ANNEX II

A The Structure of the Morocco Policy Analysis Model

A.1 Model Overview

The Morocco Policy Analysis Model (MOPAM) is derived from the Flexible System of Global Models (FSGM) which the IMF Research Department developed to facilitate macroeconomic analysis of a wide range of issues in open economies that experience major cross-country spillovers. Working with the FSGM, we customized the original model to the Moroccan economy. Several aspects were altered or added to take into account specific sectoral dynamics, capital account regulation, current Moroccan policy, and the importance of traditional agriculture, and the adaptation paid special attention to phosphate exports. The model also addresses monetary policy, which in Morocco combines a fixed exchange rate with a partly open capital account. Tailored to fiscal policy, the MOPAM incorporates energy subsidies and proactive use of import tariffs to alleviate pressures on the currency.

The eclectic MOPAM approach strikes a balance between theory and empirical insights. It has four blocks: The core block, fully micro-founded, describes private consumption and the private investment of overlapping generations (OLG) households. Households optimize their utility with respect to their budget constraints while accounting for different sources of wealth, human and financial. The use of OLG households rather than infinitely-lived ones, breaks down the Ricardian equivalence and removes government debt neutrality. The model also comprises households that because of their financial situation can neither save nor borrow; their consumption equals their income from wages and government transfers. Private investment follows the Tobin's Q model augmented by real adjustment costs, and capital stock can be inferred from the law of capital accumulation.

The supply block is semistructural. The production function is Cobb-Douglas, with labor and private capital as production factors. Total factor productivity (TFP) includes the effects of accumulation of public capital and the second-round effects of commodity prices to capture their impacts on aggregate supply. Total labor force is determined by an exogenous participation rate, and the labor supply is then determined by the unemployment rate, which is modeled by a reduced-form version of Okun's law. In the MOPAM core consumer price inflation is described by a reduced-form, hybrid, open-economy Phillips curve, to reflect the price stickiness and changes in marginal costs captured by the output gap and developments in the real exchange rate and oil prices. Non-core prices of food and energy are determined by world prices and the exchange rate, and for food also by the domestic food supply. Wage inflation is modeled by a wage Phillips curve.

As for the government block, both revenue and expenditure sides of the government balance are captured, and different fiscal rules can be explored depending on the government's objectives for long-term debt or the long-term deficit. To meet its objectives, the government chooses fiscal instruments that affect either the demand side (consump-

tion tax, transfers to households); the supply side (tax on capital); or both (public investment). Distortionary taxes weaken the Ricardian equivalence.

Finally, we model carefully Morocco's current monetary regime, which is quite different from the floating or fixed exchange rate regimes that are commonly studied, and which are accompanied by an open capital account. As this paper was being written, Morocco fixed its exchange rate against a basket of currencies, with weights equal to 60% for the euro and 40% for the US dollar. With the partly open capital account and active use of import duties, such a regime opens up maneuvering space to achieve such internal objectives as stabilizing inflation and growth. The MOPAM can also capture a wide range of intermediate and hybrid exchange rate regimes and monetary policy reaction functions that correspond to different stages in making the dirham more flexible.

Before we describe the main equations of the model we must make a crucial comment about notation: All nonstationary real variables in the equations below are detrended by an exogenous trend in technology ($\overline{G}$), all nominal prices by the price of the core consumption basket (P^{core}) and all other nonstationary nominal variables by the trends in technology and the core consumption price ($P^{\text{core}}\overline{G}$). Also, variables with periods after the current period refer to rational expectations for the variables in the future period (i.e., for brevity, we omit the expectations operator). Further, an increase in the exchange rate, whether nominal or real, always means appreciation of the currency. Finally, as the MOPAM is an annual model, all growth rates, inflation rates and interest rates are annualized rates.

A.2 Private Consumption

To introduce non-Ricardian features into the MOPAM, the model includes two types of households: those with overlapping generations (OLG) features and those that are liquidity-constrained (LIQ). The share of the LIQ households in the population is λ_{LIQ}. OLG households can accumulate wealth and draw it down, but LIQ households consume only out of current labor income, remittances, and net transfers from the government. Total household consumption is

$$C_t = C_t^{\text{OLG}} + C_t^{\text{LIQ}} \tag{1}$$

A.2.1 OLG Households

OLG consumption is a time-varying proportion of wealth with respect to the marginal propensity to consume:

$$P_t^C \, C_t^{\text{OLG}} = MPC_t \, W_t \tag{2}$$

The marginal propensity to consume is given by expected future nominal interest rates (r^C), the tax rate on consumption (τ^C), the tax rate (τ^{B^*}) on changes in household net foreign assets positions (B^*), the probability of dying (ρ) and the stochastic pricing kernel (j):

$$MPC_t^{-1} = 1 + \tau_t^C + \frac{\tau^{B^*}}{2}\left(\frac{B_t^* - B_{t-1}^*}{P_t^C C_t^{\text{OLG}} Z_t}\right)^2 + \frac{\rho j_t \pi_{t+1}}{1 + r_t^C} MPC_{t+1}^{-1} \tag{3}$$

$$j_t = \left(\beta \frac{1 + r_t^C}{\pi_{t+1}} \frac{1 + \tau_t^C}{1 + \tau_{t+1}^C}\right)^{\frac{1}{\sigma}} \left(\frac{C_t^{\text{OLG}}}{C_{t-1}^{\text{OLG}}} \Delta\overline{G}\right)^{\gamma \frac{\sigma - 1}{\sigma}} \tag{4}$$

The wealth of OLG households has four components: financial wealth (WF), capital wealth (WK), human wealth (WH) and other wealth (WO),

$$W_t = WF_t + WK_t + WH_t + WO_t \tag{5}$$

Financial wealth is the current value of domestic government bonds and net foreign assets converted to the domestic currency:

$$WF_t = \left(1 + r_{t-1}^B\right) \frac{B_{t-1}}{\pi_t^{\text{core}} \Delta\overline{G}} + \left(1 + r_{t-1}^{B^*}\right) \frac{B_{t-1}^*}{Z_t \pi_t^* \Delta\overline{G}} \tag{6}$$

Capital wealth is the value of accumulated capital at the beginning of the current period; the price of the capital (QR) is the Tobin's Q:

$$WK_t = QR_t \frac{K_{t-1}}{\Delta\overline{G}} \tag{7}$$

Human wealth is the present value of expected future labor income after tax, dis-counted by both the OLG household's probability of dying (ρ) and the decline in labor productivity over the life of the household (χ),

$$WH_t = \left(1 - \tau_t^L\right) WN_t \, L_t^{\text{OLG}} + \frac{\rho \, \chi \, \Delta\overline{G}}{(1 + r_t^C)} \, WH_{t+1} \tag{8}$$

where τ^L is the labor income tax rate, WN is the nominal wage, and L^{OLG} is the supply of labor by the OLG household.

Other wealth is the present value of current and future lump-sum transfers from the government, both general (TF) and targeted (TF^{OLG})), less lump-sum taxes (TAX^{ls}), royalties from phosphate production paid to the government ($RYLT$) and remittances received from abroad ($REMIT^{\text{OLG}}$)

$$\begin{aligned} WO_t = {} & (1 - \lambda_{\text{LIQ}}) \left(TF_t - TAX_t^{\text{ls}}\right) + TF_t^{\text{OLG}} - RYLT_t + REMIT_t^{\text{OLG}} \\ & + \frac{\rho \, \Delta\overline{G}}{(1 + r_t^C)} \, WO_{t+1}. \end{aligned} \tag{9}$$

A.2.2 Liquidity-constrained Households (LIQ)

Liquidity-constrained households consume up to their net labor income, net government transfers, and remittances from abroad:

$$\left(1+\tau_t^C\right) P_t^C\, C_t^{\text{LIQ}} = \left(1-\tau_t^L\right) WN_t\, L_t^{\text{LIQ}} + WN_t^{\text{Agr}}\, L_t^{\text{Agr}} + TF_t^{\text{LIQ}} + \lambda_{\text{LIQ}} \left(TF_t - TAX_t^{\text{ls}}\right) \tag{10}$$

The MOPAM assumes that some LIQ households work in the traditional agriculture sector (TAS), which is not subject to income taxes. LIQ household income therefore includes income from work in TAS ($W^{\text{Agr}}\, L^{\text{Agr}}$).

A.3 Aggregate Supply

A.3.1 The Traditional Agricultural Sector (TAS)

The TAS produces unprocessed food, uses only labor as an input, is not subject to business cycles, and is not the target of any special transfers,

$$Y_t^{\text{Agr}} = A_t^{\text{Agr}}\, L_t^{\text{Agr}}. \tag{11}$$

All TAS labor is provided by LIQ and the share of such households employed in TAS is λ_{Agr}. Thus, the shares of OLG and LIQ households in non-TAS labor are

$$\frac{1-\lambda_{\text{LIQ}}}{1-\lambda_{\text{LIQ}}\,\lambda_{\text{Agr}}} \qquad \text{and} \qquad \frac{\lambda_{\text{LIQ}}\,(1-\lambda_{\text{Agr}})}{1-\lambda_{\text{LIQ}}\,\lambda_{\text{Agr}}}. \tag{12}$$

A.3.2 Nonagriculture Sectors

Nonagricultural production follows the Cobb-Douglas production function

$$Y_t^{\text{ExAgr}} = A_t\, K_{t-1}^{\alpha_t} L_t^{1-\alpha_t}, \tag{13}$$

The labor share α_t in equation **??** is time-varying in order to capture the observation that the wage share increases during cyclical upswings.

A.3.3 Private Capital and Investment

Private capital evolves according to the capital accumulation equation:

$$K_t = (1-\delta)\,\frac{K_{t-1}}{\Delta\overline{G}} + I_t. \tag{14}$$

The shadow price of investment (Tobin's Q) is based on the after-tax return on the investment (PR^K) adjusted by tax deductions for depreciation,

$$QR_t = \frac{\left(1-\tau_{t+1}^K\right) PR_{t+1}^K + \tau_{t+1}^K\,\delta\, QR_{t+1} + (1-\delta)\, QR_{t+1}}{1+r_t^{\text{corp}}}, \tag{15}$$

where δ is the depreciation rate of capital and τ^K is the capital tax rate, and r^{corp} is the corporate interest rate.

The supply of investment is then given by the following equation:

$$QR_t = P_t^I + q_1 \left(P_t^I \frac{I_t(I_t - I_{t-1})}{I_{t-1}} - \frac{\rho \Delta \overline{G} \pi_{t+1}}{1 + r_t^{\text{corp}}} P_{t+1}^I \left(\frac{I_{t+1}}{I_t} \right)^2 \left(\frac{I_{t+1}}{I_t} - 1 \right) \right) \tag{16}$$

The equation assumes investment adjustment costs of

$$\frac{q_1}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \tag{17}$$

A.3.4 Labor Supply

For use in the MOPAM, potential labor supply is defined with respect to the nonaccelerating inflation rate of unemployment (NAIRU),

$$\overline{L}_t = \left(1 - \overline{U}_t\right) LF_t. \tag{18}$$

where $\overline{U}$ is the NAIRU and LF is labor force.

Because the TAS labor supply is exogenous and acyclical,

$$L_t^{\text{Agr}} = \lambda_{\text{LIQ}} \, \lambda_{\text{Agr}} \, LF_t \tag{19}$$

,

the labor supply in non-TAS sectors is given by:

$$L_t = (1 - U_t) \left(LF_t - L_t^{\text{Agr}} \right), \tag{20}$$

$$L_t^{\text{OLG}} = \frac{1 - \lambda_{\text{LIQ}}}{1 - \lambda_{\text{LIQ}} \, \lambda_{\text{Agr}}} \, L_t, \tag{21}$$

$$L_t^{\text{LIQ}} = \frac{\lambda_{\text{LIQ}} \, (1 - \lambda_{\text{Agr}})}{1 - \lambda_{\text{LIQ}} \, \lambda_{\text{Agr}}} \, L_t. \tag{22}$$

A.4 Business Cycle Features

A.4.1 The Phillips Curve for Core Inflation

The MOPAM assumes a sticky-price Phillips curve for core CPI inflation with forward-looking inflation expectations; the output gap as a measure of domestic producer marginal costs; and depreciation of the real exchange rate as a measure of importer costs and a specific term for pass-through from oil price inflation (after oil subsidies):

$$\begin{aligned} \log\left(\pi_t^{core}\right) =& c_1 \, \log\left(\pi_{t-1}^{core}\right) + (1 - c_1) \log\left(\pi_{t+1}^{core}\right) + c_2 \log\left(\frac{Y_t}{\overline{Y}_t}\right) \\ &+ c_3 \Delta \log\left(Z_t\right) + c_4 \log\left(\frac{\pi_t^{\text{oil}}}{\pi_{target}^{\text{core}}}\right) + \varepsilon_t^{\pi} \end{aligned} \tag{23}$$

A.4.2 Domestic Oil Prices

Domestic oil prices are determined by international oil prices and imposed oil subsidies. The oil subsidy costs are:

$$GSUB_t^{\text{oil}} = \left(\frac{P_t^{*,\text{oil}}}{Z_t} - P_t^{\text{oil}} \right) C_t^{\text{oil}}. \tag{24}$$

In the MOPAM domestic oil prices after subsidy (P^{oil}) can be determined in two ways: They are either directly set at a government-defined price or endogenously adjusted, depending on the total costs of the subsidy the government is willing to absorb ($GSUB^{\text{oil}}$)

A.4.3 Domestic Food Prices

Domestic food prices depend on domestically produced food, Y_t^{Agr}, which is inelastic to prices, and net imports of food, $\left(M_t^{\text{food}} - X_t^{\text{food}}\right)$:

$$P_t^{\text{food}} C_t^{\text{food}} = P_t^{Agr} Y_t^{Agr} + \frac{P_t^{*,food}}{Z_t} \left(M_t^{\text{food}} - X_t^{\text{food}} \right), \tag{25}$$

where P_t^{Agr} is the price of domestically produced food and $P_t^{*,food}$ is the price of traded food.

A.4.4 The Wage Phillips Curve

Wage inflation is modeled by a wage Phillips curve linking wages to the output gap and the time-varying share of labor in production $(1 - \alpha)$:

$$\begin{aligned} \log\left(\pi_t^W\right) = c_1^W \log\left(\pi_{t-1}^W\right) + \left(1 - c_1^W\right) \log\left(\pi_{t+1}^W\right) \\ + c_2^W \log\left(\frac{Y_t}{\overline{Y}_t}\right) + c_3^W \log\left(\frac{1-\overline{\alpha}}{1-\alpha_t}\right) + \varepsilon_t^{\pi^W} \end{aligned} \tag{26}$$

The output gap in the equation captures the procyclical nature of wages, and the labor share term ensures the long-term stability of the labor share.

A.4.5 Cyclical Unemployment and Okun's Law

Because the NAIRU is exogenous, cyclical unemployment is based on Okun's law,

$$U_t = \overline{U}_t + c_1^U \left(U_{t-1} - \overline{U}_{t-1} \right) - c_2^U \left(\frac{Y_t}{\overline{Y}_t} \right), \tag{27}$$

and cyclical unemployment is negatively linked to the output gap.

A.5 Monetary Policy, the Exchange Rate Regime and Capital Controls

The MOPAM is flexible in order to capture alternative monetary and exchange rate regimes, the degree of capital controls, and residents' access to foreign assets.

The MOPAM assumes first that the monetary policy interest rate, r_t^{MP}, follows the forward-looking reaction function, which takes into account rate-setting inertia, the neutral interest rate, the inflation differential, and the output gap. When the monetary policy pursues also exchange rate stabilization objective and capital account is not fully open (more details below), the interest rate rule also takes into account an interest rate differential stemming from capital account restrictions ($Cprem$).

$$\begin{aligned}\left(1+r_t^{MP}\right) = \left(1+r_{t-1}^{MP}\right)^{c_1^r} \left(\left(1+r_t^{Neutral}\right) \left(\frac{\pi_t^{core}}{\pi_{target}^{core}}\right)^{c_2^r} \left(\frac{Y_t}{\overline{Y}_t}\right)^{c_3^r} \right)^{(1-c_1^r)} \\ \sum_{i=1}^{6} \left(1+Cprem_{t+i}\right) * exp(\varepsilon_t^{r^{MP}})\end{aligned} \tag{28}$$

If the central bank also chooses to control exchange rate movements while preserving (some degree of) monetary policy autonomy, it needs to adopt capital account restrictions. The restrictions cause a discrepancy in the uncovered interest rate parity (UIP) that is captured by $Cprem$. The UIP conditions with capital restrictions are

$$1+r_t^{MP} = \left(1+Cprem_t\right)\left(1+r_t^*\right)\frac{S_t}{S_{t+1}}\tau^{B^*}\frac{\frac{\left(B_{t+1}^*-B_t^*\right)\pi_t^*\Delta\overline{G}}{P_{t+1}^C C_{t+1}^{\mathrm{OLG}} Z_{t+1}}}{1+\frac{B_t^*\left(B_t^*-B_{t-1}^*\right)}{P_t^C C_t^{\mathrm{OLG}} Z_t}} * exp(\varepsilon_t^S) \tag{29}$$

where the last term results from restrictions on changes in households net foreign asset (NFA) positions. The parameter $capopen$ determines the extent of tolerated deviations of exchange rate (S) from the targeted value achieved by imposing capital account restrictions. The effect of restrictions is an endogenous ``premium" ($Cprem$) which weakens the relationship between the domestic and foreign returns on capital. The trade-off between the exchange rate stabilisation objective and resulting premium is captured by the equation:

$$1 = \left(\frac{S_t}{S^{target}}\right)^{(1-capopen)} \left(\frac{1}{1+Cprem_t}\right)^{capopen}. \tag{30}$$

When the $capopen$ is set to zero, the model operates as a closed capital account regime with a currency peg, effectively decoupling domestic and foreign interest rates (as if the UIP condition was not part of the model). When the $capopen$ is equal to one, the capital account is fully open, the UIP condition holds, and thus $Cprem$ equals zero at all times.

It is worth mentioning that $capopen$ does not represent any specific measures (e.g. taxes or administrative restrictions). It rather represents a weight the monetary policy puts on exchange rate stabilization achieved by imposing unspecified capital control measures. Stable $capopen$ does not imply stable capital flow restrictions either. The implicit capital control measures can be changing with stable $capopen$ depending on exchange rate pressures.

A.6 Fiscal policy

A.6.1 Debt Accumulation

The government budget constraint is

$$B_t = \frac{B_{t-1}}{\Delta\overline{G}\pi_t^{\text{core}}} + DEF_t = \frac{B_{t-1}}{\Delta\overline{G}\pi_t^{\text{core}}} + EXP_t - REV_t. \tag{31}$$

A.6.2 Government Expenditures

Expenditures (EXP) are broken into seven categories: government consumption (GC); public investment (GI); general subsidies ($GSUB$); transfers targeted to OLG and LIQ households (STF^{OLG} and STF^{LIQ}); general (not targeted) transfers (GTF); and interest payments ($INTP$):

$$EXP_t = GC_t + GI_t + GSUB_t + STF_t^{\text{OLG}} + STF_t^{\text{LIQ}} + GTF_t + INTP_t. \tag{32}$$

Nominal interest payments are given by

$$INTP_t = r_{t-1}^B \frac{B_{t-1}}{\Delta\overline{G}\pi_t^{\text{core}}}. \tag{33}$$

The model takes into account the government energy subsidy system, $GSUB$, which is defined in equation **??**.

The other expenditure items—government consumption, public investment, specific transfers to OLG and LIQ households, and general targeted transfers—are treated as a fixed proportion of GDP unless otherwise specified in scenario simulations.

A.6.3 Government Revenues

Similarly, revenues are broken into seven components: taxes on consumption (TAX^c); labor (TAX^l) and capital (TAX^k) income; tariffs on imports (TAX^m); lump sum taxes paid by OLG and LIQ households ($TAX^{\text{ls, OLG}}$ and $TAX^{\text{ls, LIQ}}$); and phosphate royalties ($RYLT^{phos}$).

$$\begin{aligned} REV_t = {} & TAX_t^C + TAX_t^L + TAX_t^K + TAX_t^M + TAX_t^{\text{ls, OLG}} \\ & + TAX_t^{\text{ls, LIQ}} + RYLT_t^{phos}. \end{aligned} \tag{34}$$

The individual categories are treated as a product of the relevant tax rate and tax base:

$$TAX_t^C = \tau_t^C\, C_t \tag{35}$$

$$TAX_t^L = \tau_t^L\, W_t\, L_t \tag{36}$$

$$TAX_t^K = \tau_t^K \left(PR_t^K - \delta\, Q_t\right) \frac{K_{t-1}}{\Delta\overline{G}} \tag{37}$$

$$TAX_t^M = \tau_t^M\, P_t^M\, M_t \tag{38}$$

Except for the tax on imports, the tax rates are exogenous; the import tax rate adjusts endogenously in order to stabilize the real exchange rate:

$$\tau_t^M = \bar{\tau}^M - c^{\tau^M} \Delta \log\left(Z_t\right) + \varepsilon_t^{\tau^M}. \tag{39}$$

Lump sum taxes are divided proportionally between the OLG and LIQ households:

$$TAX^{\text{ls, OLG}} = \left(1 - \lambda_{\text{LIQ}}\right) TAX_t^{\text{ls}} \tag{40}$$

$$TAX^{\text{ls, LIQ}} = \lambda_{\text{LIQ}}\, TAX_t^{\text{ls}}. \tag{41}$$

A.6.4 Fiscal Rules

The government targets a constant debt-to-GDP ratio ($B_t^{rat,\text{tar}}$). Overall and primary deficit-to-GDP ratios consistent with the debt target are thus:

$$DEF_t^{rat,\text{tar}} = B_t^{rat,\text{tar}} - \frac{B_t^{rat,\text{tar}}}{\Delta \overline{G} \pi_{target}^{\text{core}}} + \varepsilon_t^{DEF^{rat,\text{tar}}}, \tag{42}$$

$$PDEF_t^{rat,\text{tar}} = DEF_t^{rat,\text{tar}} - r_t^b \frac{B_t^{rat,\text{tar}}}{\Delta \overline{G} \pi_{target}^{\text{core}}} + \varepsilon_t^{PDEF^{rat,\text{tar}}} \tag{43}$$

The MOPAM has two main alternative fiscal policy rules. Policy can follow the rule for the overall deficit:

$$DEF_t^{rat} = DEF_t^{rat,\text{tar}} - 100 * c_1^{DEF} \log\left(\frac{Y_t^{\text{ExAgr}}}{\bar{Y}_t^{\text{ExAgr}}}\right) - c_2^{DEF}\left(B_t^{rat} - B_t^{rat,\text{tar}}\right) \tag{44}$$

or the rule for the primary deficit:

$$\begin{aligned} PDEF_t^{rat} = PDEF_t^{rat,\text{tar}} &- 100 * c_1^{PDEF} \log\left(\frac{Y_t^{\text{ExAgr}}}{\bar{Y}_t^{\text{ExAgr}}}\right) \\ &- c_2^{PDEF}\left(B_t^{rat} - B_t^{rat,\text{tar}}\right). \end{aligned} \tag{45}$$

Both rules aim at keeping government debt as targeted while allowing for countercyclical fiscal policy.

Because the fiscal rule on the overall or the primary deficit determines the total budget envelope, the MOPAM includes simple policy rules for revenue and expenditure components. Most of the tax rules assume constant rates, and expenditure rules assume constant spending-to-GDP ratios. For the fiscal block to work with either of the deficit rules, one of the budget components is always endogenously determined by the deficit rule and the rules on all other budget components. The choice of which budget component is treated as endogenous depends on the simulation.

A.7 External Sector

A.7.1 Current Account Balance and Net Foreign Assets

The current account balance, CB_t, is a sum of the trade balance, TB_t, net remittances inflow ($REMIT_t$), and the current value of the previous-period interest on net foreign assets (B^*):

$$CB_t = TB_t + REMIT_t + r_{t-1}^{B^*} * \left(\frac{S_{t-1} B_{t-1}^*}{S_t Z_{t-1} \pi_t^{\text{core}} \Delta \overline{G}} \right), \tag{46}$$

The export and import components of the trade balance will be explained later.

Remittances are modeled as

$$REMIT_t = REMIT_{t-1}^{c_1^{REMIT}} \left(\left(\frac{Z_t}{\tilde{Z}_t} \right)^{c_2^{REMIT}} Act_t^* c_3^{REMIT} \right)^{1-c_1^{REMIT}} \exp\left(\varepsilon_t^{REMIT}\right), \tag{47}$$

where $\tilde{Z}_t$ is a five-year moving average of the real exchange rate, Z_t, centered at the current year t. Act_t^* measures the extent of foreign economic activity and is defined as the weighted average of the outputs of foreign countries. The formulation of equation (47) makes remittances increase in foreign currency terms when the domestic currency appreciates (relative to the moving average exchange rate, $\tilde{Z}$) or foreign activity goes up (which implies that the incomes of the Moroccan diaspora also go up).

The NFA accumulation process assumes that the assets depend on the current account balance and the last-period value of NFA:

$$\frac{B_t^*}{Z_t} = CB_t + \left(\frac{S_{t-1} B_{t-1}^*}{S_t Z_{t-1} \pi_t^{\text{core}} \Delta \overline{G}} \right). \tag{48}$$

A.7.2 Exports

The MOPAM covers three export products: manufactured goods (X^{man}), food items (X^{food}), and phosphate (X^{phos}):

$$P_t^X X_t = P_t^{X^{\text{man}}} X_t^{\text{man}} + P_t^{X^{\text{food}}} X_t^{\text{food}} + P_t^{X^{\text{phos}}} X_t^{\text{phos}}. \tag{49}$$

Manufactured Exports

$$\begin{aligned} \Delta \log\left(X_t^{man}\right) = {} & c_1^{X^{man}} \Delta \log\left(Act_t^*\right) - c_2^{X^{man}} \Delta RCI_t \\ & + c_3^{X^{man}} \left(-c_4^{X^{man}} RCI_{t-1} + \log\left(\frac{Act_{t-1}^*}{X_{t-1}^{man}} \right) + c_5^{X^{man}} \right) \\ & + \Delta \varepsilon_t^{X^{man}}, \end{aligned} \tag{50}$$

where X_t^{man} denotes manufactured exports, Act_t^* is the foreign activity index, and RCI denotes the manufactured goods competitiveness index (see equation **??**).

Food Exports

$$\begin{aligned}\Delta \log\left(X_t^{food}\right) = & \, c_1^{X^{food}} \Delta \log\left(Act_t^{*,food}\right) \\ & - c_2^{X^{food}} \Delta \log\left(RP_t^{*,food}\right) \\ & + c_3^{X^{food}} \log\Big(\left(RP_{t-1}^{*,food}\right)^{-c_7^{X^{food}}} * \frac{Act_{t-1}^{*,food}}{X_{t-1}^{food}}\Big) \\ & + c_5^{X^{food}} \left(\log\left(\frac{P_{t-1}^{*,food}}{P_{t-1}^{\text{Agr}}}\right) + c_8^{X^{food}}\right) \\ & + c_6^{X^{food}} \left(\log\left(\frac{P_t^{*,food}}{P_t^{\text{Agr}}}\right) - \log\left(\frac{P_{t-1}^{*,food}}{P_{t-1}^{\text{Agr}}}\right)\right) \\ & + \Delta\varepsilon_t^{X^{food}},\end{aligned} \tag{51}$$

where X_t^{food} denotes food exports, $Act_t^{*,food}$ is the foreign food activity index, $RP_t^{*,food}$ denotes world food prices relative to the world overall price level, $P_t^{*,food}$ denotes world food prices, and P_t^{Agr} denotes prices of domestic food production.

Phosphate Exports

$$\begin{aligned}\Delta \log\left(X_t^{phos}\right) = & \, c_1^{phos} \Delta \log\left(Act_t^{*,phos}\right) \\ & - c_2^{phos} \Delta \log\left(RP_t^{*,phos}\right) \\ & + c_3^{phos} \left(\log\left(\left(RP_{t-1}^{*,phos}\right)^{-c_4^{phos}} \frac{Act_{t-1}^{*,phos}}{X_{t-1}^{phos}}\right) + c_5^{phos}\right) \\ & + \Delta\varepsilon_t^{X^{phos}},\end{aligned} \tag{52}$$

where X_t^{phos} denotes phosphates exports, $Act_t^{*,phos}$ is the foreign phosphates activity index, and $RP_t^{*,phos}$ denotes world phosphate prices relative to world overall price level.

Foreign Activity Indexes and World Prices

Foreign activity is defined in terms of the trade weights of US and EU imports:

$$Act_t^* = \left(M^{US} * c_1^{US} + M^{EU} * c_2^{EU}\right). \tag{53}$$

Similarly, foreign food and foreign phosphate activity indexes are based on food and phosphate imports, taking into account the applicable trade weights.

The export prices of manufactured goods are given as:

$$\begin{aligned}\Delta \log\left(P_t^{X,man}\right) = c_1^{P^{X^{man}}} \Delta \log\left(P_t^{GDP,\text{ExAgr}}\right) \\ + \left(1 - c_1^{P^{X^{man}}}\right) \Delta \log\left(P_t^{*,man}\right) \\ + c_2^{P^{X^{man}}} \log\left(\frac{P_{t-1}^{GDP,\text{ExAgr}}}{P_{t-1}^{X,man}}\right) \\ + c_3^{P^{X^{man}}} + \varepsilon_t^{P^{X^{man}}},\end{aligned} \tag{54}$$

where $P^{X,man}$ represents the domestic price of manufactured exports and $P^{*,man}$ the world price of manufactured goods which is defined as:

$$\begin{aligned}\log\left(P_t^{*,man}\right) = w_{US}^{share} \log\left(P_t^{X^{US}} * Z_t^{US}\right) + w_{EU}^{share} \log\left(P_t^{X^{EU}} * Z_t^{EU}\right) \\ - \log\left(Z_t\right).\end{aligned} \tag{55}$$

The difference relates to the manufactured goods competitiveness index:

$$RCI_t = \log\left(\frac{P_t^{X,man}}{P_t^{*,man}}\right). \tag{56}$$

For relative world food prices ($RP^{*,food}$) we differentiate between trend and cyclical components:

$$\log\left(RP_t^{*,food}\right) = \log\left(\overline{RP}_t^{*,food}\right) + \log\left(\widehat{RP}_t^{*,food}\right), \tag{57}$$

$\overline{RP}^{*,food}$ is the trend component and $\widehat{RP}^{*,food}$ is the cyclical component, where:

$$\log\left(\overline{RP}_t^{*,food}\right) = c_1^{\overline{RP}^{*,food}} + \varepsilon_t^{\overline{RP}^{*,food}} \tag{58}$$

and

$$\begin{aligned}\log\left(\widehat{RP}_t^{*,food}\right) = c_1^{\widehat{RP}^{*,food}} \log\left(\widehat{RP}_{t-1}^{*,food}\right) + c_2^{\widehat{RP}^{*,food}} \log\left(\frac{Y_t^*}{\overline{Y}_t^*}\right) \\ + \varepsilon_t^{\widehat{RP}^{*,food}}.\end{aligned} \tag{59}$$

World phosphate and oil prices relative to the world price level ($RP^{*,phos}$ and $RP^{*,oil}$) are defined the same way as food prices.

A.7.3 Imports

Imports consist of manufactured good (M^{man}), food (M^{food}), and oil (M^{oil}):

$$P_t^M M_t = P_t^{M^{man_{adj}}} M_t^{man} + P^{M_t^{food}} M_t^{food} + P^{M_t^{oil}} M_t^{oil}. \tag{60}$$

Manufactured Imports

Demand for manufactured goods imports, M_t^{man}, is a function of the domestic activity index (Act_t), applicable import tariffs, (τ_t^M), their price after import tariffs, ($P_t^{M_{adj}^{\text{man}}}$), and the non-agriculture real GDP gap, $\widehat{Y}_t^{\text{ExAgr}}$:

$$\begin{aligned}\Delta \log\left(M_t^{\text{man}}\right) = \; & c_1^{M^{\text{man}}} \Delta \log\left(Act_t\right) - c_2^{M^{\text{man}}} \Delta \log\left(P_t^{M_{adj}^{\text{man}}}\right) \\ & - c_3^{M^{\text{man}}} \log\left(\frac{1+\tau_t^M}{1+\tau_{t-1}^M}\right) \\ & + c_4^{M^{\text{man}}} \log\left(\left(P_{t-1}^{M_{adj}^{\text{man}}}\right)^{-m5} \frac{Act_{t-1}}{M_{t-1}} + c_6^{M^{\text{man}}}\right) \\ & + \; c_7^{M^{\text{man}}} \Delta \widehat{Y}_t^{\text{ExAgr}} + \Delta \varepsilon_t^{M^{\text{man}}}.\end{aligned} \tag{61}$$

The price of imported manufactured goods before import tariffs ($P_t^{M^{\text{man}}}$) is determined by the relative import shares of the US and the EU, their real exchange rates, export prices, and the domestic exchange rate:

$$\begin{aligned}\log\left(P_t^{M^{\text{man}}}\right) = \; & m_{US}^{share} \log\left(P_t^{X^{US}} * Z_t^{US}\right) + m_{EU}^{share} \log\left(P_t^{X^{EU}} * Z_t^{EU}\right) \\ & - \log\left(Z_t\right) + c^{P^{M^{\text{man}}}} + \varepsilon_t^{P^{M^{\text{man}}}}.\end{aligned} \tag{62}$$

Oil Imports

Demand for oil imports, M_t^{oil}, is modeled similarly:

$$\begin{aligned}\Delta \log\left(M_t^{\text{oil}}\right) = \; & c_1^{M^{\text{oil}}} \Delta \log\left(Act_t\right) - \; c_2^{M^{\text{oil}}} \Delta \log\left(P_t^{\text{oil}}\right) \\ & + \; c_3^{M^{\text{oil}}} \left(-c_4^{M^{\text{oil}}} \log\left(P_{t-1}^{\text{oil}}\right) + \log\left(\frac{Act_{t-1}}{M_{t-1}^{\text{oil}}}\right) + c_5^{M^{\text{oil}}}\right) \\ & + \; c_6^{M^{\text{oil}}} \Delta \widehat{Y}_t^{\text{ExAgr}} + \Delta \varepsilon_t^{M^{\text{oil}}}.\end{aligned} \tag{63}$$

Food Imports

The food import function also incorporates the effects of prices of domestic food production (P_t^{Agr}):

$$\begin{aligned}\Delta \log\left(M_t^{\text{food}}\right) = \; & c_1^{M^{\text{food}}} \Delta \log\left(Act_t\right) - \; c_2^{M^{\text{food}}} \Delta \log\left(\frac{P_t^{*,\text{food}}}{Z_t}\right) \\ & + \; c_3^{M^{\text{food}}} \left(-c_4^{M^{\text{food}}} \log\left(\frac{P_{t-1}^{*,\text{food}}}{Z_{t-1}}\right) - c_5^{M^{\text{food}}} \log\left(\frac{P_{t-1}^{*,\text{food}}}{Z_{t-1} P_{t-1}^{\text{Agr}}}\right)\right. \\ & \left. + \log\left(\frac{Act_{t-1}}{M_{t-1}^{\text{food}}}\right) + c_6^{M^{\text{food}}}\right) + \; c_7^{M^{\text{food}}} \Delta \widehat{Y}_t^{\text{ExAgr}} \\ & - c_8^{M^{\text{food}}} \Delta \log\left(\frac{P_t^{*,\text{food}}}{Z_t P_t^{\text{Agr}}}\right) + \Delta \varepsilon_t^{M^{\text{food}}}.\end{aligned} \tag{64}$$

A.7.4 Market Clearing Conditions

The MOPAM has three consumption goods: core, food, and oil. Therefore, total consumption is

$$P_t^C C_t = P_t^{\text{core}} C_t^{\text{core}} + P_t^{\text{food}} C_t^{\text{food}} + P_t^{\text{oil}} C_t^{\text{oil}}. \tag{65}$$

The total production consists of TAS and non-TAS production

$$P_t^Y Y_t = P_t^{GDP,ExAgr} Y_t^{ExAgr} + P_t^{Agr} Y_t^{Agr}, \tag{66}$$

and must equal aggregate demand:

$$P_t^Y \, Y_t = P_t^C \, C_t + P_t^I \, I_t \left(1 + \frac{q_1}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right) + P_t^G \, G_t + P_t^X \, X_t - P_t^M \, M_t \tag{67}$$

Consumption of food and oil must satisfy

$$C_t^{\text{core}} = M_t^{\text{oil}} \tag{68}$$

$$C_t^{\text{food}} + X_t^{\text{food}} = Y_t^{\text{Agr}} + M_t^{\text{food}}, \tag{69}$$

and total consumption is the sum of consumption of both types of household:

$$C_t = C_t^{\text{OLG}} + C_t^{\text{LIQ}}. \tag{70}$$

A.8 Calibration

Estimating the model size of a MOPAM for a country like Morocco is not feasible. Instead, we calibrate the model parameters to correspond with Moroccan data. We also use extensive predefined simulations to assess the behavior of the calibrated model and further improve the calibration. The tables below summarize the steady-state values for main MOPAM variables, the monetary policy rule coefficients and the assumptions about capital account openness.

Table 4. Real and Nominal Growth Rates, Percent

Variable	Value
Real GDP growth	3.500
Nominal GDP growth	5.570

Table 5. Nominal GDP by Expenditures, Percent

Variable	Value
Private consumption to GDP	58.60
Private investment to GDP	26.00
Government absorption to GDP	23.50
Trade balance to GDP	−8.10

Table 6. Nominal GDP by Source, Percent

Variable	Value
Export commodity production to GDP	82.90
Food production to GDP	13.00
Phosphates production to GDP	4.10

Table 7. Consumption Shares, Percent

Variable	Value
LIQ households share of consumption	47.82
Oil share of consumption	7.00
Food share of consumption	37.00

Table 8. Government Overview, Percent of Nominal GDP

Variable	Value
Government deficit	3.48
Primary government balance	2.29
Public debt	66.00

Table 9. Government Revenues, Percent of Nominal GDP

Variable	Value
Tariff revenues	0.80
Tax revenue	21.00
Consumption tax revenue	10.50
Capital tax revenue	5.24
Labor tax revenue	2.96
Phosphate royalties	0.52
Lumpsum tax revenue	0.98

Table 10. Government Expenditures, Percent of Nominal GDP

Variable	Value
Government expenditures	24.48
Government consumption	17.00
Government investment	6.50
Government subsidies	0.75
Interest cost	5.77

Table 11. Balance of Payments, Percent of Nominal GDP

Variable	Value
Current account balance	−4.33
Trade balance	−8.10
Remittances	6.10
Net foreign assets	−82.16

Table 12. Exports, Percent of Nominal GDP

Variable	Value
Total exports	35.00
Manufactured goods	26.00
Food	4.50
Phosphates	4.50

Table 13. Imports, Percent of Nominal GDP

Variable	Value
Total imports	43.10
Manufactured goods	32.10
Oil	7.00
Food	4.00

Table 14. Capital

Variable	Unit	Value
Capital stock	% of nominal GDP	179.310
Capital share of income	fraction	0.500
Depreciation rate of private capital	fraction	0.110
Return on private capital	Local currency yield (LCY) per unit of capital	0.243

Table 15. Labor, Percent

Variable	Unit	Value
Labor force	% of total population	40.95
Employment in agriculture	% of labor force	40.00
Unemployment rate	% of labor force	9.00
Labor age population	% of total population	65.00
Participation rate	% of labor age population	63.00
Labor income	% of nominal GDP	50.00

Table 16. Inflation Measures, Percent

Variable	Value
Headline CPI inflation	2.0
Core CPI inflation	2.0
Wage inflation	5.7

Table 17. Monetary policy and capital account strategy

Coefficient	Description	Value
$capopen$	Capital account openness	0.1
τ^{B^*}	NFA adjustment costs	0.6
c_1^r	MP rule inertia	0.3
c_2^r	Inflation gap weight	0.2
c_3^r	Output gap weight	0.0