
- Pigou, A. C. (1947). *A study in public finance* (3rd ed.). Macmillan.
- Ramsey, F. P. (1927). A contribution to the theory of taxation. *The Economic Journal*, 37(145), 47–61. <https://doi.org/10.2307/2222721>
- Raouf, R., Dahane, H., & Baouchari, N. E. (2021). Impact of AfCFTA implementation on the Moroccan economy: A CGE modeling assessment. Paper presented at the 24th Annual Conference on Global Economic Analysis (Virtual). Global Trade Analysis Project (GTAP). https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=6221
- Schürenberg-Frosch, H. (2015). *We could not care less about Armington elasticities – but should we? A meta-sensitivity analysis of the influence of Armington elasticity misspecification on simulation results* (Ruhr Economic Papers No. 594). RWI – Leibniz-Institut für Wirtschaftsforschung. <https://doi.org/10.4419/86788689>
- World Bank. (2019). *Environmental fiscal reform in Morocco: Options and pathways*. World Bank Group. <https://openknowledge.worldbank.org/handle/10986/34030>
- Zhu, Y., Ghosh, M., Luo, D., Macaluso, N., & Rattray, J. (2018). Revenue recycling and cost effective GHG abatement: An exploratory analysis using a global multi-sector multi-region CGE model. *Climate Change Economics*, 9(1), Article 1840009. <https://doi.org/10.1142/S2010007818400092>

Technical Appendix

This appendix provides the full mathematical specification of the PEP-1-1 computable general equilibrium model used in the paper (Appendix A), the structure and aggregated baseline accounts of the SAM-PEP-2019 used to calibrate it (Appendix B), and the complete results of the 59-simulation robustness and sensitivity analysis summarized in Section 5 of the main text (Appendix C).

Appendix A. Full Model Specification

A.1 Sets and Notation

Indices: j, i = industries / commodities; l = labour category; k = capital category; h = household type; f = firm; “gvt” = government; “row” = rest of the world.

- Industries and commodities (j, i): 22 active branches — Agriculture, forestry and related services (A00); Fishing and aquaculture (B05); Mining and extractive industries (C00); Food and tobacco industries (D01); Textile and leather industries (D02); Chemical and para-chemical industry (D03); Mechanical, metallurgical and electrical industries (D04); Other manufacturing (excl. petroleum refining) (D05); Electricity and water (E00); Construction and public works (F45); Trade (G00); Hotels and restaurants (H55); Transport (I01); Post and telecommunications (I02); Financial activities and insurance (J00); Real estate, rental and business services (K00); Public administration and social security (L75); Market education (EM); Non-market education (ENM); Social benefits and health (SN); Other non-financial services (OP0).
- Labour categories (l): unskilled (USK), skilled (SK), medium-skilled (MSK).
- Capital (k): a single composite capital category (cap).
- Households (h): poor (HP), middle-income (HM), rich (HR).
- Other institutions: firms (f), government (gvt), rest of the world (row).

A.2 Production Block

Output is produced under a two-level nested technology. At the top level, value added and intermediate consumption combine in fixed (Leontief) proportions:

$$VA_j = v_j \cdot XST_j \quad IC_j = io_j \cdot XST_j \quad (A.1-A.2)$$

where v_j and io_j are the fixed value-added and intermediate-consumption coefficients. Value added is itself a CES aggregate of composite labour and composite capital:

$$VA_j = BVA_j \cdot [\beta VA_j \cdot LDC_j - \rho VA_j + (1 - \beta VA_j) \cdot KDC_j - \rho VA_j]^{-1/\rho VA_j} \quad (A.3)$$

with $\rho VA_j = (1 - \sigma VA_j) / \sigma VA_j$, and the associated first-order (relative factor demand) condition:

$$LDC_j / KDC_j = \{[\beta VA_j / (1 - \beta VA_j)] \cdot [RC_j / WC_j]\}^{\sigma VA_j} \quad (A.4)$$

Composite labour is itself a CES aggregate over the three skill types, and composite capital a CES aggregate over capital types (here, a single type):

$$LDC_j = BLD_j \cdot [\sum_l \beta LD_{l,j} \cdot LDL_{l,j} - \rho LD_{l,j}]^{-1/\rho LD_{l,j}} \quad KDC_j = BKD_j \cdot [\sum_k \beta KD_{k,j} \cdot KDK_{k,j} - \rho KD_{k,j}]^{-1/\rho KD_{k,j}} \quad (A.5-A.7)$$

Intermediate consumption is allocated across products in fixed (Leontief) input–output proportions:

$$DLi,j = aij \cdot Clj \quad (A.9)$$

Equation numbers follow the internal GAMS numbering of the model file (EQ1–EQ9); labels A.1–A.9 are used here for readability. Source: PEP-1-1 model file, Section 5.3.1.

A.3 International Trade Block

Domestic output is allocated between the domestic market and exports through a constant-elasticity-of-transformation (CET) function:

$$XSTj = BXT,j \cdot [\sum_i \beta_{XT,j,i} \cdot XS_{j,i} \cdot \rho_{XT,j}]^{1/\rho_{XT,j}} \quad (A.10)$$

with the associated relative-supply condition governing the domestic/export split, and analogous CET nesting (elasticity $\sigma_{X(j,i)} = 3$) where a sector produces more than one commodity. On the demand side, the composite good consumed domestically is a CES (Armington) aggregate of the imported and domestically produced varieties:

$$Qi = BM,i \cdot [\beta_{M,i} \cdot IMi - \rho_{M,i} + (1 - \beta_{M,i}) \cdot DDi - \rho_{M,i}]^{-1/\rho_{M,i}} \quad (A.11)$$

$$IMi / DDi = \{[\beta_{M,i} / (1 - \beta_{M,i})] \cdot [PDi / PMi]\}^{\sigma_{M,i}} \quad (A.12)$$

Export demand facing each commodity is downward-sloping in the relative world/domestic price, with elasticity $\sigma_{XD,i}$:

$$EXDi = EXDi0 \cdot [e \cdot PWXi / PE_FOBi]^{\sigma_{XD,i}} \quad (A.13)$$

A.4 Household Demand: Linear Expenditure System (Stone-Geary)

Households allocate their consumption budget across goods according to a linear expenditure system (LES), derived from a Stone-Geary utility function. Each household first purchases a minimum (incompressible) quantity of every good, $CMINi,h$, and then allocates the residual (“supernumerary”) budget across goods in fixed marginal budget shares $\gamma_{LES,i,h}$:

$$PCi \cdot Ci,h = PCi \cdot CMINi,h + \gamma_{LES,i,h} \cdot [CTHh - \sum_{ij} PCij \cdot CMINij,h] \quad (A.14)$$

The marginal budget shares $\gamma_{LES,i,h}$ are calibrated from the Frisch parameter (−1.5 for all households) and product-specific income elasticities (ranging from 0.7 for agricultural products to 1.5 for fish, food and textile products) via the standard Frisch/Geary calibration method. The corresponding household welfare (utility) index used to construct Table 5’s “household welfare” rows is:

$$uh = \Pi_i (Ci,h - CMINi,h)^{\gamma_{LES,i,h}} \quad (A.15)$$

A.5 Labour Market and the Wage Curve

Labour supply of category l is related to employment and the unemployment rate:

$$LSl = \sum_j LDI,j / (1 - Unempl) \quad (A.16)$$

Following Blanchflower and Oswald (1995), the nominal wage in each labour-market segment responds to the segment’s unemployment rate through a wage curve:

$$\omega_l = A_l \cdot PIXCON \cdot Unempl_{wage,l} \quad (A.17 \text{ (= eq. 6, main text)})$$

with $\sigma_{wage,l} = -0.1$ for all l , following the meta-analytic estimate in Blanchflower and Oswald (1995); A_l is a scale parameter calibrated so that the baseline wage and unemployment rate are reproduced exactly.

A.6 Income, Savings and Government

Household total income is the sum of labour income, capital income and net transfers received:

$$YHh = YHLh + YHKh + YHTRh \quad (A.18)$$

Household savings and direct-tax liabilities are linear functions of disposable/total income:

$$SHh = PIXCON\eta \cdot sh0,h + sh1,h \cdot YDHh \quad TDHh = PIXCON\eta \cdot ttdh0,h + ttdh1,h \cdot YHh \quad (A.19-A.20)$$

Government revenue is the sum of capital income, direct taxes (household and corporate), production taxes, taxes on products and imports, and net transfers received; government savings is the residual after current expenditure:

$$SG = YG - \sum agng \ TR(agng, gvt) - G \quad (A.21)$$

It is this variable, SG, that is held endogenous under the Experiment-1 closure (Section 4.1) and fixed under the Experiment-2 closure (Section 4.2), with the aggregate lump-sum transfer LUMPSUM taking the complementary role.

A.7 Macro Closure and Market Equilibrium

The goods market clears for every commodity:

$$Qi = \sum h \ Ci,h + CGi + INVi + VSTKi + DITi + MRGNi \quad (A.22)$$

factor markets clear for labour and capital, and total investment equals aggregate savings (households, firms, government, and the rest of the world):

$$IT = \sum h \ SHh + \sum f \ SFf + SG + SROW \quad (A.23)$$

The nominal exchange rate e is the model's numéraire (fixed, except under the CABFLEX closure tested in Section 5.3, where the current account balance is fixed instead and e is allowed to float). Walras' law is verified residually on the market for commodity A00.

A.8 Calibrated Elasticities and Distribution Parameters

Table A.1. Calibrated substitution and demand elasticities (central values, uniform across sectors/households unless noted)

Parameter	Governs	Central value
σ_{VA} (capital-labour CES)	Value-added nest (eq. A.3–A.4)	1.8
σ_{LD} (labour-skill CES)	Composite labour nest (eq. A.5)	0.8
σ_{KD} (capital-type CES)	Composite capital nest (eq. A.6–A.7)	0.8
σ_{XT} (CET, domestic/export)	Output transformation (eq. A.10)	1.5
$\sigma_{X(j,i)}$ (multi-output CET)	Multi-product sectors	3.0
σ_M (Armington)	Import/domestic composite (eq. A.11–A.12)	2.0
σ_{XD} (export demand)	World demand for exports (eq. A.13)	2.0
σ_{wage} (wage curve)	Labour market (eq. A.17)	–0.1
Frisch parameter	LES calibration (households)	–1.5
Income elasticity (LES)	By product, households	0.70 – 1.50

Source: Authors, from the model's calibrated parameter file and the PEP-1-1 GAMS code. These are the exact central values used to construct the $\times 0.5/\times 1.5$ elasticity brackets tested in Section 5 and Appendix C.

Appendix B. SAM Structure and Aggregated Baseline Accounts

B.1 Structure of the SAM-PEP-2019

The full Social Accounting Matrix underlying the model (SAM-PEP-2019) is an 81×81 matrix built from the 2019 Table of Resources and Uses (TRU), the HCP Social Accounting Matrices (2013, 2015), the HCP employment survey (2015) and the ENCDM household expenditure survey (2014), following the disaggregation procedure described in Section 3.1 of the main text (Raouf et al., 2021; El Baouchari & Raouf, 2024a). Table B.1 summarizes its account structure.

Table B.1. Account structure of the SAM-PEP-2019

Account	Number of sub-accounts	Role in the matrix
Activities	22 branches	Production accounts (Table A.1 list); receive intermediate and value-added payments, make sales to the commodity accounts.
Commodities	22 products	Absorb domestic supply and imports; distribute to intermediate consumption, investment, households, government and exports.
Factors	4 (USK, SK, MSK, capital)	Receive value-added payments from activities; distribute factor income to households, firms, government and the rest of the world.
Households	3 (HP, HM, HR)	Receive labour income, capital income and transfers; pay direct taxes, consume, save, and make transfers to other agents.
Firms	1	Receive capital income and transfers; pay corporate income tax; save (retained earnings).
Government	1	Receives all tax revenue (direct, indirect, import) and capital income; finances current expenditure and transfers; residual = public savings (SG).
Taxes	3 categories	Direct taxes (TD), indirect taxes and subsidies (TI), customs duties (TM); recorded as government receipts, disaggregated by instrument in the GAMS reporting variables (TDHT, TDFT, TPROD, TPRCTS).
Savings–Investment	1	Collects savings from all institutions (households, firms, government, rest of world) and finances gross fixed capital formation and inventory change.
Rest of the world	1	Receives import payments and factor income paid abroad; supplies imports and receives exports; the current account balance closes the account.

Source: Authors, based on Section 3.1 of the main text and the set/account declarations in the PEP-1-1 GAMS model file. The full 81×81 numerical matrix is not reproduced here (it is stored in binary GAMS/GDX format); it is available from the authors upon request.

B.2 Aggregated Baseline Macroeconomic Accounts

Table B.2 reports the aggregated (macro) baseline values underlying the SAM calibration, drawn directly from the “Initial value” columns of Tables 3 and 5 in the main text and from the calibrated GAMS output files. Where a quantity is not directly reported elsewhere in the paper, it is derived using the model’s own accounting identities (noted in the table).

Table B.2. Aggregated baseline macroeconomic accounts, SAM-PEP-2019 (2019 values)

Account / aggregate	Baseline value	Source / derivation
GDP at basic prices (GDP_BP)	1,019,658.0	Table 3.
GDP at market prices (GDP_MP)	1,152,806.0	Table 3.
Net taxes on products and imports (TPRCTS = GDP_MP – GDP_BP)	133,148.0	Derived from eq. 91 of the GAMS model (identity, not an independent estimate).
Total baseline tax revenue (TREV0 = TDHT0+TDFT0+TPRODN0+TPRCTS0)	243,016.0	Scalar sheet, simulation output files.

Account / aggregate	Baseline value	Source / derivation
Direct + production tax revenue (TDHT0+TDFT0+TPRODN0 = TREV0 - TPRCTS0)	109,868.0	Derived residually; not separately disaggregated in the model output files.
Household income — poor (HP)	151,890.5	Table 3.
Household income — middle (HM)	112,877.1	Table 3.
Household income — rich (HR)	653,664.5	Table 3.
Household consumption — total	646,450.4	Table 3.
Household savings — total	93,752.0	Table 3.
Government final consumption (G)	221,812.0	Table 3.
Government savings (SG)	44,271.0	Table 3.
Corporate (firm) savings (SF)	182,536.0	Table 3.
Total imports	563,942.0	Table 3.
Labour income share, poor / middle / rich households	26% / 13% / 61%	Figure 4.
Capital income share, poor / middle / rich households	9% / 13% / 78%	Figure 4.

Source: Authors' compilation from Tables 3 and 5 and the GAMS simulation output files. Monetary values are in the SAM's native units, as reported in Table 3. Cells marked "derived" follow directly from the model's own accounting identities and are not independent estimates.

Two limitations of Table B.2 should be noted for full transparency. First, it reports macro-aggregate and institutional totals rather than the complete disaggregated 81×81 matrix (activity-by-activity intermediate flows, factor payments by skill type and sector, and the detailed tax-instrument breakdown are calibrated internally by the GAMS code and are not reproduced here). Second, the row "Direct + production tax revenue" is obtained residually (TREV0 minus the independently reported TPRCTS) rather than read directly from a single source; it is not further split between household income tax, corporate tax and production tax, as the model's reporting variables do not record that breakdown separately.

Appendix C. Complete Robustness and Sensitivity Test Results

Table C.1 reports the complete results of all 59 simulations underlying the robustness analysis summarized in Section 5 (Tables 7–9 and Figures 8–10 of the main text), including the Σ EV and real-GDP-at-basic-prices results not shown in the main-text summary tables. "Central (no-transfer, internal reference)" is each instrument's own baseline re-run, against which the Δ columns are computed (see the methodological note at the start of Section 5).

Table C.1. Full results of the 59-scenario robustness and sensitivity analysis

Tax instrument	Scenario	MCPF	Δ (pts)	Δ (%)	Σ EV	Δ GDP_BP (%)
Direct tax	Central (no-transfer, internal reference)	1.35	+0.00	+0.0%	-341.4	+0.0013%
Direct tax	Lump-sum transfer to households	0.62	-0.73	-54.1%	363.0	-0.0016%
Direct tax	Flexible exchange rate (CABFLEX)	1.36	+0.01	+0.7%	-354.0	-0.0010%
Direct tax	Sector-specific capital (KMOB0)	1.25	-0.10	-7.4%	-254.2	+0.0178%
Direct tax	Armington elasticity $\times 0.5$	1.35	+0.00	+0.0%	-341.4	+0.0013%
Direct tax	Armington elasticity $\times 1.5$	1.35	+0.00	+0.0%	-341.4	+0.0013%
Direct tax	Capital-labour elasticity $\times 0.5$	1.34	-0.01	-0.7%	-340.1	+0.0014%
Direct tax	Capital-labour elasticity $\times 1.5$	1.35	+0.00	+0.0%	-341.9	+0.0013%
Direct tax	CET elasticity $\times 0.5$	1.34	-0.01	-0.7%	-338.4	+0.0019%

Tax instrument	Scenario	MCPF	Δ (pts)	Δ (%)	Σ EV	Δ GDP_BP (%)
Direct tax	CET elasticity $\times 1.5$	1.35	+0.00	+0.0%	-343.0	+0.0010%
Direct tax	Wage-curve elasticity $\times 0.5$	1.35	+0.00	+0.0%	-341.4	+0.0013%
Direct tax	Wage-curve elasticity $\times 1.5$	1.35	+0.00	+0.0%	-341.4	+0.0013%
Production tax	Central (no-transfer, internal reference)	1.66	+0.00	+0.0%	-76.3	-0.0017%
Production tax	Lump-sum transfer to households	0.99	-0.67	-40.4%	0.8	-0.0020%
Production tax	Flexible exchange rate (CABFLEX)	1.67	+0.01	+0.6%	-77.1	-0.0018%
Production tax	Sector-specific capital (KMOB0)	1.49	-0.17	-10.2%	-61.1	+0.0012%
Production tax	Armington elasticity $\times 0.5$	1.66	+0.00	+0.0%	-76.4	-0.0017%
Production tax	Armington elasticity $\times 1.5$	1.66	+0.00	+0.0%	-76.3	-0.0017%
Production tax	Capital-labour elasticity $\times 0.5$	1.64	-0.02	-1.2%	-73.7	-0.0015%
Production tax	Capital-labour elasticity $\times 1.5$	1.67	+0.01	+0.6%	-77.5	-0.0017%
Production tax	CET elasticity $\times 0.5$	1.64	-0.02	-1.2%	-75.2	-0.0014%
Production tax	CET elasticity $\times 1.5$	1.67	+0.01	+0.6%	-76.9	-0.0018%
Production tax	Wage-curve elasticity $\times 0.5$	1.66	+0.00	+0.0%	-76.3	-0.0017%
Production tax	Wage-curve elasticity $\times 1.5$	1.66	+0.00	+0.0%	-76.3	-0.0017%
Import tax	Central (no-transfer, internal reference)	2.77	+0.00	+0.0%	-71.6	-0.0135%
Import tax	Lump-sum transfer to households	2.31	-0.46	-16.6%	-51.9	-0.0135%
Import tax	Flexible exchange rate (CABFLEX)	1.42	-1.35	-48.7%	-34.2	-0.0065%
Import tax	Sector-specific capital (KMOB0)	4.00	+1.23	+44.4%	-100.2	-0.0185%
Import tax	Armington elasticity $\times 0.5$	2.26	-0.51	-18.4%	-68.5	-0.0130%
Import tax	Armington elasticity $\times 1.5$	4.21	+1.44	+52.0%	-75.5	-0.0140%
Import tax	Capital-labour elasticity $\times 0.5$	2.75	-0.02	-0.7%	-70.8	-0.0134%
Import tax	Capital-labour elasticity $\times 1.5$	2.78	+0.01	+0.4%	-72.0	-0.0135%
Import tax	CET elasticity $\times 0.5$	2.67	-0.10	-3.6%	-70.2	-0.0132%
Import tax	CET elasticity $\times 1.5$	2.83	+0.06	+2.2%	-72.4	-0.0136%
Import tax	Wage-curve elasticity $\times 0.5$	2.77	+0.00	+0.0%	-71.6	-0.0135%
Import tax	Wage-curve elasticity $\times 1.5$	2.77	+0.00	+0.0%	-71.6	-0.0135%
Consumption tax (VAT)	Central (no-transfer, internal reference)	1.79	+0.00	+0.0%	-687.0	-0.1305%
Consumption tax (VAT)	Lump-sum transfer to households	1.15	-0.64	-35.8%	-128.2	-0.1328%
Consumption tax (VAT)	Flexible exchange rate (CABFLEX)	1.54	-0.25	-14.0%	-551.9	-0.1055%
Consumption tax (VAT)	Sector-specific capital (KMOB0)	1.77	-0.02	-1.1%	-694.8	-0.1314%
Consumption tax (VAT)	Armington elasticity $\times 0.5$	1.76	-0.03	-1.7%	-680.7	-0.1296%
Consumption tax (VAT)	Armington elasticity $\times 1.5$	1.83	+0.04	+2.2%	-694.5	-0.1316%
Consumption tax (VAT)	Capital-labour elasticity $\times 0.5$	1.77	-0.02	-1.1%	-668.7	-0.1291%
Consumption tax (VAT)	Capital-labour elasticity $\times 1.5$	1.80	+0.01	+0.6%	-695.2	-0.1312%
Consumption tax (VAT)	CET elasticity $\times 0.5$	1.73	-0.06	-3.4%	-654.4	-0.1245%

Tax instrument	Scenario	MCPF	Δ (pts)	Δ (%)	Σ EV	Δ GDP_BP (%)
Consumption tax (VAT)	CET elasticity $\times 1.5$	1.83	+0.04	+2.2%	-705.6	-0.1339%
Consumption tax (VAT)	Wage-curve elasticity $\times 0.5$	1.79	+0.00	+0.0%	-687.0	-0.1305%
Consumption tax (VAT)	Wage-curve elasticity $\times 1.5$	1.79	+0.00	+0.0%	-687.0	-0.1305%
Combined (all 4 taxes)	Central (no-transfer, internal reference)	1.58	+0.00	+0.0%	-1175.6	-0.1443%
Combined (all 4 taxes)	Flexible exchange rate (CABFLEX)	1.46	-0.12	-7.6%	-1016.6	-0.1149%
Combined (all 4 taxes)	Sector-specific capital (KMOB0)	1.53	-0.05	-3.2%	-1109.8	-0.1309%
Combined (all 4 taxes)	Armington elasticity $\times 0.5$	1.57	-0.01	-0.6%	-1166.3	-0.1429%
Combined (all 4 taxes)	Armington elasticity $\times 1.5$	1.61	+0.03	+1.9%	-1186.8	-0.1460%
Combined (all 4 taxes)	Capital-labour elasticity $\times 0.5$	1.57	-0.01	-0.6%	-1152.6	-0.1425%
Combined (all 4 taxes)	Capital-labour elasticity $\times 1.5$	1.59	+0.01	+0.6%	-1185.9	-0.1451%
Combined (all 4 taxes)	CET elasticity $\times 0.5$	1.56	-0.02	-1.3%	-1137.6	-0.1372%
Combined (all 4 taxes)	CET elasticity $\times 1.5$	1.60	+0.02	+1.3%	-1197.3	-0.1483%
Combined (all 4 taxes)	Wage-curve elasticity $\times 0.5$	1.58	+0.00	+0.0%	-1175.6	-0.1443%
Combined (all 4 taxes)	Wage-curve elasticity $\times 1.5$	1.58	+0.00	+0.0%	-1175.6	-0.1443%

Note: Σ EV is the sum across households of the equivalent variation (SAM units), before the revenue adjustment of equation 8. Δ GDP_BP is the percentage change in real GDP at basic prices relative to the baseline. Source: Authors' calculations from the 59 GAMS scenario output files underlying Section 5.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Simulationsresults.rar](#)