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FINEX - A New Workhorse Model for Macroeconomic Forecasting and Policy Analysis

Prepared by Andrew Berg, Yaroslav Hul, Philippe Karam, Adam Remo, and Diego Rodriguez Guzman

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ABSTRACT: This paper presents a semi-structural macroeconomic model aimed at facilitating policy analysis and forecasting, primarily in countries with imperfect capital mobility and hybrid monetary policy regimes. Compared to earlier gap-trend projection models, the Forecasting Model of Internal and External Balance (FINEX) contains three main innovations: it accentuates external and internal balances; explicitly incorporates fiscal policy; and partly endogenizes the main trends. FINEX thus covers a broad set of policy instruments, including foreign exchange interventions (FXI), capital flow management measures (CFM), as well as common fiscal policy instruments. The model incorporates insights from the recent DSGE literature, while maintaining a more accessible gap-trend structure that lends itself to practical policy applications. While the paper refrains from drawing broad policy lessons, it emphasizes the model's ability to interpret recent data in terms of structural shocks and policy responses, thereby aiding policymakers in constructing coherent economic narratives and considering alternative scenarios.

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1 Introduction

The management of internal and external balance lies at the heart of macroeconomic policy in many small open economies. Central banks set interest rates to stabilize inflation and growth, while managing foreign exchange reserves and coping with volatile capital flows and terms of trade shocks. Ministries of finance tax and spend to control demand and promote development, borrow in domestic and foreign currencies, and receive unpredictable aid and natural resource revenues. Both institutions worry about debt sustainability, exchange rate misalignment, and the adequacy of foreign exchange reserves. This paper proposes a workhorse model to help policy institutions address these diverse and interrelated issues.

In recent decades, many central banks and policy institutions have found value in utilizing a family of simple, forward-looking semi-structural macroeconomic models. These models, inspired by New Keynesian dynamic stochastic general equilibrium (DSGE) models, have become known as quarterly projection models (QPMs). They feature as core components an IS curve, a Phillips curve, a Taylor-type rule, and an uncovered-interest-parity condition for the exchange rate. QPMs have helped central banks interpret macroeconomic conditions, generate policy-dependent forecasts, and communicate with the public.[1]

These models are dynamic stochastic forward-looking models, with roots in the DSGE literature.[2] They are 'semi-structural': they lack explicit micro-foundations, and the equilibrium values (for example potential output) are derived from the data as trends. The economics in these models is about the relationships among the gaps—for example the inflation deviation from its target and the output gap. Their flexibility facilitates the understanding of the shocks hitting the economy and the production of forecasts conditional on policy, particularly with data that contains many trends and structural breaks. At the same time, the equations permit economic, not econometric, interpretations, and the models thus support economic narratives about the forecast and alternative scenarios.[3]

[1] IMF (2021) describes in depth the uses of semi-structural models in central banks, including estimation/calibration, the role of a range of satellite tools from DSGE models to near-term-forecasting, and the integration of the modeling apparatus into policy formulation and communication. See also Berg et al. (2006) for comprehensive discussions of this family of models. To pick a few somewhat arbitrary examples, see Abradu-Otoo et al. (2022), Szilágyi et al. (2013), and Marioli et al. (2020).

[2] Clarida et al. (1999) derives the core equations in these types of models from optimizing behavior.

[3] The QPMs models described in the text are members of a wider array of policy-oriented semi-structural models. Canova et al. (2019) and Blanchard (2018) discuss the role of different types of macro models in policy institutions. The family of models discussed here, of which Forecasting Model of Internal and External Balance (FINEX) is an extension, would be 'first-generation new-Keynesian models' in the terminology of Canova et al. (2019). The ECB-base core macro model, described in Angelini et al. (2019), is an example of another type of semi-structural model. Com-

DSGE models are of course the benchmark for macroeconomic policy analysis. Some high-capacity institutions use them for forecasting as well. Our experience working with a large number of EMDEs is that semi-structural models are often more suitable for forecasting in part because they are easily adapted to the flexible combination of judgment and model. Yet, they can provide enough economic structure to support an economic narrative to accompany the forecast and alternative scenarios. They can cope with multiple trends and structural breaks—a key feature, particularly for application to EMDEs. In academic and even policy oriented DSGE models, there is usually one trend in the model associated with 'total factor productivity'. QPMs, in contrast, do not impose theory straightjackets and can readily generate multiple time-varying trends as model-consistent smoothed versions of the underlying data.[4]

This paper takes this QPM approach three steps forward.

- Internal and external balance are at center stage. The traditional model focuses on domestic stabilization. And indeed this makes sense in countries with floating exchange rate regimes, open capital accounts, deep foreign exchange markets, and access to foreign borrowing in their own currency. But countries with these characteristics remain rare.
- The model takes fiscal policy seriously, both in the policy block and in that it incorporates mechanisms important to fiscal policy transmission. Model-based analysis generally plays a smaller role in fiscal policy institutions than in central banks, and the associated policy-oriented literature on model-based forecasting in support of fiscal policy is much smaller.[5] This paper represents an effort to make progress on this front.
- The trends of the main variables are partly endogenous. That is, they are connected by economic relationships analogous to those applied to the gaps. For example the equilibrium exchange rate is a function of trends in interest

pared to many semi-structural models, the QPMs models discussed in the text put even less emphasis on explicit micro-foundations and more on the importance of careful attention to the multiple trends in the data, and hence the model. The latter feature may reflect in part a focus on emerging markets and developing economies (EMDEs), where multiple breaking trends are more common than in advanced economies.

[4]The trends are identified jointly with the gaps based on the data and the business-cycle properties of the model (Box 5). Our experience is that imposing model- and data-based consistency on the trends is more informative and useful than feeding detrended data (usually using univariate techniques) to the model, then reconstructing the trends for purposes of making the forecast.

[5]Fainboim and Lienert (2018) discusses the macro-fiscal function and its organization, while Cespedes et al. (2023) is closer to the focus of this paper in describing and assessing the role of general equilibrium forecasting models in supporting fiscal policy in ministries of finance and economy in a range of countries.

rates and the trend determinants of the balance of payments, while a production function links potential output to capital stocks. Thus, fiscal policy has equilibrium as well as business-cycle effects through implications for debt and the capital stock, while foreign exchange intervention (FXI) and capital flow management measures (CFMs) can move reserves and net foreign assets (NFA) and thus uncovered interest parity (UIP) premia, in the short and the long run.

Three elements interact to drive the model economy: *internal balance*, where a disaggregated IS curve and associated set of Phillips curves represent aggregate demand and supply; *external balance*, where private financial flows—responding to expected relative rates of return—help close the balance of payments; and *policy*, where monetary (interest rates, FXI, possibly CFMs) and fiscal (government consumption, investment, taxes) policies respond to inflation, output gaps, the exchange rate, debt levels, and other objectives.[6] FINEX accommodates a wide range of monetary and fiscal policies in support of traditional and hybrid exchange rate and monetary policy regimes. Available exchange rate regimes include the full spectrum from hard pegs to pure floats with inflation targeting (IT) with varying degrees of capital mobility.

At one level there is little new here. The internal balance equations are familiar from the New-Keynesian tradition and existing QPM models. The determinants of external balance hark back to the Mundell-Fleming tradition in which higher interest rate differentials attract more private capital flows, and also to the portfolio balance model of exchange rates in Kouri (1976) and Blanchard et al. (2005). The ensemble may recall the IS-LM-BP model.[7]

At the same time, we follow in the footsteps of the more recent literature, notably recent work at the International Monetary Fund (IMF) on the integrated policy framework (IPF). Basu et al. (2020) provides a conceptual framework to characterize the optimal use of FXI, CFMs, and macroprudential policies, along with monetary policy, while Adrian et al. (2021) develop a complementary quantitative microfounded New Keynesian approach. This paper includes many of the same policy instruments and captures many of the mechanisms articulated in these papers.[8] In particular, it is consistent with the microfounded portfolio balance approach to international capital flows in Gabaix and Maggiori (2015) which, in extended form, gov-

[6]'Capital flow management measures (CFMs)' is the IMF's preferred term for what are often called capital controls. See for example IMF (2022b).

[7]The related DSGE literature is huge, of course. Adrian et al. (2021) is a closely-related policy-oriented DSGE model. Within the semi-structural family, Karam and Pagan (2008) models the current account while Hledik et al. (2018) and Beneš et al. (2008) focus on alternative exchange rate regimes.

[8]The big gap here in terms of the IPF, as with Adrian et al. (2021), is macroprudential policy, which is left to a future extension.

erns FXI and CFMs in the IPF papers.[9] As such, the model is useful to understand what may happen under different policy trajectories and combination of policy instruments. These model-based responses to policy trajectories are consistent with IPF mechanisms. However, fully microfounded IPF models (Basu et al. (2020) and Adrian et al. (2021)) are more appropriate tools for analyzing welfare-maximizing optimal mix of policies.

The model is linear, except in a few places where nonlinear dynamics are critical. Investors' required rates of return are much more responsive to changes in the stocks of public debt, NFA, and reserves when levels are already vulnerable. A further nonlinearity limits foreign exchange intervention when reserves get too low. Finally, the model also includes an effective lower bound (ELB) for the policy interest rate.

The goal of this paper is to introduce the FINEX as a coherent, systematic, and practical approach to facilitating structured forecasting and policy analysis of monetary and fiscal policy in a range of institutions and regimes. The paper does not claim that FINEX contains some new mechanism or feature that explains here-tofore misunderstood phenomena. Rather, this paper demonstrates the range of issues the model can usefully address. With respect to monetary policy, users can analyze the interaction of interest rates, FXI, and CFMs in determining the reaction of the economy to a range of shocks. It can explore how these reactions depend on features of the economy such as initial debt levels and the sensitivity of inflation to exchange rate depreciation. The fiscal block can assess short and long-term implications of different combinations of fiscal measures, such as the mix of government consumption and investment. The model is also well-suited to analyzing the interactions among all these factors. For example, it shows how the source of government financing matters for the nature of fiscal-monetary-exchange rate interactions.

We have begun using this model, or variants, in joint work with various central banks, ministries of finance, and IMF country teams, and this paper reflects this experience. However, while we discuss the empirical application of the model, we examine the properties of the model with a generic calibration, leaving an application of the model to specific cases to other papers.[10]

The baseline version is built on an annual frequency, because this seems useful for the analysis of fiscal policy and the endogenous dynamics of longer-term trends,

[9] Gabaix and Maggiori (2015) reinvigorates an older and less well-microfounded literature based on the idea that financial assets are imperfect substitutes across countries (Kouri (1976), Beneš et al. (2008), Blanchard et al. (2017)). Hau et al. (2010) provides evidence of imperfect substitutability in a large sample of advanced and emerging economies. Our focus is on EMDEss, but Gabaix and Maggiori (2015) considers an advanced-economy context, and Blanchard et al. (2005) and Krugman (1980) apply a portfolio balance approach to the United States.

[10] Box 5 motivates and sketches our recommended approach to the calibration of the model.

particularly in the many EMDEs where annual data are more reliable and of higher quality. However, it can be readily adapted to quarterly frequency.

The model is, in essence, simple. But all the gaps, trends, and steady states, and the number of variables required for practical use, can overwhelm. Section 2 thus lays out the core elements in stylized form. The reader frustrated by the presentational short-cuts there may skip to Section 3, which presents the full model. On the other hand, Section 2 readers may wish to jump to Section 4, which puts the full model through its paces. Section 5 concludes.

2 Overview

Macroeconomic dynamics in FINEX depend on the interplay of internal balance, external balance, and policy.

- *Internal Balance:* Output and inflation are determined by the interaction of demand and supply in the form of an extended IS curve and an associated set of Phillips curves.
- *External Balance:* The exchange rate adjusts to close the balance of payments (BoP).[11] It does so through its effects on net exports and other components of the BoP. Notably, financial flows depend on the difference between domestic and foreign interest rates adjusted for expected depreciation—i.e. the deviation from UIP. This simple formulation captures the implications of all external shocks and policies, such as FXI, that affect the need for portfolio capital flows to close the BoP. It also provides a role for CFMs, which can influence the effective interest rate received by foreign investors, the stock of NFA that shapes the economy's response to shocks, and the magnitude of the capital flow response to the UIP differential.
- *Policy:* Fiscal policy, monetary policy, FXI, and CFMs are in general functions of inflation, output, debt, the exchange rate, and other objectives.

  We now discuss each of these elements in turn.

2.1 Internal balance

The FINEX has a more detailed breakdown of aggregate demand than is common for semi-structural forecasting models. Explicit treatment of exports and imports

[11] In a peg, the FXI and/or interest rate reaction functions obviate the need for exchange rate adjustment.

strengthens the connection with the BoP. These plus the components of absorption facilitate the analysis of a larger range of fiscal policy instruments.

Demand is captured through an IS curve, i.e. a domestic market clearing condition (1) that states that real gross domestic product (Y^R) equals the sum of private consumption (C^R), private investment (I^R), government absorption (G^R) and exports (X^R) minus imports (M^R).

$$Y_t^R = C_t^R\left(r_t^R, \cdot\right) + I_t^R\left(r_t^R, \cdot\right) + G_t^R + X_t^R\left(Z_t, Y_t^{R,*}, \cdot\right) - M_t^R\left(Z_t, Y_t^R, \cdot\right) \tag{1}$$

Private consumption and investment are functions of the real interest rate (r^R) and other factors denoted here and elsewhere by '$\cdot$'. Exports and imports depend on the real exchange rate (Z). Exports also depend on real foreign output ($Y^{R,*}$) and imports on domestic output (Y^R). In sum, Y^R depends on the real exchange rate, the real interest rate, and external demand.

A set of Phillips curves (described in Section 3) determines the evolution of prices as a function of the output gap and other terms.

A simple production function $\overline{Y}_t^R\left(K_{t-1}^R\right)$ determines trend (i.e. potential) output, where K^R is stock of capital. Capital accumulates according to (2) where δ^{K^R} is depreciation rate.[12]

$$K_t^R = \left(1 - \delta^{K^R}\right) K_{t-1}^R + I_t^R \tag{2}$$

The explicit dependence of potential output on capital stocks has important implications. Fiscal policy affects trend growth, both directly through the public capital stock and indirectly because the level of public debt can affect UIP premia, as we will see below. Similarly, policies such as CFMs and FXI that affect the stock of foreign exchange reserves and NFA can matter for long-run real interest rates and hence for the private capital stock and the level of potential output.

2.2 External balance

We model the BoP constraint explicitly. Because of imperfect capital mobility, all external shocks—such as to global risk appetite, aid flows, or the terms of trade—have implications for the required quantity of financial flows and therefore for the exchange rate and thus for internal balance. Thus, we capture the implications of all these shocks. We also capture the implications of different degrees of cross-border capital mobility, as well as of policies such as FXI and CFMs that act directly on the BoP.

[12] The full model features both private and public capital.

The BoP constraint is represented by the BoP identity (3): Exports (X^Y) less imports (M^Y) together with net exogenous financial inflows ($FA^{Exo,Y}$) and net endogenous (i.e. interest-rate-sensitive) financial inflows ($FA^{O,Y}$) less foreign exchange purchases (FXI^Y) must equal zero. Note that variables with superscript “Y” in equation (3) and elsewhere, represent ratios to nominal gross domestic product (GDP).

$$\begin{aligned} 0 =& X_t^Y\left(Z_t, Y_t^{R,*}, \cdot\right) - M_t^Y\left(Z_t, Y_t^R, \cdot\right) + FA_t^{Exo,Y} \\ &+ FA_t^{O,Y}\left(\gamma_t - \tilde{\gamma}_t\left(\overset{(+)}{B_t^Y}, \overset{(-)}{FXR^Y}_t, \overset{(-)}{NFA^{O,Y}}_t\right) - \varepsilon_t^\gamma\right) - FXI_t^Y \end{aligned} \tag{3}$$

Exports (both real and nominal) are a function of the real exchange rate (Z) and foreign demand represented by foreign real GDP ($Y^{R,*}$). Similarly, imports (both real and nominal) depend on the real exchange rate and domestic demand. Exogenous (non-interest-sensitive) flows could include, for example foreign aid, remittances, or foreign direct investment.

Endogenous private financial inflows $FA^{O,Y}$—think portfolio flows and cross-border bank lending — play a special role in FINEX. They depend on the expected rate of return on domestic vs foreign interest-bearing assets, γ, defined in (4) as the difference between the domestic (r^R) and the foreign real interest rate ($r^{R,US}$), adjusted for expected real exchange rate depreciation (Δz_{t+1}).[13] This is just the uncovered interest parity (UIP) premium.

$$\gamma_t = r_t^R - r_t^{R,US} - \Delta z_{t+1} \tag{4}$$

In assessing how much financing they are willing to provide, investors compare the UIP premium to their required rate of return, which has an exogenous risk-on/off term ε_t^γ and a state-contingent component, $\tilde{\gamma}_t$. The state-contingent component rises with a higher public-debt-to-GDP ratio and falls with higher reserves and private NFA. As discussed in Section 3.2, these functions are exponential, such that changes in the stocks have little effect until the stocks are at vulnerable levels, at which point the impacts are much larger. These nonlinearities are important for capturing, albeit in a more continuous manner, the effect of ‘sudden stops’ of capital flows.[14]

[13] z_t denotes 100 times the natural logarithm of Z_t. Δz_{t+1} stands for the model-consistent rational expectation of real exchange rate depreciation; we omit the usual expectations operator E_t. Box 2 explains the notation in more detail.

[14] These sudden stops are modeled as occasionally-binding constraints in Basu et al. (2020) and Adrian et al. (2021). The approach here is tractable and produces plausible forecasts, at least outside of extreme crises.

In other words, $FA^{O,Y}$ is a supply function for endogenous capital flows:[15]

$$FA_t^{O,S} = FA_t^{O,Y}\left(\gamma_t - \tilde{\gamma}_t\left(\overset{(+)}{B_t^Y}, \overset{(-)}{FXR^Y}_t, \overset{(-)}{NFA^{O,Y}}_t\right) - \varepsilon_t^{\gamma}\right) \tag{5}$$

The derivative $\frac{\partial FA^{O,Y}}{\partial\gamma}$ plays a critical role. It captures the responsiveness of capital flows to the UIP premium and is thus a measure of the degree of capital mobility (or, equivalently, the substitutability of domestic and foreign assets, or, as is said in Basu et al. (2020), the depth of foreign exchange markets.) Thus it partly depends on the intensity of capital controls, as we will see in Section 2.3.[16]

Meanwhile, the rest of the BoP constraint defines a demand curve as an implicit function of the policy interest rate and the exchange rate, because of their implications for imports and exports:

$$FA_t^{O,D} = M_t^Y\left(Z_t, Y_t^R, \cdot\right) - X_t^Y\left(Z_t, Y_t^{R,*}, \cdot\right) + FXI_t^Y - FA_t^{Exo,Y} \tag{6}$$

The UIP premium and the scale of endogenous financial inflows are then equilibrium outcomes of supply and demand for these flows. Box 3 in Section 3.2 elaborates more on this interpretation after explaining in more detail how external balance is modeled.

Figure 1 presents (5) and (6) in $\left(\gamma, FA^{O,Y}\right)$ space. Supply slopes up because portfolio flows respond to the UIP premium, in essence the basic Gabaix and Maggiori (2015) (or Mundell-Fleming) mechanism. The slope of the supply curve is a measure of the openness of the capital account. Demand slopes down because, through the rest of the model and other things being equal, a higher premium (through some combination of higher policy rates and a depreciated exchange rate) increases the trade balance.[17]

The supply-demand framing helps illustrate some general features of the interaction between BoP shocks, the UIP premium, and openness of the capital account.[18] A shock to demand for portfolio flows, such as to $FA_t^{Exo,Y}$ or imports, shifts the demand curve laterally. For example, FXI in the form of the sale of foreign exchange

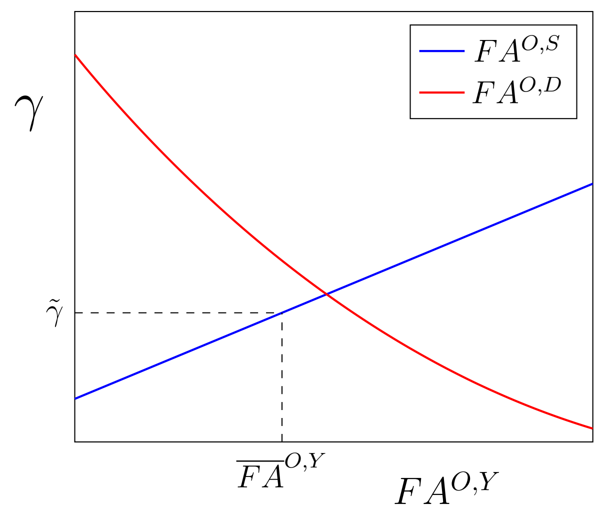
[15] This is for a (managed) floating regime. In a peg, the quantity of FXI responds endogenously to close the BoP.

[16] Even absent explicit capital account restrictions, however, domestic assets are generally not perfect substitutes for foreign assets, as discussed in footnote 9.

[17] Conceivably, the premium could be higher through a combination of higher interest rates and a (less) appreciated exchange rate, and the negative exchange rate effect on the trade balance could outweigh the positive interest rate effect. For reasonable calibrations this does not seem likely.

[18] These features can also be found in Basu et al. (2020) and Adrian et al. (2021).

Figure 1. Supply and demand for endogenous capital flows



shifts demand to the left, lowering the UIP premium and reducing the size of financial inflows. Similarly, a negative shock to the supply curve shifts the supply curve to the left, raising the UIP premium and reducing the scale of financial inflows.[19] Finally, a decline in risk appetite, understood as a shock to investors' required rate of return (ε_t^{γ} in (5)), shifts the supply curve up, also calling for an increase in the UIP premium and a decline in financial inflows.[20]

Capital mobility plays a critical role in the response of the system to these various shocks. When the capital account is open, the supply curve is flat, and quantity shocks such as due to imports, FXI, or 'noisy traders' induce lateral shifts that do not call for much adjustment—endogenous flows compensate, with little need for change in the UIP premium. When in contrast the capital account is closed, for example because of extensive administrative CFMs, the same shifts call for large movements in the premium. In the limit of financial autarky, changes in the premium must adjust fully to any changes to demand or supply for portfolio capital, and the quantity of financial flows does not change. In contrast, negative shocks to investor risk appetite or increases in capital inflow taxes, which shift the supply curve vertically, call for large changes in the premium, even with an open capital account.

This specification of the UIP premium is consistent with that in Basu et al. (2020) and Adrian et al. (2021), though it is more general in one respect. In these papers, it is the *stock* of NFA that determines the UIP premium. Here, the UIP premium depends both on the size of portfolio *flows* and, through their effect on investors' re-

[19] This is analogous to a 'noisy trader' (Basu et al. (2020)) or 'non-optimizing financial intermediary' (Adrian et al. (2021)) capital account shock.

[20] As we will see later, changes in price-based CFMs, such as those emphasized in Basu et al. (2020) and Adrian et al. (2021), also cause vertical shifts in the supply curve.

quired rate of return, on the *stock* of public debt, the NFA position, and reserves.[21]

We choose this hybrid flow-and-stock specification for practical purposes. In many EMDEs, changes in capital inflows that are modest relative to the NFA stock can lead to strong pressures on the exchange rate. Changes in stocks of debt and reserves also have an influence, but one that is quantitatively much smaller, dollar for dollar. This hybrid formulation captures both effects and thus fits the data better and lends itself to producing plausible forecasts.

Of course the figure shows only the impact of the shocks, and it abstracts from some key features of the capital account. It also neglects the endogenous response of policy, to which we now turn. Section 4 presents simulations using the full quantitative model.

2.3 Macroeconomic policies

In FINEX a central bank wields a policy interest rate, possibly complemented with FXI and CFMs. The government sets various fiscal instruments.

2.3.1 Monetary policy

The baseline specification assumes an IT regime. The central bank sets the short-term nominal policy interest rate r according to an interest-rate rule (7), of the general form:

$$r_t = \mathcal{F}^r \left(\pi^C_{t+1} - \overline{\pi}^C, \cdot\right) \tag{7}$$

Under a free floating exchange rate regime, $FXI^Y_t = 0$. The model accommodates pegged and managed exchange rates under any degree of capital mobility. These regimes follow an FXI rule along the lines of (8).

$$FXI^Y_t = \mathcal{F}^{FXI^Y} \left(\Delta s^{US}, \cdot\right) \tag{8}$$

FXI affects the exchange rate and the UIP premium because it affects the quantity of capital inflows required to close the BoP constraint (3).[22]

[21] Gabaix and Maggiori (2015) emphasize that both stocks and flows matter for exchange rate determination when assets are imperfect substitutes. In Kumhof et al. (2010), the UIP premium depends on the ratio of the current account balance-to-GDP.

[22] In the limiting case of perfect capital mobility, the interest rate needs to adjust fully to changes in the foreign interest rate and risk appetite, with no role for FXI. In terms of Figure 1, the supply curve is flat and thus the lateral shifts in demand for capital flows induced by FXI have little effect, as the induced endogenous flows exactly compensate for the FXI, with no effect on the UIP premium.

CFMs can be captured in two places. First, administrative measures such as restrictions on net foreign exchange positions of financial institutions will reduce the responsiveness of capital inflows to the UIP premium $\frac{\partial FA_t^{O,Y}}{\partial \gamma_t}$. Second, measures such as explicit taxes on capital flows can be captured by modifying (3) as follows, where τ^{FA^O} is the tax rate on capital inflows:[23]

$$\begin{aligned} 0 = X_t^Y\left(Z_t, Y_t^{R,*}, \cdot\right) - M_t^Y\left(Z_t, Y_t^R, \cdot\right) + FA_t^{Exo,Y} \\ + FA_t^{O,Y}\left(\gamma_t - \tilde{\gamma}_t\left(B_t^Y, FXR_t^Y, NFA_t^{O,Y}\right) - \tau_t^{FA^O} - \varepsilon_t^{\gamma}\right) - FXI_t^Y \end{aligned} \tag{9}$$

2.3.2 Fiscal policy

FINEX introduces various fiscal policy instruments together with local currency (LCY) and foreign currency (FCY)-denominated debt. Several other parts of the model are also enriched to accommodate fiscal policy transmission mechanisms. In doing so, the model does not assume Ricardian equivalence.

A simplified version of the fiscal block consists of:

- a deficit identity (10) which states that the overall government deficit (GD) equals government absorption (G) and interest payments ($\frac{r_{t-1}^G}{100}B_{t-1}$) less revenues ($GR$);
- a debt accumulation identity (11);
- a fiscal policy reaction function (12) according to which the government deficit depends on nominal GDP (Y), the debt-GDP ratio target ($\overline{B}^Y$), the output gap ($\hat{y}^R$), deviations of the debt-GDP ratio from its target ($\hat{B}^Y$), and other factors denoted by ($\cdot$).

$$GD_t = G_t + \frac{r_{t-1}^G}{100}B_{t-1} - GR_t\left(Y_t, C_t, M_t, \cdot\right) \tag{10}$$

$$B_t = GD_t + B_{t-1} \tag{11}$$

$$GD_t = \mathcal{F}^{GD}\left(Y_t, \overline{B}^Y, \hat{B}_t^Y, \hat{y}_t^R, \cdot\right) \tag{12}$$

[23] In terms of Figure 1, adminisrative CFMs change the slope of the supply curve, while changes in capital-inflow taxes shift it vertically. Basu et al. (2020) and Adrian et al. (2021) emphasize the second channel.

As will be clearer from Section 3.3.2, the fiscal rules in FINEX ensure fiscal sustainability in the long term. This means that the model does not support quantitative analysis of unsustainable fiscal policies beyond just simply identifying such policies as unsustainable.

We now have an overview of internal balance, external balance, and policies. To illustrate how these three elements interact, Box 1 presents the traditional IS-MP-BP model as a static and simplified version of FINEX. This overview section concludes with an explanation of the gap-trend structure of the model.

Box 1. FINEX and IS-MP-BP

FINEX is much richer than the Mundell-Fleming/IS-MP-BP model, yet they share some core relationships and intuition. By fixing prices and removing the dynamics and the gap-trend structure, we can further simplify the stylized model presented in this section. This allows us to reproduce a textbook diagram for analyzing the interplay of internal balance, external balance, and policy. We can even gain some insight into the interactions of fiscal policy, monetary policy, financial market depth, FXI, and CFMs.

A basic reference is Dornbusch and Fischer (1981) (first or second edition only—apparently imperfect capital mobility lost favor subsequently) or Gallego (2022), though like Romer (2000) we use an MP curve that relates output to the interest rate, rather than to the money supply as in an LM curve. We focus in this box on the floating-exchange rate case.

The IS curve is a simple version of the domestic market clearing condition (1):

$$Y^R = C^R(r^R) + I^R(r^R) + G^R + X^R(Z, Y^{R,*}) - M^R(Z, Y^R) \tag{13}$$

The MP curve is a stylized interest rate rule (7):

$$r^R = \mathcal{F}^{r^R}\left(Y^R - \overline{Y}^R\right) \tag{14}$$

The BP curve is a simplified static BoP constraint (3):

$$0 = X^R(Z, Y^{R,*}) - M^R(Z, Y^R) + FA^{O,Y}(\gamma) \tag{15}$$

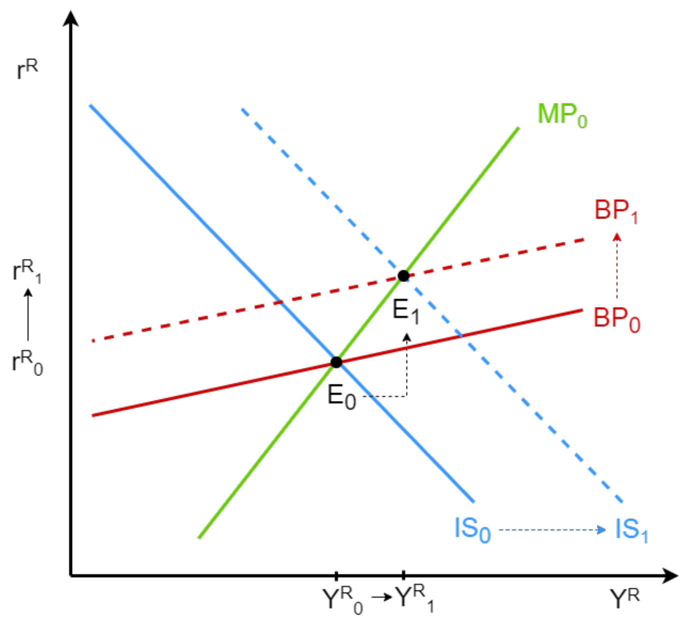
This is a one-period model. We assume that the expected exchange rate returns to the initial (and steady-state) level one period after the shock, along with all other variables. We can thus think of a simplified UIP premium term $\gamma = r^R - r^{R,*} - \frac{Z}{Z_0}$.

This curve implicitly defines an upward-sloping "BP" curve in r^R, Y^R space (for a given exchange rate). Higher Y^R raises imports, and higher r^R attracts capital inflows to finance them. The steepness of the curve depends on the balance of these two factors. A highly open capital account implies a relatively flat BP curve, because a small increase in interest rates draws in enough capital to finance a large increase in imports. Note the core role of endogenous capital flows and their responsiveness to the UIP premium in (15).

Figure 2 shows how a fiscal expansion works in this IS-MP-BP simplification of the FINEX. The government temporarily increases government transfers to households. Before the fiscal shock, the economy is in an equilibrium E_0 represented by the intersection of curves IS_0, MP_0, and BP_0. The increase in government transfers shifts the IS curve to the right. Interest rates increase as monetary policy reacts to the associated increase in aggregate demand, represented by the movement along the MP curve. The increase in aggregate demand and associated imports worsens the trade balance, but the higher interest rate attracts capital flows. If the BP curve is flatter than the MP curve, e.g. because the capital account is open, then the new intersection of the IS and MP curves will be above the BP curve, at point E_1, indicating an over-financed current account deficit. The exchange rate will thus tend to appreciate, shifting the BP curve up to BP_1. If the BP curve was steeper than the MP curve, the exchange rate would instead depreciate.

Even this simple set-up can capture some of the effects of CFM and FXI and their interactions. Administrative restrictions on capital inflows will steepen the BP curve, because they reduce the responsiveness of capital flows to a given interest rate. A tax on capital inflows, in contrast, would shift the BP curve up, to compensate for investors' loss of interest income. They would thus be effective even with a fully open capital account, i.e. with a flat BP curve. With a completely closed capital account (a vertical BP curve), a capital inflow tax would be ineffective. Sales of foreign exchange reserves (FXR) will shift the BP curve to the right by reducing the need for endogenous capital inflows to close the BoP. These, unlike a capital inflow tax, would thus be ineffective with a fully open capital account (a flat BP curve). Administrative CFMs, by steepening the BP curve, would thus increase the effectiveness of FXI. A risk-off shock could also be thought of as a downward shift in the BP curve. All this should not be pushed too far, not least given the absence of dynamics, and we prefer the richer FINEX model. But this exposition may help with some of the intuition.

Figure 2. IS-MP-BP aspect of the FINEX



2.4 Trends and the steady state

Most variables in FINEX are decomposed into a trend and a gap. For example, output consists of a supply-driven trend ($\overline{Y}^R$) and a gap ($\hat{y}^R$) determined by interaction of demand and supply (Box 2 explains the notation and concepts of gaps and trends in this paper):

$$Y_t^R = \overline{Y}_t^R\left(K_t^R, \cdot\right) \cdot \left(1 + \hat{y}^R/100\right) \tag{16}$$

The trends, in turn, converge eventually to a 'balanced-growth' steady state in which there is only one trend, such that the ratios of all trending variables, such as the share of consumption in GDP, are constant.

The interaction of gaps, trends, and the steady state plays a fundamental role in allowing the model to fit the data while maintaining theoretical consistency. In practice, great ratios, such as the share of consumption to GDP, trend for years, as do relative prices such as the relative price of traded goods, the real exchange rate, or the relative price of food. At the same time, as with any rational-expectations model, it is important to have a well-defined steady state towards which the model will converge, as long as policies are fundamentally stabilizing (e.g. monetary policy follows the Taylor principle and fiscal policy acts to stabilize the debt-GDP ratio.)

In DSGE models there is typically only one common trend.[24] This means that they

[24] Some DSGE models explicitly incorporate multiple stochastic trends (see Burriel et al. (2010)

set aside the dynamics of the trends and that convergence of economy to its steady-state balanced growth path is the same as convergence of the gaps to the trend. Here, in contrast, the convergence of economy to the steady-state balanced growth path has two components. Convergence of the gaps to the trends and convergence of the trends to the steady-state balanced growth path. This allows us to consider scenarios where the trends converge slowly to or deviate permanently from the original steady-state balanced growth path. We can thus model realistic cyclical dynamics and take into account the reality of multiple, and time-varying, trends in the data.

Box 2. Gaps, trends, and the steady state in FINEX: notation and definitions

We adopt the following notation. The trend for a variable X_t is denoted by a 'bar' ($\overline{X}_t$), the gap (i.e. $\frac{X_t - \overline{X}_t}{\overline{X}_t}$) by a 'hat' ($\hat{X}_t$), and 100 times the natural logarithm of X_t with small case letters ($x_t = 100 \cdot \ln(X_t)$). The ratio of a nominal variable X_t to nominal GDP in percent is denoted by adding 'Y' in superscript (X_t^Y). A superscript 'R' (X_t^R) denotes a real counterpart to a nominal variable. Foreign variables are denoted with an asterisk (X_t^*). X_{t+j} represents the rational expectation of variable (X) in period t+j, formed in period t.

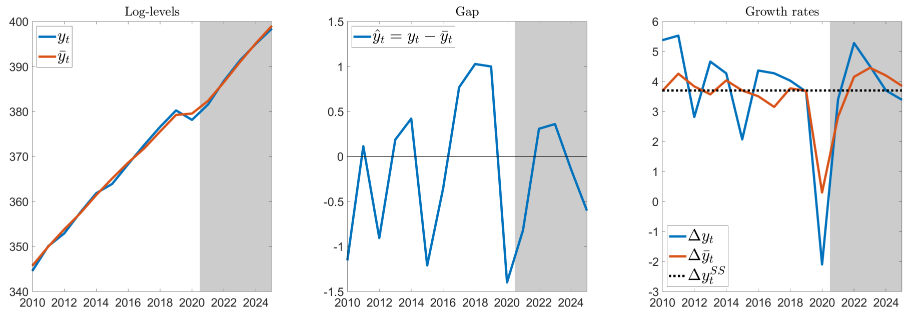
Real variables are often decomposed into 'trend' and 'gap' components, $x_t^R = \overline{x}_t^R + \hat{x}_t^R$. The gap, $\hat{x}_t^R$, describes the business cycle dynamics of a variable, and the trend, $\overline{x}_t^R$, its secular dynamics. We interchangeably refer to the business cycle dynamics as 'cyclical' or 'short-term' and to the secular dynamics as 'trend', 'medium-term', 'equilibrium', or 'potential'. 'Closing of the gap' refers to a variable's convergence to its trend path as the effects of business cycle shocks dissipate, typically over a period of 3-5 years.

The trend of a variable is smooth but time-varying; it tends to converge to a steady state or long-run value over a longer period of time, typically 10-15 years. The steady state is characterized by balanced growth. All stationary variables (e.g., growth rates, interest rates, shares of GDP) settle at constant numerical values, and all non-stationary variables (notably the levels of real and nominal macroeconomic variables) grow at a constant rate. Steady-state values for the stationary variables are either explicitly calibrated (denoted in the model as x^{SS}) or derived from the steady states of other variables (denoted as $\mathcal{S}(x_t)$ in this case).

Figure 3 illustrates the gap, trend, and steady state for an illustrative real GDP variable.

and Copaciu et al. (2015) among others). However, including an increasing number of trends poses significant modeling challenges and often relies on critical assumptions regarding the underlying drivers of economic growth.

Figure 3. A gap, a trend, and a steady state



In FINEX, the trends of the main variables (denoted by a 'bar') are connected by economic relationships analogous to those of their gap counterparts. This is important particularly because fiscal policy has both business-cycle and longer-term effects.

There are thus trend versions of the BoP constraint (17), UIP condition (18), domestic market-clearing condition (19), interest rate rule (20), government deficit identity (21) and fiscal policy rule (22).

$$
\begin{aligned}
0 = {} & \overline{X}_t^Y\left(\overline{Z}_t, \overline{Y}_t^{R,*}, \cdot\right) - \overline{M^R}_t^Y\left(\overline{Z}_t, \overline{Y}_t^R, \cdot\right) + \overline{FA}_t^{Exo,Y} \\
& + \overline{FA}_t^{O,Y}\left(\overline{\gamma}_t - \tilde{\gamma}_t\left(B_t^Y, FXR_t^Y, NFA_t^{O,Y}\right)\right)
\end{aligned} \tag{17}
$$

$$\overline{\gamma}_t = \overline{r}_t^R - \overline{r}_t^{R,US} - \Delta\overline{z}_{t+1} \tag{18}$$

$$\overline{Y}_t^R\left(K_{t-1}^R, \cdot\right) = \overline{C}_t^R\left(\overline{r}_t^R, \cdot\right) + \overline{I}_t^R\left(\overline{r}_t^R, \cdot\right) + \overline{G}_t^R + \overline{X}_t^R\left(\overline{Z}_t, \overline{Y}_t^{R,*}, \cdot\right) - \overline{M}_t^R\left(\overline{Z}_t, \overline{Y}_t^R, \cdot\right) \tag{19}$$

$$\overline{r} = \overline{r}^R + \overline{\pi}^C \tag{20}$$

$$\overline{GD}_t = \overline{G}_t + \frac{\overline{r}_{t-1}^G}{100} B_{t-1} - \overline{GR}\left(\overline{Y}, \overline{C}, \overline{M}^R, \cdot\right) \tag{21}$$

$$\overline{GD}_t = \mathcal{F}^{GD}\left(\overline{Y}_t, \overline{B}^Y, \cdot\right) \tag{22}$$

These equations connect trends in external balance, the real exchange rate ($\overline{Z}$), the UIP premium ($\overline{\gamma}$), real and nominal trend interest rates ($\overline{r}^R$ and $\overline{r}$), internal balance, potential GDP ($\overline{Y}^R$), the structural government deficit ($\overline{GD}$), and debt ($\overline{B}^Y$).

To illustrate the interaction of trend variables, consider a permanent drop in foreign demand, represented by a drop in foreign GDP ($\overline{Y}^{R,*}$). In response, exports ($\overline{X}^Y$)

fall and the current account balance (CAB) becomes more negative, which requires an immediate *permanent* depreciation of the real exchange rate ($\overline{Z}$) and a *permanent* increase in the UIP premium ($\overline{\gamma}$) in order to restore external and internal balance. The permanently higher premium would lead to permanently higher real and nominal interest rates ($\overline{r}^R$ and $\overline{r}$). The higher costs of borrowing would discourage investment and result in a gradual and permanent drop in potential GDP ($\overline{Y}^R$).

3 The FINEX in detail

3.1 Internal balance

FINEX contains a detailed decomposition of aggregate demand. Relative to a traditional QPM, this enables better identification and analysis of the drivers of economic growth, the nature of shocks, and especially a richer analysis of fiscal policies, as revenue can be linked to specific GDP components while short- and longer-run multipliers can depend on the type of expenditure.

Real aggregate demand is split into five main components: private consumption (C_t^R), private investment (I_t^R), government absorption (G_t^R), exports (X_t^R), and imports (M_t^R). Exports are further decomposed into natural resource ($X_t^{R,NR}$) and non-natural resource components ($X_t^{R,NNR}$), and imports into oil ($M_t^{R,OIL}$) and non-oil ($M_t^{R,NOIL}$).

$$\begin{aligned} Y_t = {} & P_t^{C,T} \cdot C_t^R + P_t^I \cdot I_t^R + P_t^{X^{NNR}} \cdot X_t^{R,NNR} + P_t^{X^{NR}} \cdot X_t^{R,NR} \\ & - P_t^{M^{NOIL},T} \cdot M_t^{R,NOIL} - P_t^{M^{OIL},T} \cdot M_t^{R,OIL} + P_t^G \cdot G_t^R \end{aligned} \tag{23}$$

The aggregate real output gap $\hat{y}_t^R$ (24) is the weighted sum of the corresponding gaps in each expenditure component (denoted by $\hat{c}_t^R$, $\hat{i}_t^R$, ...). The weights are determined by the nominal expenditure shares to GDP, more precisely the trend component shares of nominal GDP (denoted by $\overline{C}_t^Y$, $\overline{I}_t^Y$, ...). Similarly, potential real GDP growth $\Delta\overline{y}_t^R$ (25) is the weighted sum of growth rates in trends of expenditure components.[25]

$$\begin{aligned} \hat{y}_t^R = {} & \overline{C}_t^Y/100 \cdot \hat{c}_t^R + \overline{I}_t^Y/100 \cdot \hat{i}_t^R + \overline{X}_t^{NNR,Y}/100 \cdot \hat{x}_t^{R,NNR} + \overline{X}_t^{NR,Y}/100 \cdot \hat{x}_t^{R,NR} \\ & - \overline{M}_t^{NOIL,Y}/100 \cdot \hat{m}_t^{R,NOIL} - \overline{M}_t^{OIL,Y}/100 \cdot \hat{m}_t^{R,OIL} + \overline{G}_t^Y/100 \cdot \hat{g}_t^R \end{aligned} \tag{24}$$

[25] As is standard in semi-structural models, trend dynamic for non-stationary variables in FINEX (including potential GDP) are modeled in growth rates, which are stationary.

$$
\begin{aligned}
\Delta\overline{y}_t^R = {} & \overline{C}_{t-1}^Y/100 \cdot \Delta\overline{c}_t^R + \overline{I}_{t-1}^Y/100 \cdot \Delta\overline{i}_t^R + \overline{X}_{t-1}^{NNR,Y}/100 \cdot \Delta\overline{x}_t^{R,NNR} \\
& + \overline{X}_{t-1}^{NR,Y}/100 \cdot \Delta\overline{x}_t^{R,NR} - \overline{M}_{t-1}^{NOIL,Y}/100 \cdot \Delta\overline{m}_t^{R,NOIL} \\
& - \overline{M}_{t-1}^{OIL,Y}/100 \cdot \Delta\overline{m}_t^{R,OIL} + \overline{G}_{t-1}^Y/100 \cdot \Delta\overline{g}_t^R
\end{aligned}
\tag{25}
$$

In what follows, we first describe the general structure of the equations for demand components and their prices and discuss unifying modeling features and techniques (sections 3.1.1 and 3.1.2, respectively). We next describe the determinants of each component (section 3.1.3). Finally, we discuss the production function and the relationship between investment and potential GDP growth (section 3.1.4).

3.1.1 Demand components: generic structure

The dynamics of each of the demand components, except for government absorption G_t^R, which follows a different process (see section 3.3.2), are modeled by the following representative block of equations:[26]

$$
\hat{\boldsymbol{x}}_t = \rho_{\boldsymbol{x}} \cdot \hat{\boldsymbol{x}}_{t-1} + (1-\rho_{\boldsymbol{x}}) \cdot \hat{\boldsymbol{x}}_{t+1} + determinants_t^{\hat{\boldsymbol{x}}} + \varepsilon_t^{\hat{\boldsymbol{x}}} \tag{A1}
$$

$$
\begin{aligned}
\Delta\overline{\boldsymbol{x}}_t = {} & \alpha_1 \cdot \Delta\overline{\boldsymbol{x}}_{t-1} + (1-\alpha_1) \cdot \left(\Delta\overline{y}_t^R + \Delta\overline{p}_t^{R,Y} - \Delta\overline{p}_t^{R,\mathcal{X}}\right) \\
& - \alpha_2 \cdot \left(\overline{\mathcal{X}}_t^Y - \left(\overline{\mathcal{X}}^{Y,SS} - determinants_t^{\Delta\overline{\boldsymbol{x}}}\right)\right) + \varepsilon_t^{\Delta\overline{\boldsymbol{x}}}
\end{aligned}
\tag{A2}
$$

Small letter variables represent real GDP components expressed in logarithmic form, as per the conventional notation explained in Box 2:

$$
\boldsymbol{x}_t = 100 \cdot \log\left(\mathcal{X}_t\right), \text{ where } \mathcal{X} \in \left\{C^R, I^R, X^{R,NNR}, X^{R,NR}, M^{R,NOIL}, M^{R,OIL}\right\}
$$

Each is decomposed into a trend, $\overline{\boldsymbol{x}}_t$, and a gap, $\hat{\boldsymbol{x}}_t$ ($\boldsymbol{x}_t = \overline{\boldsymbol{x}}_t + \hat{\boldsymbol{x}}_t$). Trend growth rates are defined in log-difference terms ($\Delta\overline{\boldsymbol{x}}_t = \overline{\boldsymbol{x}}_t - \overline{\boldsymbol{x}}_{t-1}$). Variable $\Delta\overline{y}_t^R$ denotes potential real GDP growth, $\Delta\overline{p}_t^{R,\mathcal{X}}$ denotes a trend growth rate in the relative price of the component $\mathcal{X}$ with respect to private consumption, C^R, and $(\Delta\overline{p}_t^{R,Y} - \Delta\overline{p}_t^{R,\mathcal{X}}) \equiv \Delta\overline{p}_t^{R,Y,\mathcal{X}}$ represents a trend growth rate in the relative price of GDP with respect to component $\mathcal{X}$.[27]

[26] The numbering of these equations (A1, A2, …), reflects the fact that they are generic and not actually part of the model.

[27] The relative price for each component, as well as for GDP, is defined in relation to the price of consumption good, i.e., $p_t^{R,\mathcal{X}} = p_t^{\mathcal{X}} - p_t^C$. This is discussed in more detail in section 3.1.2.

A representative 'gap' equation for component $\mathcal{X}$ includes a lag term, $\hat{\boldsymbol{x}}_{t-1}$, reflecting real rigidities, e.g., habit formation in consumption; a model-consistent expectation term, $\hat{\boldsymbol{x}}_{t+1}$, reflecting forward-looking behavior of economic agents; and a range of component-specific determinants, $determinants_t^{\hat{x}}$, that impact business cycle dynamics of the component $\mathcal{X}$ (for example, a real interest rate gap or a fiscal instrument). All gaps close in equilibrium (i.e., the real variables return to their corresponding trends), underpinned by stabilizing macroeconomic policies, notably reaction functions that bring inflation back to target and that stabilize the public-debt-to-GDP ratio in the long run.

A representative 'trend' equation for component $\mathcal{X}$ (A2) is specified as an AR(1) process for the growth rate of the corresponding trend. It incorporates an adjustment mechanism (the third term in (A2)) that ensures that the level of the trend component, $\overline{\mathcal{X}}_t$, converges in the steady state to the balanced growth path (BGP) characterized by constant nominal expenditure share to GDP, $\overline{\mathcal{X}}^{Y,SS}$.[28] In other words, if $\overline{\mathcal{X}}_t^Y$ deviates from $\overline{\mathcal{X}}^{Y,SS}$, then trend growth ($\Delta\overline{\boldsymbol{x}}_t$) adjusts gradually to bring it back to steady state.

As in the case of gaps, movements of the trends relative to the BGP are determined by component-specific factors ($determinants_t^{\Delta\overline{x}}$) that impact the longer-term dynamics (e.g., government tax policies to maintain debt sustainability, shifts in the trend real interest rate, permanent changes in remittances inflows, among others).

We discuss the component-specific determinants for both gaps and trends of the demand components in section 3.1.3.

3.1.2 Price setting: generic structure

Each demand component $\mathcal{X}$, has its own price deflator, $p_t^{\mathcal{X}}$ (A3). The relative price for each component, $p_t^{R,\mathcal{X}}$, is expressed in relation to the price of the consumption good, p_t^C, and is non-stationary (A4).[29]

Trends in relative prices, such as those of food and fuel, present first-order challenges to monetary policy in many countries, particularly in EMDEss. Modeling them requires substantial additional notation and complexity, but changes in relative prices movements can be important drivers of overall inflation dynamics. Ignoring them can produce misleading analyses and forecasts, especially if these trends in relative prices are highly persistent or permanent.[30]

[28] As explained in Box 2, a BGP in the model is defined such that all real expenditure components grow at the rates which ensure that the nominal expenditure shares-to-GDP remain constant.

[29] In FINEX, p_t^C represents the headline CPI. In a typical country application, p_t^C would be further disaggregated, e.g. into core and non-core components.

[30] See for example Andrle et al. (2013) for an exploration in a similar modeling framework.

The trend growth rate of each relative price, $\Delta\overline{p}_t^{R,\mathcal{X}}$, converges to its steady state value, $\Delta\overline{p}^{R,\mathcal{X},SS}$. In addition, the trend dynamics in relative prices of export components ($X^{R,NNR}$, $X^{R,NR}$) and import components ($M^{R,NOIL}$, $M^{R,OIL}$) are determined by the changes in the corresponding component-specific equilibrium real exchange rate (RER), denoted by $\Delta\overline{z}_t^{\mathcal{X}}$ (A5). As the export-specific (import-specific) equilibrium RER appreciates, the trend relative price of exports (imports) with respect to consumption decreases.[31]

$$p_t^{\mathcal{X}} = 100 \cdot \log(P_t^{\mathcal{X}}) \tag{A3}$$

$$p_t^{R,\mathcal{X}} = p_t^{\mathcal{X}} - p_t^{C} \tag{A4}$$

$$\Delta\overline{p}_t^{R,\mathcal{X}} = \begin{cases} \rho_{\mathcal{X}} \cdot \Delta\overline{p}_{t-1}^{R,\mathcal{X}} + (1-\rho_{\mathcal{X}}) \cdot \Delta\overline{p}^{R,\mathcal{X},SS} + \varepsilon_t^{\Delta\overline{p}^{R,\mathcal{X}}}, & \mathcal{X} \in \left\{I^R, G^R\right\} \\ \Delta\overline{p}^{R,\mathcal{X},SS} + \alpha_{\mathcal{X}} \cdot \left(\Delta\overline{z}_t^{\mathcal{X}} - \Delta\overline{z}^{\mathcal{X},SS}\right) + \varepsilon_t^{\Delta\overline{p}^{R,\mathcal{X}}}, & \mathcal{X} \in \left\{X^{R,NNR}, X^{R,NR}, M^{R,NOIL}, M^{R,OIL}\right\} \end{cases} \tag{A5}$$

Inflation rates for private consumption (π_t^C), private investment (π_t^I), and government absorption (π_t^G) follow hybrid New Keynesian (NK) Phillips curves with forward- and backward-looking behavior (A7a). Import and export price changes ($\pi_t^{X^{NNR}}$, $\pi_t^{X^{NR}}$, $\pi_t^{M^{NOIL}}$, $\pi_t^{M^{OIL}}$) are driven by the dynamics in international prices for the corresponding traded goods and services, $\pi_t^{\mathcal{X},*}$, expressed in domestic currency (A7b).

$$\pi_t^{\mathcal{X}} = p_t^{\mathcal{X}} - p_{t-1}^{\mathcal{X}} \tag{A6}$$

$$\begin{aligned} \pi_t^{\mathcal{X}} = a_{1,\mathcal{X}} \cdot \pi_{t-1}^{\mathcal{X}} + (1-a_{1,\mathcal{X}}) \cdot \pi_{t+1}^{\mathcal{X}} + a_{2,\mathcal{X}} \cdot RMC_t^{\mathcal{X}} \\ - a_{3,\mathcal{X}} \cdot \hat{p}_t^{R,\mathcal{X}} + \varepsilon_t^{\pi^{\mathcal{X}}}, \quad \mathcal{X} \in \left\{C^R, I^R, G^R\right\} \end{aligned} \tag{A7a}$$

$$\begin{aligned} \pi_t^{\mathcal{X}} = \left(\Delta\overline{p}_t^{R,\mathcal{X}} + \overline{\pi}_t^{C}\right) + a_{4,\mathcal{X}} \cdot \left(\pi_t^{\mathcal{X},*} + \Delta s_t^{US} - \left(\overline{\pi}_t^{C} + \Delta\overline{z}_t^{\mathcal{X}}\right)\right) \\ - a_{5,\mathcal{X}} \cdot \hat{p}_t^{R,\mathcal{X}} + \varepsilon_t^{\pi^{\mathcal{X}}}, \quad \mathcal{X} \in \left\{X^{R,NNR}, X^{R,NR}, M^{R,NOIL}, M^{R,OIL}\right\} \end{aligned} \tag{A7b}$$

All inflation equations embed an error-correction mechanism (through relative price gaps, $\hat{p}_t^{R,\mathcal{X}}$). This ensures convergence of relative prices to their medium-term

[31] In the baseline version of the model we assume a small open economy that is a price-taker in international markets. All foreign prices in the model (i.e. commodity prices and effective foreign CPI) are quoted in U.S. dollars and then adjusted by the local currency/USD exchange rate when calculating domestic export and import price deflators. This is also consistent with the dominant currency pricing (DCP) paradigm (Gopinath et al. (2020), Adler et al. (2020).) FINEX is also able to accommodate producer currency pricing (PCP) and local currency pricing (LCP).

trend values ($p_t^{R,\mathcal{X}} \rightarrow \overline{p}_t^{R,\mathcal{X}}$) and therefore convergence of inflation rates to their respective implicit targets, taking into account trends in relative prices ($\pi_t^{\mathcal{X}} \rightarrow \left(\Delta\overline{p}_t^{R,\mathcal{X}} + \overline{\pi}_t^{C}\right) \equiv \overline{\pi}_t^{\mathcal{X}}$).

Real marginal costs of domestic producers, $RMC_t^{\mathcal{X}}$, are determined by (i) the cost of domestic production factors (approximated by the gap in the respective component, $\hat{\boldsymbol{x}}_t$) and (ii) the cost of imported production factors (approximated by the relative prices of non-oil and oil imports to prices of the corresponding expenditure component, i.e., $(\hat{p}_t^{R,M^{NOIL}} - \hat{p}_t^{R,\mathcal{X}})$ and $(\hat{p}_t^{R,M^{OIL}} - \hat{p}_t^{R,\mathcal{X}})$ in equation (A8).

$$RMC_t^{\mathcal{X}} = b_{1,\mathcal{X}} \cdot \hat{\boldsymbol{x}}_t + b_{2,\mathcal{X}} \cdot \left(\hat{p}_t^{R,M^{NOIL}} - \hat{p}_t^{R,\mathcal{X}}\right) + b_{3,\mathcal{X}} \cdot \left(\hat{p}_t^{R,M^{OIL}} - \hat{p}_t^{R,\mathcal{X}}\right) \tag{A8}$$

Therefore, as the demand for good $\mathcal{X}$ rises above trend level ($\hat{\boldsymbol{x}}_t > 0$), its price increases. Similarly, as the relative price of imported intermediate good increases compared to the price of $\mathcal{X}$ ($\hat{p}_t^{R,M,\bullet} > \hat{p}_t^{R,\mathcal{X}}$), producers of good $\mathcal{X}$ face higher input costs, forcing them to increase the price for their final good.[32]

3.1.3 Demand components: determinants

Here we discuss the idiosyncratic determinants of business cycle and secular dynamics of each component of demand.

Private consumption

$$\begin{aligned}\hat{c}_t^R = {} & c_1^{\hat{c}^R} \cdot \hat{c}_{t-1}^R + c_2^{\hat{c}^R} \cdot \hat{c}_{t+1}^R - c_3^{\hat{c}^R} \cdot \hat{r}_t^R + c_4^{\hat{c}^R} \cdot \hat{y}_t^R - c_5^{\hat{c}^R} \\ & \cdot (\tau_t^C - \tau_{t+1}^C) + c_6^{\hat{c}^R} \cdot R\hat{E}M_t^Y + c_7^{\hat{c}^R} \cdot \widehat{GE}_t^{Tr,Y} + \varepsilon_t^{\hat{c}^R}\end{aligned} \tag{26}$$

$$\begin{aligned}\Delta\overline{c}_t^R = {} & c_1^{\Delta\overline{c}^R} \cdot \Delta\overline{c}_{t-1}^R + (1 - c_1^{\Delta\overline{c}^R}) \cdot (\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^R) \\ & - c_2^{\Delta\overline{c}^R} \cdot (\overline{C}_t^Y - (C^{Y,SS} - c_3^{\Delta\overline{c}^R} \cdot (\tau_t^C - \mathcal{S}(\tau^C)) \\ & + c_4^{\Delta\overline{c}^R} \cdot (\overline{REM}_t^Y - REM^{Y,SS}) + c_5^{\Delta\overline{c}^R} \cdot (\overline{GE}_t^{Tr,Y} - \mathcal{S}(\overline{GE}^{Tr,Y})))) + \varepsilon_t^{\Delta\overline{c}^R}\end{aligned} \tag{27}$$

Equation (26) models the development of private consumption over the business cycle. The private consumption gap, $\hat{c}^R$, is driven by available income from domestic sources (approximated by the output gap, $\hat{y}_t^R$) and cyclical remittance inflows, $R\hat{E}M_t^Y$. It is also affected by macroeconomic (monetary and fiscal) policies.

[32] The second term in (A8) thus captures the effects of the real exchange rate gap in typical QPM models.

Tighter real monetary/credit conditions in the economy (represented over the business cycle by a positive real interest rate gap, $\hat{r}_t^R > 0$) would reduce the private consumption gap as economic agents would tend to borrow less and save more. On the fiscal side, both expenditure and tax policies affect private consumption: (i) direct government transfers above their trend value ($\widehat{GE}_t^{Tr,Y} > 0$) support private consumption as economic agents receive additional disposable income; and (ii) a temporary decline in the consumption tax rate ($\tau_t^C - \tau_{t+1}^C < 0$) would increase contemporaneous demand for consumer goods as economic agents would tend to front-load consumption expenditures in anticipation of rising future prices.[33] Note that exchange rate does not (directly) affect private consumption. Its effect on import substitution is captured in imports equation (33) discussed below.

Equation (27) describes the dynamics of trend private consumption. As with other demand components, trend private consumption growth follows an AR(1) process, converging to potential real GDP growth adjusted by the trend in relative prices ($\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^R$, where $\Delta\overline{p}_t^{R,Y}$ denotes the trend growth in relative price of GDP to consumption). At the same time, trend consumption as a share of GDP, $\overline{C}_t^Y$, converges in the steady state to a constant, $C^{Y,SS}$. On the convergence path, $\overline{C}_t^Y$ is affected by the trends in remittance inflows ($\overline{REM}_t^Y$) and government transfers ($\overline{GE}_t^{Tr,Y}$)—both contributing positively to a higher potential consumption (as long as they are above their respective steady states). Additionally, $\overline{C}_t^Y$ is also impacted by the consumption tax, τ_t^C, in that higher tax rates constrain potential consumption growth and any permanent increase in the tax rate would have a lasting negative impact on the consumption-to-GDP ratio (namely, if $(\tau_t^C - \mathcal{S}(\tau_t^C)) > 0$ indefinitely, then $\overline{C}_t^Y < C^{Y,SS}$ permanently).

Private investment

$$\hat{i}_t^R = c_1^{\hat{i}^R} \cdot \hat{i}_{t-1}^R + c_2^{\hat{i}^R} \cdot \hat{i}_{t+1}^R - c_3^{\hat{i}^R} \cdot \hat{r}_t^R + c_4^{\hat{i}^R} \cdot \hat{c}_{t+1}^R + c_6^{\hat{i}^R} \cdot \hat{x}_{t+1}^{R,NNR} - c_5^{\hat{i}^R} \cdot (\hat{z}_t^{Mw} - \hat{p}_t^{R,I}) + \varepsilon_t^{\hat{i}^R} \quad (28)$$

$$\begin{aligned}\Delta\bar{i}_t^R = {} & c_1^{\Delta\bar{i}^R} \cdot \Delta\bar{i}_{t-1}^R + (1 - c_1^{\Delta\bar{i}^R}) \cdot (\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^R - \Delta\overline{p}_t^{R,I}) \\ & - c_2^{\Delta\bar{i}^R} \cdot (\overline{I}_t^Y - (I^{Y,SS} - c_3^{\Delta\bar{i}^R} \cdot (\overline{r}_t^R - (\overline{r}^{R,US,SS} + \gamma^{SS} + \Delta\overline{z}^{SS,US})) \\ & - c_4^{\Delta\bar{i}^R} \cdot (\tau_t^Y - \mathcal{S}(\tau^Y)))) + \varepsilon_t^{\Delta\bar{i}^R}\end{aligned} \quad (29)$$

[33] We do not explicitly model the household budget constraint in FINEX nor, therefore, household disposable income and savings. Instead, the output gap, cyclical remittance inflows, and government transfers gap all capture components of implicit disposable income over the business cycle, while monetary policy (through interest rates) and fiscal policy (through taxes) affect implicit savings/borrowing decisions of the economic agents. In turn, calibration of the corresponding elasticities in (26) to match observed data allows a realistic modeling of the effects of short-run fiscal multipliers and monetary-fiscal interactions. Remo et al. presents analysis of fiscal multipliers with a version of this model.

Equation (28) says that over the business cycle private investment will increase if businesses expect stronger domestic and/or foreign demand and decrease if the marginal cost of capital increases. Demand is proxied by expected private consumption, $\hat{c}_{t+1}^{R}$, and non-natural resource exports, $\hat{x}_{t+1}^{R,NNR}$. The cost of capital is driven by tighter domestic credit conditions (measured here by a widening real interest rate gap, $\hat{r}_t^R$) and costs of imported capital goods (due to a weakening import-weighted real effective exchange rate (REER) adjusted for relative prices, $\hat{z}_t^{Mw} - \hat{p}_t^{R,I}$.)

Equation (29) says that high trend real interest rates, $\overline{r}_t^R$, and high corporate income tax rates, τ_t^Y, relative to their respective steady state values, discourage potential private investment growth, $\Delta\bar{i}_t^R$, and reduce the investment-to-GDP ratio, $\overline{I}_t^Y$.

Non-natural resource (NNR) exports[34]

$$\begin{aligned}\hat{x}_t^{R,NNR} = {} & c_1^{\hat{x}^{R,NNR}} \cdot \hat{x}_{t-1}^{R,NNR} + c_2^{\hat{x}^{R,NNR}} \cdot \hat{x}_{t+1}^{R,NNR} + c_3^{\hat{x}^{R,NNR}} \\ & \cdot (\hat{z}_t^{Xw} - \hat{p}_t^{R,X^{NNR}}) + c_4^{\hat{x}^{R,NNR}} \cdot \hat{y}_t^{R,*} + \varepsilon_t^{\hat{x}^{R,NNR}}\end{aligned} \tag{30}$$

$$\begin{aligned}\Delta\overline{x}_t^{R,NNR} = {} & c_1^{\Delta\overline{x}^{R,NNR}} \cdot \Delta\overline{x}_{t-1}^{R,NNR} + (1 - c_1^{\Delta\overline{x}^{R,NNR}}) \cdot (\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^R - \Delta\overline{p}_t^{R,X^{NNR}}) \\ & - c_2^{\Delta\overline{x}^{R,NNR}} \cdot (\overline{X}_t^{NNR,Y} - (X^{NNR,Y,SS} + c_3^{\Delta\overline{x}^{R,NNR}} \cdot \overline{X}_t^{R,NNR,S})) + \varepsilon_t^{\Delta\overline{x}^{R,NNR}}\end{aligned} \tag{31}$$

$$\begin{aligned}\overline{X}_t^{R,NNR,S} = {} & c_1^{\overline{X}^{R,NNR,S}} \cdot \overline{X}_{t-1}^{R,NNR,S} + c_2^{\overline{X}^{R,NNR,S}} \cdot (\Delta\overline{p}_t^{R,X^{NNR}} - \mathcal{S}(\Delta\overline{p}^{R,X^{NNR}})) \\ & + (1 - c_2^{\overline{X}^{R,NNR,S}}) \cdot (\Delta\overline{y}_t^{R,*} - \mathcal{S}(\Delta\overline{y}^{R,*})) + \varepsilon_t^{\overline{X}^{R,NNR,S}}\end{aligned} \tag{32}$$

Equation (30) stipulates that over the business cycle NNR exports are driven by foreign demand (proxied by effective export-weighted foreign output gap, $\hat{y}_t^{R,*}$) and are impacted by the relative price competitiveness of exported goods on international trade markets—this is proxied by the export-weighted REER gap adjusted for relative prices, $\hat{z}_t^{Xw} - \hat{p}_t^{R,X^{NNR}}$, so that an undervalued REER stimulates export production.

Trend NNR export growth (31) is a function of trend foreign demand for NNR exports, proxied by the variable $\overline{X}_t^{R,NNR,S}$ defined in (32). $\overline{X}_t^{R,NNR,S}$ is increasing with the rising potential foreign GDP, $\Delta\overline{y}_t^{R,*}$, and with the fundamental improvements in the productivity and competitiveness of the NNR exports (proxied by the trend relative price dynamics, $\Delta\overline{p}_t^{R,X^{NNR}}$, which in turn depends on the REER as per (A5)).

[34] Natural resource (NR) exports have similar formulation to non-natural resource (NNR) exports (albeit follow simpler dynamics) presented in Annex A.

A sustained rise in $\overline{X}_t^{R,NNR,S}$ would lead to an increase in the trend NNR export-to-GDP share ($\overline{X}_t^{NNR,Y}$ in (31)), as domestic producers would tend to shift to the booming NNR export sector.

Non-oil (NOIL) imports[35]

$$\begin{aligned}\hat{m}_t^{R,NOIL} = {} & c_1^{\hat{m}^{R,NOIL}} \cdot \hat{m}_{t-1}^{R,NOIL} + c_2^{\hat{m}^{R,NOIL}} \cdot \hat{x}_t^{R,NNR} + c_3^{\hat{m}^{R,NOIL}} \cdot \hat{i}_t^{R} + c_4^{\hat{m}^{R,NOIL}} \\ & \cdot \hat{c}_t^{R} - c_5^{\hat{m}^{R,NOIL}} \cdot \hat{p}_t^{R,M^{NOIL}} - c_6^{\hat{m}^{R,NOIL}} \cdot (\hat{p}_t^{R,M^{NOIL}} - \hat{p}_t^{R,I}) \\ & + c_7^{\hat{m}^{R,NOIL}} \cdot \hat{g}_t^{R} - c_8^{\hat{m}^{R,NOIL}} \cdot (\tau_t^{M^{NOIL}} - \tau_{t+1}^{M^{NOIL}}) + \varepsilon_t^{\hat{m}^{R,NOIL}}\end{aligned} \tag{33}$$

$$\begin{aligned}\Delta\overline{m}_t^{R,NOIL} = {} & c_1^{\Delta\overline{m}^{R,NOIL}} \cdot \Delta\overline{m}_{t-1}^{R,NOIL} + (1 - c_1^{\Delta\overline{m}^{R,NOIL}}) \cdot (\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^{R} - \Delta\overline{p}_t^{R,M^{NOIL}}) \\ & - c_2^{\Delta\overline{m}^{R,NOIL}} \cdot (\overline{M}_t^{NOIL,Y} - (M_t^{NOIL,Y,SS} + c_3^{\Delta\overline{m}^{R,NOIL}} \cdot \overline{M}_t^{R,NOIL,D} + c_4^{\Delta\overline{m}^{R,NOIL}} \\ & \cdot (\overline{C}_t^{Y} - C^{Y,SS}) + c_5^{\Delta\overline{m}^{R,NOIL}} \cdot (\overline{I}_t^{Y} - I^{Y,SS}) + c_6^{\Delta\overline{m}^{R,NOIL}} \\ & \cdot (\overline{X}_t^{NNR,Y} - X^{NNR,Y,SS}) + c_7^{\Delta\overline{m}^{R,NOIL}} \cdot (\overline{X}_t^{NR,Y} - X^{NR,Y,SS}) + c_8^{\Delta\overline{m}^{R,NOIL}} \\ & \cdot (\overline{G}_t^{Y} - \mathcal{S}(G^{Y})) - c_9^{\Delta\overline{m}^{R,NOIL}} \cdot (\tau_t^{M^{NOIL}} - \mathcal{S}(\tau^{M^{NOIL}}))))) + \varepsilon_t^{\Delta\overline{m}^{R,NOIL}}\end{aligned} \tag{34}$$

$$\overline{M}_t^{R,NOIL,D} = c_1^{\overline{M}^{R,NOIL,D}} \cdot \overline{M}_{t-1}^{R,NOIL,D} - (\Delta\overline{p}_t^{R,M^{NOIL}} - \mathcal{S}(\Delta\overline{p}^{R,M^{NOIL}})) + \varepsilon_t^{\overline{M}^{R,NOIL,D}} \tag{35}$$

Thus, cyclical non-oil (NOIL) import dynamics (33) depend on: (i) the real expenditure gaps of consumption $\hat{c}_t^R$, investment $\hat{i}_t^R$, government absorption $\hat{g}_t^R$, and NNR exports $\hat{x}_t^{R,NNR}$, (ii) the relative price of imported goods and services (if NOIL import price increases relative to the price of consumption $\hat{p}_t^{R,M^{NOIL}}$ or investment $(\hat{p}_t^{R,M^{NOIL}} - \hat{p}_t^{R,I})$, the demand for NOIL import falls), and (iii) fiscal policy decisions (if import duties $\tau_t^{M^{NOIL}}$ are expected to increase over the near term, contemporaneous demand for imported goods and services would temporarily rise as economic agents partially frontload their planned import expenditures in anticipation of more expensive future imports).

Trend NOIL import growth (34) converges in the steady state to a growth rate consistent with a constant (calibrated) share of non-oil import-to-GDP, $M^{NOIL,Y,SS}$. Along the convergence path, trend NOIL imports, $\overline{M}_t^{NOIL,Y}$, will adjust to accommodate the following developments: (i) any changes in NOIL import demand, $\overline{M}_t^{R,NOIL,D}$ (defined in (35)), which is primarily influenced by the trend dynamics of relative prices—specifically, whenever trend relative price of NOIL import to consumption increases, demand for NOIL import drops; (ii) any enduring shifts in the expenditure shares for other demand components from their steady state values—for example, if private consumption share to GDP is persistently higher than its calibrated steady

[35] The dynamics of oil imports are in Annex A.

state value ($\overline{C}_t^Y > C^{Y,SS}$), it is assumed that the additional consumption will primarily come from increased NOIL imports); (iii) a permanent change in NOIL import duties, τ_t^{MNOIL}—for example, a permanent increase in the tax rate will discourage NOIL imports and permanently reduce the trend import-to-GDP ratio, $\overline{M}_t^{NOIL,Y}$.

Government absorption

In contrast to other expenditure components, government absorption does not have specific behavioral equations. Instead, it is a function of fiscal policy decisions and is discussed in section 3.3.2.

3.1.4 Production function and investment-growth nexus

In a departure from traditional semi-structural models, potential output depends on capital stocks. As a result, public investment matters for potential output, as do interest rates and their determinants. As discussed in section 3.1.3, equations (28)-(29), a higher real interest rate stifles private investment which in turn reduces the pace of private capital accumulation and thus adversely affects potential GDP growth during the transition to the steady state. In addition, higher interest rates increase government borrowing costs and interest payments, compelling the fiscal authorities to undertake a fiscal consolidation. Depending on the calibration, this could lead to a drop in public investment expenditures, reducing potential GDP growth. Finally, links between the UIP premium and stocks of NFA and reserves connect FXI and CFMs policies to potential output, as we will see in section 4.

A Cobb-Douglas function relates potential GDP to private capital, K_t^R, public capital, $K_t^{R,G}$, and total factor productivity (TFP), $\overline{A}_t^R$. Growth in potential GDP, $\Delta\overline{y}_t^R$, is therefore driven by the growth rates in these three components (i.e., Δk_t^R, $\Delta k_t^{R,G}$, and $\Delta\overline{a}_t^R$, respectively), as expressed in (36).[36]

$$\Delta\overline{y}_t^R = c_1^{\Delta\overline{y}^R} \cdot \Delta k_t^R + c_2^{\Delta\overline{y}^R} \cdot \Delta k_t^{R,G} + \Delta\overline{a}_t^R \tag{36}$$

Private capital accumulation follows a standard process (37), which assumes that the existent capital stock, K_t^R, depreciates over time at a constant rate, δ^{K^R}, and otherwise is sustained by private investment, I_t^R.

$$I_t^R = K_t^R - (1 - \delta^{K^R}) \cdot K_{t-1}^R \tag{37}$$

[36]For simplicity labor is omitted from the model; one way to think about this is that $\Delta\overline{a}_t^R$ actually captures the effects of both TFP and growth of labor inputs; it thus could be called “quasi-TFP.”

Public capital accumulation has a similar equation (38), except that we assume that public investment only becomes fully productive after three years:

$$K_t^{R,G} = (1 - \delta^{K^{R,G}}) \cdot K_{t-1}^{R,G} + (1 - c_2^{K^{R,G}} - c_3^{K^{R,G}} - c_4^{K^{R,G}}) \cdot GE_t^{R,I^G} + c_2^{K^{R,G}} \cdot GE_{t-1}^{R,I^G} + c_3^{K^{R,G}} \cdot GE_{t-2}^{R,I^G} + c_4^{K^{R,G}} \cdot GE_{t-3}^{R,I^G} \quad (38)$$

Note that in addition to contributing to potential GDP growth via public capital accumulation, public investment, GE_t^{R,I^G}, as a component of government absorption, G_t^R, also directly contributes to growth in aggregate demand (see section 3.3.2).

TFP follows an exogenous process described by equations (42) and (43). The growth rate of TFP is stationary but is subject to both temporary ($\varepsilon_t^{\Delta\overline{a}^R}$) and persistent ($\varepsilon_t^{\Delta\overline{a}^{R,g}}$) shocks.[37]

$$\Delta\overline{a}_t^R = \Delta\overline{a}_t^{R,g} + \varepsilon_t^{\Delta\overline{a}^R} \quad (42)$$

$$\Delta\overline{a}_t^{R,g} = c_1^{\Delta\overline{a}^{R,g}} \Delta\overline{a}_{t-1}^{R,g} + \left(1 - c_1^{\Delta\overline{a}^{R,g}}\right) \cdot \Delta\overline{a}^{R,SS} + \Delta\overline{a}_t^{R,g} \quad (43)$$

We can now analyze public investment/debt tradeoffs. On the one hand, public investment, even debt-financed, will boost potential GDP growth and thus affect the level of GDP along the balanced-growth path. On the other hand, higher levels of indebtedness tend to increase UIP and term premia, and hence interest rates (details in section 3.3.2), thus reducing potential GDP growth. Which effect will prevail will depend on the productivity of public investment and the responsiveness of the premia to the additional borrowing, which may depend on the initial level of debt.

[37] For purpose of calibration, it is useful to write the equations (36), (42) and (43) in terms of *adjusted* growth rate of quasi-TFP, $\Delta\tilde{a}^R$, which is $\Delta\overline{a}_t$ adjusted by a (constant) steady state contribution of capital growth rates to the potential GDP growth:

$$\Delta\tilde{a}_t^R = \Delta\overline{a}_t^R + c_1^{\Delta\overline{y}^R} \cdot \mathcal{S}(\Delta k^R) + c_2^{\Delta\overline{y}^R} \cdot \mathcal{S}(\Delta k^{R,G})$$

Using this transformation, we can rewrite equations (36), (42) and (43) equivalently as

$$\Delta\overline{y}_t^R = c_1^{\Delta\overline{y}^R} \cdot (\Delta k_t^R - \mathcal{S}(\Delta k^R)) + c_2^{\Delta\overline{y}^R} \cdot (\Delta k_t^{R,G} - \mathcal{S}(\Delta k^{R,G})) + \Delta\tilde{a}_t^R \quad (39)$$

$$\Delta\tilde{a}_t^R = \Delta\tilde{a}_t^{R,g} + \varepsilon_t^{\Delta\tilde{a}^R} \quad (40)$$

$$\Delta\tilde{a}_t^{R,g} = c_1^{\Delta\tilde{a}^{R,g}} \cdot \Delta\tilde{a}_{t-1}^{R,g} + (1 - c_1^{\Delta\tilde{a}^{R,g}}) \cdot \Delta\tilde{a}^{R,SS} + \varepsilon_t^{\Delta\tilde{a}^{R,g}} \quad (41)$$

where $\Delta\tilde{a}^{R,SS} = \Delta\overline{a}^{R,SS} + c_1^{\Delta\overline{y}^R} \cdot \mathcal{S}(\Delta k^R) + c_2^{\Delta\overline{y}^R} \cdot \mathcal{S}(\Delta k^{R,G})$, $\varepsilon_t^{\Delta\tilde{a}^R} = \varepsilon_t^{\Delta\overline{a}^R}$ and $\varepsilon_t^{\Delta\tilde{a}^{R,g}} = \varepsilon_t^{\Delta\overline{a}^{R,g}}$. The benefit of this formulation, which is used in the model code, is that steady state potential GDP growth is directly $\Delta\tilde{a}^{R,SS}$ which is more straightforward for calibration.

Along the convergence path, additional crowding in and crowding out effects are possible. Higher public investment would, as with higher public consumption, raise demand that in itself would tend to spur private investment (*crowding in*). It would also raise trend GDP along the lines of (36). At the same time, though, higher demand would create inflationary pressures and call for a tighter monetary policy that would reduce private investment (*crowding out*).[38]

3.2 External balance

The BoP identity holds in both levels (44) and trends (45). It states that net cross-border flows of goods and services—the current account—must be matched by net flows of financial claims—the financial account.

$$0 = CA_t^Y + FA_t^Y \tag{44}$$

$$0 = \overline{CA}_t^Y + \overline{FA}_t^Y \tag{45}$$

The current account balance, CA_t^Y, equation (46), consists of the balance of trade (total exports of goods and services net of before-tax non-oil and oil imports—represented by the first three terms in equation (46)); remittances, REM_t^Y; natural resource sector profits paid abroad, $G_t^{NR,Y}$, net of royalty revenues, $GR_t^{NR,Y}$; interest payments on foreign currency-denominated debt, $GE_t^{BFCY,Y}$; interest income on private NFA, $I_t^{NFA^O,Y}$; and other current account flows, $CA_t^{O,Y}$.[39]

$$\begin{aligned} CA_t^Y &= X_t^Y - M_t^{NOIL,Y}/(1+\tau_t^{M^{NOIL}}/100) - M_t^{OIL,Y}/(1+\tau_t^{M^{OIL}}/100) \\ &\quad + REM_t^Y - (G_t^{NR,Y} - GR_t^{NR,Y}) - GE_t^{BFCY,Y} + I_t^{NFA^O,Y} + CA_t^{O,Y} \end{aligned} \tag{46}$$

Equation (47) is a trend version of equation (46), and defines the equilibrium current-account balance.

[38] The model would have to be extended to capture the idea that a higher public capital stock would raise the marginal product of private capital and hence spur private investment (*crowding in*). The calibration of such structural effects of public investment would be greatly facilitated by the implementation of a companion micro-founded DSGE model.

[39] $M_t^{NOIL,Y}$ is measured after taxes and is divided by 1 plus the tax rate to convert to a before-tax measure. Country applications may include a more detailed decomposition of the current account, including for example net interest income, profits on foreign direct investment, and foreign aid.

$$\overline{CA}_t^Y = \overline{X}_t^Y - \overline{M}_t^{NOIL,Y}/(1+\tau_t^{M^{NOIL}}/100) - \overline{M}_t^{OIL,Y}/(1+\tau_t^{M^{OIL}}/100) \\ + \overline{REM}_t^Y - (\overline{G}_t^{NR,Y} - \overline{GR}_t^{NR,Y}) - \overline{GE}_t^{B^{FCY},Y} + \overline{I}_t^{NFA^O,Y} + \overline{CA}_t^{O,Y} \tag{47}$$

Financial account inflows, FA_t^Y, are decomposed in (48). Endogenous financial inflows $FA_t^{O,Y}$, which are sensitive to the UIP premium, are discussed at length below. We distinguish two channels of foreign exchange reserve management: reserve accumulation, FXA_t^Y; and interventions, FXI_t^Y. Both are discussed in section 3.3.1 on monetary policies. The terms in the parenthesis capture net foreign currency borrowing, calculated as the change in foreign currency debt ratio, with the error term $\varepsilon^{B^{FCY,Y}}$ capturing idiosyncratic movements in foreign currency-denominated debt not included in government deficit financing (see (104) in section 3.3.2).[40]

$$FA_t^Y = FA_t^{O,Y} - FXI_t^Y - FXA_t^Y + (GF_t^{FCY,Y} + \varepsilon_t^{B^{FCY,Y}}) \tag{48}$$

Equation (49) defines trend financial account inflows.

$$\overline{FA}_t^Y = \overline{FA}_t^{O,Y} - \overline{FXA}_t^Y + \overline{GF}_t^{FCY,Y} \tag{49}$$

Here, any trend reserve management operations are by assumption planned, and thus captured fully by trend reserve accumulation, $\overline{FXA}_t^Y$, with $\overline{FXI}_t^Y = 0$. We also assume in (49) that the foreign currency-denominated debt ratio is on the target path, so that new foreign currency borrowing/lending takes place only as needed to cover the equilibrium debt ratio revaluation (see (106) in section 3.3.2 on fiscal policy).

$FA_t^{O,Y}$ gives rise to a stock of private NFA:[41]

$$NFA_t^{O,Y} = -FA_t^{O,Y} + NFA_{t-1}^{O,Y} \cdot (1+\Delta s_t^{US}/100)/(1+\Delta y_t/100) \tag{50}$$

[40] We assume, for simplicity, that there is only one type of endogenous capital flows, which could encompass portfolio flows, commercial cross-border lending, and FDI. If necessary, these could be decomposed and treated differently, e.g. with different elasticities of response to the UIP differential. FDI flows are often thought of as being exogenous, for example; see however Blanchard and Acalin (2016).

[41] For simplicity, we assume that both foreigners lend to the government and the private sector only in foreign currency. If foreigners were to lend in local currency, (49) could be modified so that a fraction of capital inflows would involve foreigners taking local currency risk. We would need to take account the currency composition of NFA in considering exchange rate valuation effects in (50) and allow for foreigners' accumulation of $GF^{LCY,Y}$ in (48).

Which yields the aforementioned net interest income $I_t^{NFA^O,Y}$ given by:

$$I_t^{NFA^O,Y} = r_{t-1}^{NFA^O}/100 \cdot NFA_{t-1}^{O,Y} \cdot (1 + \Delta s_t^{US}/100)/(1 + \Delta y_t/100) \tag{51}$$

We now discuss the dynamics of endogenous financial inflows in level ($FA_t^{O,Y}$) and trend ($\overline{FA}_t^{O,Y}$).

First, the UIP premium is defined simply as the interest rate differential adjusted by the expected exchange rate depreciation (52). It is decomposed into a gap, $\hat{\gamma}_t$, and a trend, $\overline{\gamma}_t$, in equation (53).

$$\gamma_t = r_t^R - r_t^{R,US} - \Delta z_{t+1} \tag{52}$$

$$\gamma_t = \overline{\gamma}_t + \hat{\gamma}_t \tag{53}$$

The gap component, $\hat{\gamma}_t$, captures business cycle (i.e. transitory) movements of the UIP premium, while the trend component, $\overline{\gamma}_t$, captures its secular (i.e., non-business cycle) dynamics.

Whenever cyclical pressures force $FA_t^{O,Y}$ to deviate from its trend level, a UIP premium gap $\hat{\gamma}_t$ has to open (54). The gap $\hat{\gamma}_t$ is relative to the risk appetite shock $\varepsilon_t^{\hat{\gamma}}$, such that a positive value of $\varepsilon_t^{\hat{\gamma}}$ implies a decline in investor appetite for the country's assets and dictates that a given financial inflow requires a larger UIP premium.[42]

$$FA_t^{O,Y} = \overline{FA}_t^{O,Y} + c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm}) \cdot (\hat{\gamma}_t - \varepsilon_t^{\hat{\gamma}}) \tag{54}$$

The extent to which the UIP premium needs to rise to attract a given quantity of financial inflows is governed by the product of parameters, $c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm})$, which jointly capture the degree of cross-border capital mobility. The value of parameter $c_1^{FA^{O,Y}}$ would typically reflect structural characteristics, such as the depth of domestic financial markets, while the value of $\tau^{FA^O,adm}$ reflects strength of *administrative* CFMs (different from *capital inflow tax*, which is modeled separately), e.g., restrictions on banks' open foreign exchange positions.[43]

Equation (55) specifies the determinants of trend endogenous flows $\overline{FA}_t^{O,Y}$.

[42] $\varepsilon_t^{\hat{\gamma}}$ is often called a "UIP premium shock." In a model of perfect asset substitutability, i.e. where $c_1^{FA^{O,Y}} = \infty$, it is indeed the case that $\hat{\gamma}_t = \varepsilon_t^{\hat{\gamma}}$ (see (63)), but with imperfect asset substitutability, adjustments in financial flows (which are themselves a function of all the other influences on the BoP) can break this equivalence.

[43] The parameter $c_1^{FA^{O,Y}}$ is the analogue in FINEX to $1/\Gamma$ in Gabaix and Maggiori (2015). Gabaix and Maggiori (2015) model administrative CFMs as a parameter τ, such that the combined parameter in their analogue to (54) equals $\frac{\Gamma}{1-\tau}$. This is the slope of the BP curve in Box 1.

$$\overline{FA}_t^{O,Y} = \mathcal{S}(\overline{FA}^{O,Y}) + \overline{FA}_t^{O,Exo,Y} + c_1^{\overline{FA}^{O,Y}} \cdot (1 - \tau^{FA^O,adm}) \cdot (\overline{\gamma}_t - (\gamma^{SS} + \gamma_t^B + \gamma_t^{FXR} + \gamma_t^{NFA^O} + (\tau_t^{FA^O} - \tau^{FA^O,SS}) + \varepsilon_t^{\overline{\gamma}})) \quad (55)$$

Any deviation in $\overline{FA}_t^{O,Y}$ from its steady state value $\mathcal{S}(\overline{FA}^{O,Y})$ is a function of the difference between the trend UIP premium, $\overline{\gamma}_t$, and the steady-state required excess return, γ^{SS}.[44]

Equation (55) also contains a variable $\overline{FA}_t^{O,Exo,Y}$, that captures a permanent shift in the quantity of financial flows. It could, for example, capture longer-term risk appetite cycles in global capital markets.[45]

Increases in the capital inflow tax $\tau_t^{FA^O}$ relative to its steady state value increase investors' required excess return, as in Basu et al. (2020) and Adrian et al. (2021). This policy variable is discussed in section 3.3.1 below.

In addition, the trend risk appetite for the country's assets depends on the level of government debt, the stock of foreign reserves (for managed exchange rate regimes and pegs), and the stock of private NFA. These risk appetite terms (γ_t^B, γ_t^{FXR}, $\gamma_t^{NFA^O}$) are modeled in equations (56), (57), (58), respectively.

$$\gamma_t^B = \exp(c_1^{\gamma^B} \cdot (B_t^Y - B^{Y,SS})) - 1 \quad (56)$$

$$\gamma_t^{FXR} = c_4^{\gamma^{FXR}} \cdot (\gamma^{FXR,max} + \min(c_1^{\gamma^{FXR}} + c_3^{\gamma^{FXR}} \cdot \exp(-c_2^{\gamma^{FXR}} \cdot FXR_t^Y) - \gamma^{FXR,max}, 1e-8)) \quad (57)$$

$$\gamma_t^{NFA^O} = \exp(-c_1^{\gamma^{NFA^O}} \cdot (NFA_t^{O,Y} - \mathcal{S}(NFA^{O,Y}))) - 1 \quad (58)$$

These nonlinear relationships capture 'sudden stops', i.e. the way small changes in debt, net foreign liabilities, and reserves can have explosive effects on capital flows when risks are already high.[46] The risks associated with public debt, γ_t^B, and the country's NFA position, $\gamma_t^{NFA^O}$, grow exponentially with the public debt ratio (Figure

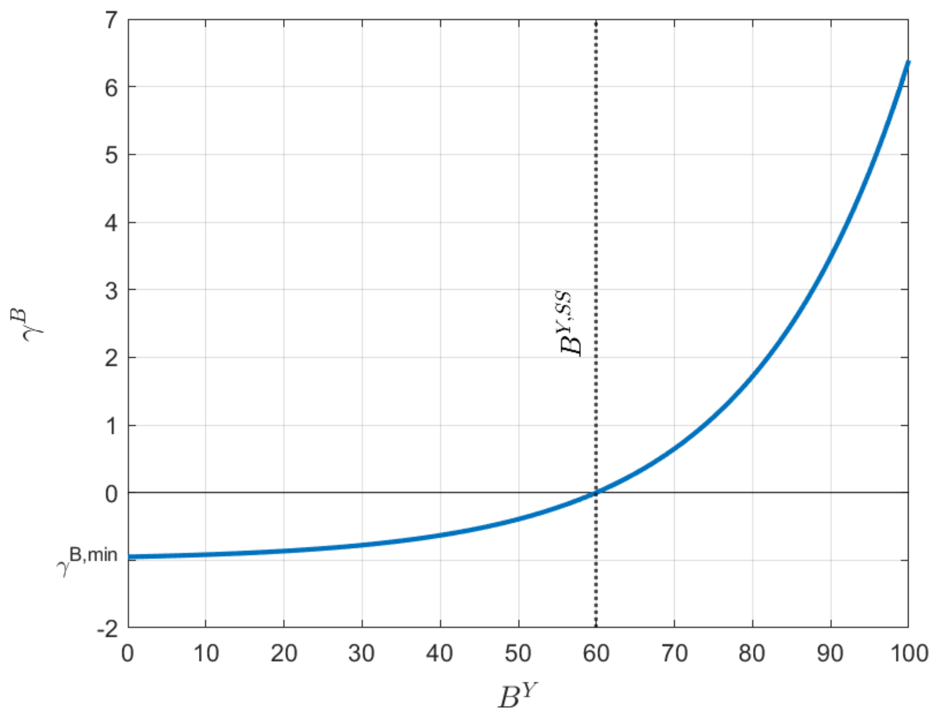
[44] If the capital account is perfectly closed ($c_1^{\overline{FA}^{O,Y}} = 0$ or $\tau^{FA^O,adm} = 1$), then in addition $\overline{\gamma}_t = \gamma^{SS} + \gamma_t^B + \gamma_t^{FXR} + \varepsilon_t^{\overline{\gamma}}$. This pins down the real rate of return under autarky. Note also that the term

[45] See Burger et al. (2022) for the discussion of the time-varying supply-side measure of the natural level of capital flows. $\overline{FA}_t^{O,Exo,Y}$ is redundant, in that it is exactly proportional to the shock term in the equation. However, it can be useful to have both a volume-based and a price-based shifter for these flows, as explained in 3 below.

[46] The effect is continuous, in contrast with Basu et al. (2020) and Adrian et al. (2021). The specification here is tractable and may be useful for the many times when spreads rise sharply but not to

4) and net foreign liabilities ratio (Figure 6), respectively. The risk related to foreign exchange reserves, γ_t^{FXR}, grows exponentially as the ratio of FXR to GDP falls towards some minimum, below which market participants assume that there are insufficient reserves to do any good (Figure 5).[47]

Figure 4. Contribution of the public debt ratio to the UIP premium



Finally, a trend risk appetite shock, $\varepsilon_t^{\overline{\gamma}}$ in (55), captures trend risk-off shocks.

Taken together, equations (54) and (55) represent a supply function for endogenous capital flows (Box 3). International investors will supply financial flows as an increasing function of the gap and trend UIP premia ($\hat{\gamma}_t$ and $\overline{\gamma}_t$). The terms $\overline{FA}_t^{O,Exo,Y}$ and $\mathcal{S}(\overline{FA}^{O,Y})$ represent short-run and long-run shifts in the supply of financial

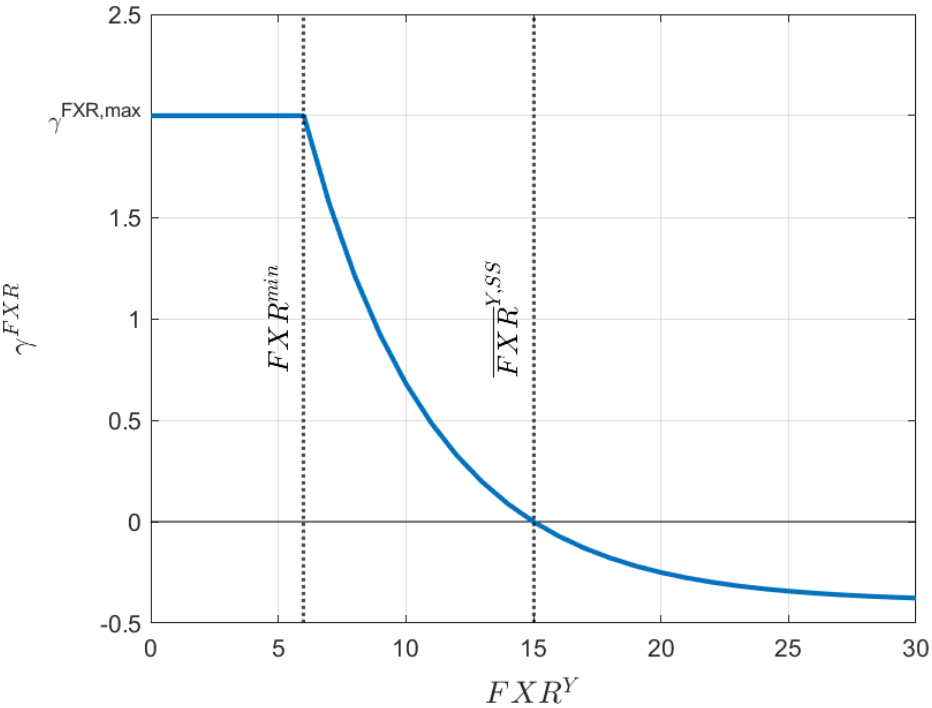
essentially infinity. It also avoids a discrete off-on-off effect of sudden stops which is rare in the data. However, for particular applications functional forms could be adapted to include sharper kinks. The γ_t^{FXR} function (Figure 5) could be calibrated with reference to the IMF's approach to the assessment of reserve adequacy (Rabanal et al. (2019)).

[47] The parameter γ_t^{FXR} is capped by $\gamma^{FXR,max}$ and is limited from below by $c_1^{\gamma^{FXR}}$. The value of the $c_1^{\gamma^{FXR}}$ is calculated to ensure that γ_t^{FXR} equals zero in the steady state, according to the following formula:

$$c_1^{\gamma^{FXR}} = -\gamma^{FXR,max} \cdot \frac{\exp\left(c_2^{\gamma^{FXR}} \cdot (FXR^{min} - \overline{FXR}^{Y,SS})\right)}{1 - \exp\left(c_2^{\gamma^{FXR}} \cdot (FXR^{min} - \overline{FXR}^{Y,SS})\right)}$$

where $c_2^{\gamma^{FXR}}$ represents the curvature of γ_t^{FXR} and is set to 0.05 in the baseline calibration.

Figure 5. Contribution of the FX reserves position to the UIP premium



flows. The risk-appetite terms γ_t^B, γ_t^{FXR}, and $\gamma_t^{NFA^O}$ capture the influence of the stocks of public debt, reserves, and NFA on investors' required rates of return.

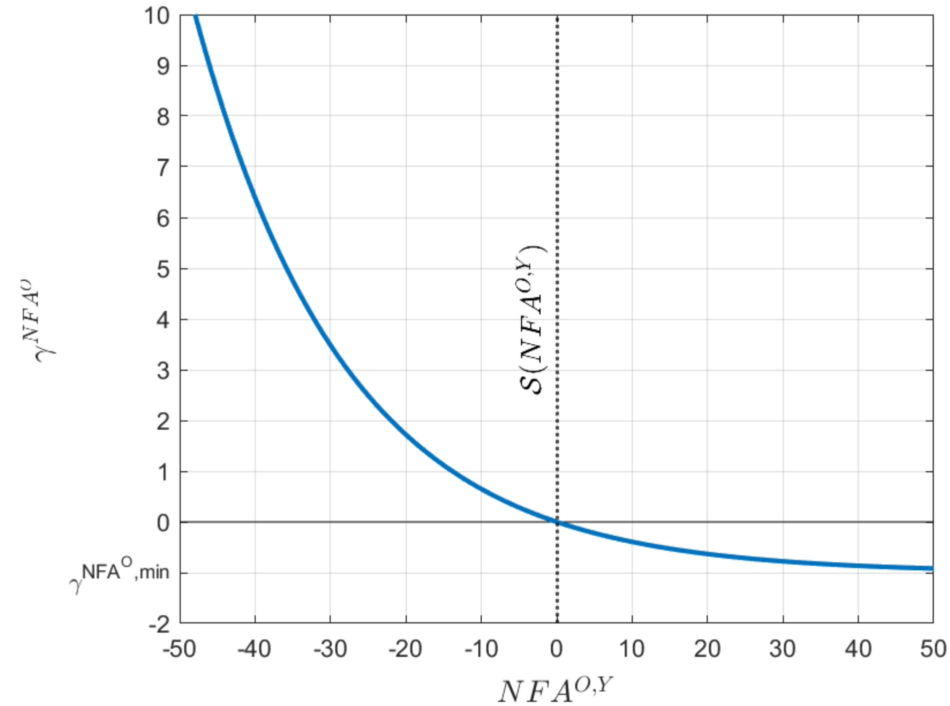
The rest of the model determines demand for endogenous capital flows as a function of all the drivers of the rest of the BoP, including FXI, remittances, and official financing.[48] Demand for $FA_t^{O,Y}$ is a declining function of the UIP premium, because high interest rates and a depreciated exchange rate reduce the need for endogenous capital flows to close the BoP. The UIP premium and the size of endogenous capital flows are thus equilibrium outcomes of all these factors. Given the policy interest rate, this also determines the equilibrium exchange rate.[49]

The degree of capital mobility shapes the operation of the system, as we will see in section 4. Parameters $c_1^{FA^{O,Y}}$ and $\tau^{FA^O,adm}$ control the degree of capital account

[48] Figure 1 presents a simplified graphical representation.

[49] In a pegged regime, FXI and the policy interest rate are the equilibrating factors; see the discussion of various monetary and exchange rate policy frameworks in section 3.3.1. It may seem that embedded in the model is a 'theory' of the equilibrium real exchange rate. However, unlike in a DSGE model, the equilibrium real exchange rate in the model is a result of number of conditions (e.g. a function of the dependence of risk appetite terms on the NFA position, equations for trends in exports and imports) which, although being grounded in economic theory, are not strictly speaking micro-founded behavioral conditions. This is a consequence of the semi-structural nature of the model.

Figure 6. Contribution of the private NFA ratio to the UIP premium



openness to financial flows in the short run (through equation (54)) and over the longer term (through equation (55)).[50]

When the product $c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm})$ is small, financial flows will be unresponsive to the UIP premium and to changes in investors' required rates of return, including due to risks associated with debt sustainability, adequacy of foreign reserves, or weak NFA positions. Similarly, the effect of price-based CFM will be smaller if the domestic financial markets are shallow (i.e., $c_1^{FA^{O,Y}}$ is small) and/or if capital account is tightly regulated (i.e., $\tau^{FA^O,adm}$ is close to one). On the other hand, changes in other components of the BoP, or exogenous shifts in the the quantity of financial flows, would tend to have large impacts on the equilibrium UIP premium, because stabilizing capital flows would be weaker.[51]

Section 4 explores these general-equilibrium features more systematically. First,

[50] In the baseline version of the model, parameters' product $c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm})$ in (55) is the same as in (54). However, for the country-specific applications, the degree of secular (longer term) cross-border capital mobility may be assumed different—often higher—than over the cycle. In that case it would be reasonable to use a different parameter $c_1^{\overline{FA}^{O,Y}}$ in (55), such that $c_1^{\overline{FA}^{O,Y}} > c_1^{FA^{O,Y}}$, and/or assume a different measure of $\tau^{\overline{FA}^O,adm}$, such that $\tau^{\overline{FA}^O,adm} < \tau^{FA^O,adm}$.

[51] Section 2, including Figure 1 and Box 1, provides some basic intuition. For example these two boundary cases correspond to a vertical and a horizontal BP curve in Box 2.

though, we take a closer look at policies.

Box 3. The supply of financial flows

The text provides an interpretation of the UIP premium, and the quantity of endogenous capital flows, as equilibrium outcomes of the supply and demand for these flows. Here we explore the supply curve.

To see the bigger picture, it is useful to combine equations (54) and (55) while assuming, for simplicity, no CFMs ($\tau^{FA^O,adm} = 0$, $\tau_t^{FA^O} = \tau^{FA^O,SS}$) and the same level of capital mobility in equilibrium and business cycle ($c_1^{\overline{FA}^{O,Y}} = c_1^{FA^{O,Y}}$), yielding:

$$FA_t^{O,Y} = \mathcal{S}(\overline{FA}^{O,Y}) + \overline{FA}_t^{O,Exo,Y} + c_1^{FA^{O,Y}}\left(\gamma_t - (\tilde{\gamma}_t + \varepsilon_t^{\gamma})\right) \tag{59}$$

with state-dependent risk appetite term:

$$\tilde{\gamma}_t \equiv \gamma^{SS} + \gamma_t^{B} + \gamma_t^{FXR} + \gamma_t^{NFA^O} \tag{60}$$

and idiosyncratic risk appetite shock:

$$\varepsilon_t^{\gamma} \equiv \varepsilon_t^{\overline{\gamma}} + \varepsilon_t^{\hat{\gamma}} \tag{61}$$

Equation (59) is the supply curve for foreign financial inflows. It characterizes the UIP premium implicitly. Substituting for γ_t in (59) using its definition in (52) and rearranging to have domestic interest rate on the left-hand-side, we get the supply curve sketched in Figure 1:

$$r_t^R = r_t^{R,US} + \Delta z_{t+1} + \frac{FA_t^{O,Y} - \mathcal{S}(\overline{FA}^{O,Y}) - \overline{FA}_t^{O,Exo,Y}}{c_1^{FA^{O,Y}}} + \tilde{\gamma}_t + \varepsilon_t^{\gamma} \tag{62}$$

With perfect capital mobility ($c_1^{FA^{O,Y}} \to \infty$), we get a familiar UIP condition (albeit with a state-dependent premium):

$$r_t^R = r_t^{R,US} + \Delta z_{t+1} + \tilde{\gamma}_t + \varepsilon_t^{\gamma} \tag{63}$$

The supply curve (59) has two types of terms that can be interpreted as shifters or supply shocks:

- *an exogenous quantity-based component* captured by $\mathcal{S}(\overline{FA}^{O,Y}) + \overline{FA}_t^{O,Exo,Y}$; and
- *a price-based component* we have labeled investors' risk appetite and expressed as a rate of return ($\tilde{\gamma}_t + \varepsilon_t^{\gamma}$)

These two sorts of shift factors are in general redundant: We can express the price-based supply shocks as a quantity shock, with $c_1^{FA^{O,Y}}$ as the conversion factor. However, in some cases it may be relevant to consider the effects of capital supply shocks for different degrees of capital mobility (e.g. as a thought experiment, as in Section 4, in the context of changes in administrative CFMs, or when comparing across countries), and in these cases the two different types of supply shocks will have differing effects.

Moreover, at the extremes, the equivalence breaks down. With a closed capital account ($c_1^{FA^{O,Y}} = 0$), the price-based shocks do not matter for the supply of financial flows (though interest rates and the exchange rate may still matter for demand though implications for the current account.) With a fully open capital account ($c_1^{FA^{O,Y}} \rightarrow \infty$), the quantity shifters no longer matter, but the price-based risk appetite shocks still move the UIP premium one-for-one.

Finally, it may be useful in practice to think in terms of either the quantity or the price formulation. Basu et al. (2020) expresses these supply shifts in quantity terms only, as 'noisy trader' shocks. However, it is also common that relevant information is expressed in terms of yields, such as spreads on sovereign bonds.

3.3 Macroeconomic policies

Recognizing reality on the ground, FINEX accommodates a wide range of monetary and fiscal policies in support of traditional and hybrid exchange rate and monetary policy regimes. Available exchange rate regimes include the full spectrum from hard pegs to pure floats with IT. Available instruments consist of a policy interest rate, foreign exchange intervention to accumulate reserves and stabilize the exchange rate, and price-based and regulatory capital controls. Various types of deficit and debt anchors guide expenditure- and revenue-based instruments to stabilize deficits and the public debt as well as build productive public infrastructure. Idiosyncratic policy adjustments are also part of the toolkit.

3.3.1 Monetary policy

An interest rate reaction function aims to stabilize inflation and the output gap. Planned purchases of foreign exchange can accumulate reserves, while foreign exchange intervention can target the exchange rate and other objectives. Both price-based and regulatory CFMs can influence capital inflows directly. We first describe the various instruments and channels and then discuss how FINEX can reflect different monetary and exchange rate regimes by calibrating selected parameters and switching between alternative model equations.

The policy interest rate

The policy interest rate (r_t) follows a standard Taylor-type rule (64); it reacts to expected deviations of consumer price inflation (π^C_{t+1}) from the target ($\overline{\pi}^C_t$) and to contemporaneous deviations of output from potential ($\hat{y}^R_t$). The policy rate can be subject to an ELB ($\underline{r}$), which is implemented in the model through equation (65), where r^{unc}_t denotes the unconstrained policy rate.

$$r^{unc}_t = c^r_1 \cdot r_{t-1} + (1 - c^r_1) \cdot (\overline{r}^R_t + \pi^C_t + c^r_2 \cdot (\pi^C_{t+1} - \overline{\pi}^C_t) + c^r_3 \cdot \hat{y}^R_t) + \varepsilon^r_t \tag{64}$$

$$r_t = \max(r^{unc}_t, \underline{r}) \tag{65}$$

In a regime where the inflation rate is the nominal anchor, the inflation target path $\overline{\pi}^C_t$ is a policy variable. It is specified in (66) as a random walk, with $c^{\overline{\pi}^C}_1 = 1$. A stable inflation target would be constant at $\overline{\pi}^C_t$ with the shocks $\varepsilon^{\overline{\pi}^C}_t$ set to 0. On the other hand, with appropriate non-zero shocks, (66) can also accommodate a declining inflation target during a disinflation episode, or situations—not uncommon in EMDEss—where the inflation target is subject to occasional revision, for example as part of a disinflation strategy.

$$\overline{\pi}^C_t = c^{\overline{\pi}^C}_1 \cdot \overline{\pi}^C_{t-1} + (1 - c^{\overline{\pi}^C}_1) \cdot \overline{\pi}^{C,SS} + \varepsilon^{\overline{\pi}^C}_t \tag{66}$$

The domestic inflation target ($\overline{\pi}^C_t$), the foreign inflation target ($\pi^{C,US,SS}$), and the changes in the equilibrium REER ($\Delta\overline{z}^{US}_t$) together pin down the trend nominal exchange rate ($\Delta\overline{s}^{US}_t$):

$$\overline{\pi}^C_t = \pi^{C,US,SS} + \Delta\overline{s}^{US}_t - \Delta\overline{z}^{US}_t \tag{67}$$

The real interest rate in the model, r^R_t, is defined in terms of actual inflation (68), given that the underlying nominal interest rate is a short-term rate while the model is annual. The equilibrium (trend) real interest rate, $\overline{r}^R_t$, is determined by the trend version of the UIP condition (69). The resulting gap ($\hat{r}^R_t$ in equation (70)) then serves as a proxy for cyclical domestic credit conditions and enters the equations for private consumption and private investment gaps as discussed in section 3.1.3.

$$r^R_t = r_t - \pi^C_t \tag{68}$$

$$\overline{r}^R_t = \overline{r}^{R,US}_t + \overline{\gamma}_t + (\overline{z}^{US}_{t+1} - \overline{z}^{US}_t) \tag{69}$$

$$r_t^R = \bar{r}_t^R + \hat{r}_t^R \tag{70}$$

Foreign reserves management

Monetary authorities in the model can manage the level of foreign exchange reserves (FXR), through FXIs aimed at influencing conjunctural outcomes and/or by conducting systematic reserve accumulation to build stocks.

Equation (71) is the law of motion for the stock of reserves, assumed here to be valued in dollars and expressed as a ratio of nominal GDP. In managing its foreign reserves, the monetary authority: (i) conducts interventions responding to variables such as the exchange rate or to specific shocks (FXI_t^Y); (ii) accumulates reserves to achieve an objective for reserve stocks (FXA_t^Y); and (iii) invests existing stock of reserves at prevailing U.S. interest rates (the third term in equation (71)). An FXR shock, $\varepsilon_t^{FXR^Y}$, accounts for the discrepancy between the actual data on the stock of foreign reserves and the modeled FXR_t^Y.

$$\begin{aligned} FXR_t^Y = {} & FXI_t^Y + FXA_t^Y \\ & + (1 + r_{t-1}^{US}/100) \cdot FXR_{t-1}^Y \cdot (1 + \Delta s_t^{US}/100)/(1 + \Delta y_t/100) + \varepsilon_t^{FXR^Y} \end{aligned} \tag{71}$$

FXI_t^Y is defined as sterilized intervention to buy reserves as a response to economic conditions:

$$FXI_t^{Y,unc} = c_1^{FXI^Y} \cdot FXI_{t-1}^Y - c_2^{FXI^Y} \cdot (\Delta s_t^{US} - \Delta \bar{s}_t^{US}) + \varepsilon_t^{FXI^Y} \tag{72}$$

Here, such interventions respond to exchange rate deviations from the equilibrium path, as measured by the dynamics of the trend REER and inflation targets or trends. The parameter $c_2^{FXI^Y}$ controls the magnitude of the FXI response to exchange rate misalignment while $c_1^{FXI^Y}$ allows for persistence. A discretionary FXI shock, $\varepsilon_t^{FXI^Y}$, allows for ad-hoc interventions.

Rule (72) is neither an optimal rule nor prescription for modeling FXI. It is rather a one of many possible specifications.[52] Of course intervention policies vary substantially across countries, and the specification of the rule can be modified to reflect that. No matter what the utilized rule will be in the model applications, it will

[52] Adrian et al. (2021) propose a different approach to intervening in foreign exchange markets. They suggest two motives for intervention. The first is to address inefficient fluctuations in exchange rates caused by limited risk-bearing capacity among financiers, which they capture, in our terms, through the inclusion of the UIP premium γ in the FXI reaction function. The second motive is to address sudden stops, which occur in their model when the economy hits the debt limit and faces a sharp increase in the borrowing spread. This approach to intervention could potentially be implemented in FINEX through changing functional form of the risk appetite term γ^{NFA^O} in (58) to include a steeply increasing premium beyond certain point.

always be a stylized rule providing general guidance for the policy decisions. As such, there will always be other considerations (outside the scope of the model and any FXI rule) which should be taken into account as detailed in the IMF's integrated policy framework (IMF (2020)).[53]

The ability of the central bank to intervene (against currency weakening) can be constrained by an ELB on stock of FXR (FXR^{min}). Equation (73) represents that constraint for FXI where $FXI_t^{Y,unc}$ denotes the unconstrained intervention before taking into account the ELB.

$$
\begin{aligned}
FXI_t^Y = \max(&FXI_t^{Y,unc}, FXR^{min} \\
&- (FXA_t^Y + (1 + r_{t-1}^{US}/100) \cdot FXR_{t-1}^Y \cdot (1 + \Delta s_t^{US}/100)/(1 + \Delta y_t/100)))
\end{aligned}
\tag{73}
$$

In addition to FXI, the monetary authorities use foreign exchange accumulation (FXA) to steer the stock of foreign reserves towards a desired level. This systematic accumulation of reserves by the monetary authority, FXA_t^Y, is modeled next.

First, the objective for the stock of foreign exchange, $\overline{FXR}_t^Y$, is a policy choice of the monetary authorities.[54] Its evolution is determined by equation (74), which allows for persistent or even near-permanent (if $c_1^{\overline{FXR}^Y}$ is almost 1) shocks to the desired stock of reserves.

$$
\overline{FXR}_t^Y = c_1^{\overline{FXR}^Y} \cdot \overline{FXR}_{t-1}^Y + (1 - c_1^{\overline{FXR}^Y}) \cdot \overline{FXR}^{Y,SS} + \varepsilon_t^{\overline{FXR}^Y} \tag{74}
$$

The targeted path of systematic foreign exchange accumulation, $\overline{FXA}_t^Y$, is defined implicitly in equation (75) as the level of FXA that stabilizes reserves at the desired level, $\overline{FXR}_t^Y$.

$$
\begin{aligned}
\overline{FXR}_t^Y = \overline{FXA}_t^Y &+ (1 + (\overline{r}_t^{R,US} + \pi^{C,US,SS})/100) \cdot \overline{FXR}_t^Y \\
&\cdot (1 + (\Delta \overline{z}_t^{US} - \pi^{C,US,SS} + \overline{\pi}_t^C)/100)/(1 + \Delta \overline{y}_t/100)
\end{aligned}
\tag{75}
$$

Actual systematic foreign exchange accumulation converges to the targeted path, becoming more aggressive if the stock is expected to fall below the desired level:

[53] Footnote 52 discusses different specifications for FXI, with reference to Adrian et al. (2021). Our experience with modeling FXI reaction functions in EMDEs is in practice that considerable judgment will be required in assessing the application of the model in particular cases, about the nature of the shocks and the modeled- and non-modeled factors that condition the appropriate policy response.

[54] Tradition suggests that FXR should cover three months of imports or 100 percent of short-term external debt. IMF (2016) provides much richer guidance.

$$FXA_t^Y = c_1^{FXA^Y} \cdot FXA_{t-1}^Y + (1 - c_1^{FXA^Y}) \cdot \overline{FXA}_t^Y - c_2^{FXA^Y} \cdot \widehat{FXR}_t^Y + \varepsilon_t^{FXA^Y} \tag{76}$$

$$\widehat{FXR}_t^Y = c_1^{\widehat{FXR}^Y} \cdot (FXR_t^Y - \overline{FXR}_t^Y) + (1 - c_1^{\widehat{FXR}^Y}) \cdot \widehat{FXR}_{t+1}^Y \tag{77}$$

Capital flow management

The monetary authorities can impose two broad types of measures to restrict capital flows:[55]

- *Administrative* restrictions or bans on cross-border transactions reduce the responsiveness of endogenous capital flows $FA_t^{O,Y}$ to the UIP premium γ_t and are implemented in the model by changing the calibration of $\tau^{FA^O,adm}$ in equations (54) and (55). Limits on banks' unhedged foreign exchange positions or direct limits on borrowing from abroad, for example, would reduce the responsiveness of capital flows to relative yields and thus increase the value of $\tau^{FA^O,adm}$.
- A *capital inflow tax* makes capital inflows more costly. This way of characterizing CFMs is more suited to *market-based measures* such as requirement to hold a fraction of capital inflows as unremunerated reserves. These increase the excess return demanded by investors. Such a CFM is captured by the policy variable $\tau_t^{FA^O}$ in equation (55) for trend endogenous financial flows on page 34.[56]

We do not specify reaction functions for either type of CFM. For now, we posit rules of the form:

$$\tau_t^{FA^O} = c_1^{\tau^{FA^O}} \cdot \tau_{t-1}^{FA^O} + (1 - c_1^{\tau^{FA^O}}) \cdot \tau^{FA^O,SS} + \varepsilon_t^{\tau^{FA^O}} \tag{78}$$

The shocks $\varepsilon_t^{\tau^{FA^O}}$ represent idiosyncratic policy adjustments to τ^{FA^O}.[57]

Richer reaction functions can capture various motivations for CFMs. In Adrian et al. (2021), for example, $\tau_t^{FA^O}$ reacts by leaning against foreign borrowing, which has

[55] Examples of specific CFMs that are better thought of as 'Administrative' are surrender requirements for exporters' foreign exchange proceeds, and approval requirements for capital transfers. Examples of market-based measures include property stamp duty rates that differ between residents and nonresidents, and taxes on capital flows. IMF (2022a) provides a database of CFMs identified by the IMF, while Binici et al. (2023) provides detailed database of CFMs for 49 countries and presents indices of capital policies based on the CFMs data.

[56] Basu et al. (2020) and Adrian et al. (2021) focus on this type of CFM.

[57] With $c_1^{\tau^{FA^O}}$ set to 1, these shocks are essentially permanent.

a precautionary flavor. We leave this area for country-specific applications and further work, partly because there is a relative lack of experience for the integration of CFMs into practical forecasting models.

Similarly as in the case of FXI rule, any adopted rule will not be able to reflect all relevant circumstances and motives for CFMs. Even though we show latter how the model can help analyze CFMs for prudential motives (Section 4.4) or in times of sudden capital outflows (Section 4.3), it still lacks the granularity (as any other practical forecasting model would) to take into account all relevant circumstances and justifiable motives for using CFMs as stipulated in IMF (2022b).

Monetary and exchange rate policy frameworks

Reflecting the complex reality, monetary authorities in FINEX can choose among a wide range of monetary policy frameworks. The choices are not one-dimensional, but they range from IT with a fully flexible exchange rate and open capital account to an exchange rate targeting framework with full control over capital flows. In line with the Mundell-Fleming policy trilemma, the decision over the monetary policy framework in the model comes down to a coherent choice among three policy variables: the level of control over domestic interest rates, the flexibility of the exchange rate, and the openness of the capital account. In what follows we illustrate the workings of the model by showing how to apply it to some standard regimes. Extensions can model more heterodox regimes, such as money targeting or the use of the exchange rate as an intermediate target, if they are coherent.[58]

IT with free-floating exchange rate

In this simple benchmark case, the monetary authorities exercise full control over the domestic interest rates, which they set in accordance with the Taylor-type rule (equation (64)).

The inflation target path is set exogenously as a policy choice in equation (66). The capital account is broadly open, with reasonably deep financial markets and no CFMs. For an advanced economy with fully developed and integrated financial markets, a value close to 1000 might be chosen for $c_1^{FA^{O,Y}}$, with $\tau^{FA^O,adm}$ set to zero, to reflect fully open capital account and assets that are nearly perfect substitutes. For an EMDEs, a reasonable value for $c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm})$ in equations (54) and (55) might be 1 (one).[59]

Of course there are many other places where the calibration would need to re-

[58] On some of these regimes, see IMF (2021).

[59] We suggest specific numerical calibrations for key regime-related parameters here to illustrate the mapping of the regimes into the model. The full calibration for the baseline and other cases presented in Section 4 are presented in Annex A.III. See Remo et al. for a full illustration of a calibration strategy for this model.

flect country-specific characteristics. For example if inflation expectations are well-anchored, the weight of the exchange rate in inflation expectations might be low, as discussed in Adrian et al. (2021). It is also reasonable to think that in such a regime the stock of reserves may have little effect on required return of foreign investors, so that parameter $\gamma^{FXR,max}$ in equation (71) would be set to zero, to ensure that $\gamma^{FXR} = 0$.

The exchange rate will adjust to reflect exchange rate expectations and interest rates. It will also help adjust to restore external balance, though as $c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm})$ approaches infinity, any temporary BoP shocks will be met with stabilizing financial flows with (almost) no need for interest rates or the exchange rate to adjust. Permanent BoP and other shocks would be reflected immediately in the equilibrium REER, which along with the inflation target and foreign trend inflation would determine the equilibrium (trend) nominal exchange rate path.

IT with managed exchange rate and partially-closed capital account

This case is similar to the previous one, except that the monetary authorities decide to lessen the volatility of the exchange rate by intervening in response to exchange rate deviations from equilibrium, as reflected in the model by setting the value of the parameter $c_2^{FXI^Y}$ in (72) above zero. The larger the parameter, the stronger the preference of the monetary authorities to keep the nominal exchange rate, Δs_t^{US} aligned with its equilibrium path. It equals 2.0 in the calibration for this case in what follows. Sales and purchases of foreign exchange thus help close the BoP gaps that otherwise put pressure on the exchange rate to adjust.

It would be natural in such a regime to suppose that the capital account is not fully open, e.g. with a value for $c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm})$ in equations (54) and (55) of around 1 (one), as suggested above as reasonable value for an EMDEs. With a parameter close to 1000, as was suggested above for an advanced economy with fully developed and integrated financial markets, FXI would be ineffective at reasonable volumes.

In this regime it is now reasonable to suppose that low reserves may contribute to increasing risk and thus a higher required return on the part of foreign investors. In particular, if stock of foreign reserves, FXR^Y, falls below a certain threshold (reflected in the model by a parameter $\overline{FXR}^{Y,SS}$ in (74), set to 15 percent in the baseline calibration, a foreign reserve contribution to the UIP premium (γ_t^{FXR} in equations (57) and (55)) becomes positive (see Figure 5). On the other hand, it would become negative if the stock of reserves rises above $\overline{FXR}^{Y,SS}$, indicating that plentiful reserves are considered favorably by the markets.[60]

Exchange rate peg with open capital account

[60] IMF (2016) and references therein may help calibrate this parameter in specific cases.

Under this regime, the monetary authority sets the target path for nominal exchange rate depreciation, $\Delta\overline{s}_t^{US}$, as in equation (66′).

$$\Delta\overline{s}_t^{US} = c_1^{\Delta\overline{s}^{US}} \cdot \Delta\overline{s}_{t-1}^{US} + (1 - c_1^{\Delta\overline{s}^{US}}) \cdot \Delta\overline{s}^{SS,US} + \varepsilon_t^{\Delta\overline{s}^{US}} \tag{66′}$$

The open capital account (with deep financial markets) implies very large value for the parameters' product $c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm})$ in equations (54) and (55).

Because of the open capital account, FXI has little (in the limit, no) effect, in that very large (in the limit, infinite) FXI would be required to change the UIP premium enough to stabilize the exchange rate. Along the same lines, the monetary policy authority loses control over the interest rates in the economy (r_t), which become determined endogenously (by equations (54), (55), (53) and (52)).

Trend inflation rate and trend nominal exchange rate are still linked by equation (67). Over the cycle, however, adjustments to prices become an important tool to adjust to shocks, along of course with fiscal policy through its ability to influence aggregate demand. A tax-based CFM could still be effective with the fully open capital account, as emphasized in Basu et al. (2020). For example, in the face of a temporary risk-on episode (e.g., a decrease in $\varepsilon_t^{\hat{\gamma}}$ in equation (54)), a temporary increase in $\tau_t^{FA^O}$ (equation (55)) would avoid the need for a change in the policy interest rate or the exchange rate, with associated volatility. Or, in a more precautionary vein, a permanent increase in $\tau_t^{FA^O}$ would tend to reduce foreign borrowing and thus reduce vulnerabilities to risk-off shocks.

Fixed exchange rate with partially closed capital account

We now assume that the response of cross-border capital flows to the UIP premium is limited, because of some combination of structural factors and explicit CFMs. This is reflected in the model by decreasing the parameters' product $c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm})$ in equations (54) and (55) to 0.1 in the baseline calibration.

Compared to the previous case, FXI is now more effective, and there is in general more scope for independent monetary policy. A decline in policy rates would not induce an unsustainable capital outflow, for example, in that a moderate sale of foreign exchange (or reduction in the current account deficit) could introduce a fall in the size of endogenous capital flows required to close the BoP and thus a fall in the return required by foreign investors. We say 'in general' because other features of the economy and regime will condition this effectiveness. For example, if reserves are low and perceived risks rise sharply with declines in reserves, then FXI will remain ineffective and the interest rate will have to be used to defend the peg.

Fully closed capital account

Cross-border financial flows are no longer influenced by the UIP premium (parameters' product $c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm})$ is set to zero). In a pure floating regime (i.e.

with no FXI), the exchange rate has to adjust to close the BoP through its effects on trade flows. As always, the outcome depends on all the sectors of the economy; for example a decline in aggregate demand will also close a current account deficit. Under a fixed exchange rate regime, FXI would generally speaking sustain the peg, by providing or absorbing foreign exchange resulting from current account and other financial account transactions. Interest rates help close the BoP only through their influence on aggregate demand.

3.3.2 Fiscal policy

The fiscal block provides an empirically realistic account of government spending and revenue in a model which does not assume Ricardian equivalence. This allows us to analyze: (i) the macroeconomic effects of expenditure and revenue policies, with plausible fiscal multipliers; (ii) public debt projections and the fiscal adjustment required to achieve sustainability; (iii) the macroeconomic implications of different financing choices, such as between official and private, and foreign and domestic, debt; (iv) longer-term implications of public investment for debt levels and growth; and (v) fiscal/monetary interactions.

FINEX includes fiscal *targets* and *reaction functions.* A fiscal target is an objective for a fiscal variable such as the ratio of debt to GDP. A reaction function adjusts fiscal policy to achieve the target, for example reducing (increasing) spending when the projected debt ratio is too high (low). FINEX is a forward-looking model, and thus a stable solution implies that variables return to their values along the balanced-growth path. This requires that policy acts to stabilize the model economy. One such requirement is the familiar one that monetary policy stabilizes the inflation rate around the target. Similarly, fiscal reaction functions ensure that debt eventually converges to sustainable levels.

Fiscal reaction functions have an obvious analogy with Taylor rules, but the institutional and policy context is quite different. As with some interpretations of Taylor rules, fiscal reaction functions in the literature are largely interpreted as empirical summaries of the general behavior of fiscal authorities, with important implications for debt sustainability and system dynamics (Bohn (1998), Mauro et al. (2015)). In practical applications of FINEX, fiscal reaction functions may be reference points for fiscal policy formulation, as Taylor rules are also sometimes used for monetary policy.

An important related literature discusses ‘fiscal rules’ as explicitly normative guidelines for fiscal policy (e.g., IMF (2018), Caselli et al. (2022)). These fiscal rules are generally expressed as inequality constraints, such as limits on the maximum ratio of debt to GDP, and as such do not provide an anchor for fiscal policy such as required in FINEX. Fiscal reaction functions can help implement fiscal rules, but the relationship is complex.[61] For example, a stochastic simulation of FINEX could produce a probabilistic assessment of the risk of breaking a fiscal rule such as a ceiling on the ratio of debt to GDP. This risk would depend on the structure of the economy, the nature of the shocks, and the fiscal and monetary policy framework, including the fiscal reaction functions, all of which can be captured in FINEX. This takes us outside the scope of this paper, however.[62]

In what follows, we first discuss the various tax- and expenditure-based instruments through and then describe specific fiscal policy targets under stylized fiscal reaction functions.

Government revenues

The government collects revenues from various sources (79), including corporate income taxes ($GR_t^{Y,Y}$), consumption taxes ($GR_t^{C,Y}$), import duties ($GR_t^{M^{NOIL},Y}$ and $GR_t^{M^{OIL},Y}$), natural resource (NR) royalties ($GR_t^{NR,Y}$), and others ($GR_t^{O,Y}$).

$$GR_t^{Y} = GR_t^{Y,Y} + GR_t^{C,Y} + GR_t^{M^{NOIL},Y} + GR_t^{M^{OIL},Y} + GR_t^{NR,Y} + GR_t^{O,Y} \qquad (79)$$

Revenues are a function of exogenous tax rates and the pre-tax tax base. The tax revenue for each of the first four sources of revenues in (79) is given by a generic equation (A9), where $\tau_t^{\mathcal{X}}$ is a tax rate (in percent) and $\mathcal{X}_t^{Y}$ is *after-tax* $\mathcal{X}$-to-GDP share (defined in (A10)):

$$GR_t^{\mathcal{X},Y} = \frac{\tau_t^{\mathcal{X}}/100}{1+\tau_t^{\mathcal{X}}/100} \cdot \mathcal{X}_t^{Y} \qquad (A9)$$

$$\mathcal{X}_t^{Y} = 100 \cdot (1+\tau_t^{\mathcal{X}}/100) \cdot \frac{P_t^{\mathcal{X}} \cdot \mathcal{X}_t}{P_t^{Y} \cdot Y_t^{R}}, \quad \text{for } \mathcal{X} \in \left\{C^R, M^{R,NOIL}, M^{R,OIL}, Y^R\right\} \qquad (A10)$$

Natural resource (NR) royalties, in contrast, are defined as a share of the overall NR profits:

$$GR_t^{NR,Y} = \tau_t^{NR}/100 \cdot G_t^{NR,Y} \qquad (80)$$

Other revenues are assumed exogenous and follow a simple AR(1) process:

$$GR_t^{O,Y} = c_1^{GR^{O,Y}} \cdot GR_{t-1}^{O,Y} + (1-c_1^{GR^{O,Y}}) \cdot \overline{GR}_t^{O,Y} + \varepsilon_t^{GR^{O,Y}} \qquad (81)$$

[61] Reaction functions are labeled 'operational rules' in IMF (2018).

[62] The fiscal reactions functions in FINEX are linear. Nonlinearities in the fiscal reaction function are potentially critical; see Ghosh et al. (2013) and Buffie et al. (2012), for example.

All tax rates in the model (τ_t^{x}) follow a simple AR(1) process (equation (A11)), typically a random walk ($\rho = 1$), with the shock term representing policy changes, such that changes in tax rates are perceived permanent:

$$\tau_t^{x} = \rho \cdot \tau_{t-1}^{x} + (1-\rho) \cdot \tau^{x,SS} + \varepsilon_t^{\tau^{x}} \tag{A11}$$

Overall government revenues GR_t^Y are decomposed into their trend and gap components (82). GR_t^Y is the ratio of overall revenues to *nominal* GDP. $\overline{GR}_t^Y$ and $\widehat{GR}_t^Y$, on the other hand are defined as ratios to *potential* nominal GDP. In order to make the decomposition in (82) consistent, we adjust GR_t^Y by the value of the 'nominal GDP gap', which is approximated in (82) by multiplying the real GDP gap, $\hat{y}_t^R$, by a factor capturing the typical relationship between nominal and real GDP fluctuations, proxied by $c_1^{GR^Y}$.[63]

$$GR_t^Y \cdot (1 + c_1^{GR^Y} \cdot \hat{y}_t^R/100) = \overline{GR}_t^Y + \widehat{GR}_t^Y \tag{82}$$

The trend revenue share is simply a product of the tax rates and the trends in each base:

$$\begin{aligned} \overline{GR}_t^Y &= \tau_t^Y + \tau_t^C/100/(1+\tau_t^C/100) \cdot \overline{C}_t^Y + \tau_t^{M^{NOIL}}/100/(1+\tau_t^{M^{NOIL}}/100) \cdot \overline{M}_t^{NOIL,Y} \\ &\quad + \tau_t^{M^{OIL}}/100/(1+\tau_t^{M^{OIL}}/100) \cdot \overline{M}_t^{OIL,Y} + \overline{GR}_t^{NR,Y} + \overline{GR}_t^{O,Y} \end{aligned} \tag{83}$$

The gap share is then the residual from (82).

Government expenditures

Total government expenditures, GE_t^Y, are the sum of: government absorption, G_t^Y, debt service, $GE_t^{B,Y}$, other government expenditures, $GE_t^{O,Y}$, and direct government transfers, $GE_t^{Tr,Y}$:

$$GE_t^Y = G_t^Y + GE_t^{B,Y} + GE_t^{O,Y} + GE_t^{Tr,Y} \tag{84}$$

Government absorption, in turn, consists of government consumption $GE_t^{C,Y}$ and public investment $GE_t^{I^G,Y}$:

$$G_t^Y = GE_t^{C,Y} + GE_t^{I^G,Y} \tag{85}$$

[63] Other 'gap' definitions in the model measure real variables as a ratio to real potential GDP. Here, uniquely, we need gaps for a nominal variable relative to nominal potential GDP. The term $c_1^{GR^Y} \cdot \hat{y}_t^R$ is a proxy for a 'gap' in nominal GDP. Because we do not explicitly model potential *nominal* GDP, we also do not have an explicit nominal GDP gap. Instead, we assume that the business cycle oscillations of nominal GDP are systematically proportional to real GDP oscillations (i.e., the output gap $\hat{y}^R$). This delivers consistency, but this adjustment is empirically unimportant, because it will only make a small difference to $\overline{GR}_t^Y$ and $\widehat{GR}_t^Y$.

Interest expenditures are decomposed into interest payments on local currency-denominated debt $GE_t^{B^{LCY},Y}$ and foreign currency-denominated debt $GE_t^{B^{FCY},Y}$:[64]

$$GE_t^{B,Y} = GE_t^{B^{LCY},Y} + GE_t^{B^{FCY},Y} \tag{86}$$

Government consumption ($GE_t^{C,Y}$), government transfers ($GE_t^{Tr,Y}$), and other government expenditures ($GE_t^{O,Y}$) are modeled as exogenous processes. They follow simple AR(1) processes, with the shock term capturing policy changes, interpreted as unanticipated shocks to spending.

Government transfers, in contrast, are further decomposed into trend ($\overline{GE}_t^{Tr,Y}$) and gap ($\widehat{GE}_t^{Tr,Y}$) components to reflect the potential role of automatic stabilizers and thus inform the estimation of the cyclical and secular dynamics in private consumption.[65]

Public investment ($GE_t^{IG,Y}$) is the only fully endogenous component of the fiscal accounts.[66] With this assumption, it is implicitly the component that adjusts to achieve the fiscal targets described below.

Interest expenditures on foreign currency- and local currency-denominated debt from (86) are modeled as follows:

$$GE_t^{B^{FCY},Y} = r_{t-1}^{G,FCY}/100 \cdot B_{t-1}^{FCY,Y} \cdot (1 + \Delta s_t^{US}/100)/(1 + \Delta y_t/100) \tag{87}$$

$$GE_t^{B^{LCY},Y} = (r_{t-1}^{G,LCY}/100) \cdot B_{t-1}^{LCY,Y}/(1 + \Delta y_t/100) \tag{88}$$

The interest rate on foreign currency-denominated debt, $r_t^{G,FCY}$, is approximated by the sum of a compounded foreign interest rate, $r_t^{G,Comp,FCY}$, and a foreign currency term premium, $\gamma_t^{G,FCY}$ (equation (89)). The shock, $\varepsilon_t^{r^{G,FCY}}$, accounts for the discrepancy with actual data.

$$r_t^{G,FCY} = r_t^{G,Comp,FCY} + \gamma_t^{G,FCY} + \varepsilon_t^{r^{G,FCY}} \tag{89}$$

[64] In applications of the model, other debt breakdowns may be important; an application to Israel in Remo et al. introduces CPI-linked debt, for example.

[65] See equations (26) and (27) in section 3.1.3. The specification and calibration of this decomposition is detailed in appendix A.IV.

[66] Tax rates are policy choices; transfers depend partly on economic activity. Clearly the endogeneity of public investment is consequential for the response of the economy to shocks. This assumption is motivated partly by the empirical observation that indeed investment spending seems often to be the variable that adjusts and also by the thought that taxes and current expenditures are more likely to require legislative action. However, it could easily be changed such that another component of the fiscal accounts would be endogenous.

The compounded rate, $r_t^{G,Comp,FCY}$, is defined in (90) as a weighted sum of the expected short-term foreign interest rates ($r_t^{US}, r_{t+1}^{US}, r_{t+2}^{US}, ...$) with weights $IN^{FCY} \cdot \left(1 - IN^{FCY}\right)^j$ for $j = 0, 1, \ldots$. This means that the average maturity of the compounded rate $r_t^{G,Comp,FCY}$ is $\frac{1}{IN^{FCY}}$ periods.[67] Here, the calibrated parameter IN^{FCY} is an inverse of the average maturity of the foreign currency bonds that comprise the foreign currency-denominated public debt.

$$r_t^{G,Comp,FCY} = IN^{FCY} \cdot r_t^{US} + (1 - IN^{FCY}) \cdot r_{t+1}^{G,Comp,FCY} \tag{90}$$

The non-Ricardian effects of fiscal policy on $r_t^{G,FCY}$ are captured through the effect of the public debt on the foreign currency term premium:

$$\begin{aligned}\gamma_t^{G,FCY} = {} & c_1^{\gamma^{G,FCY}} \cdot \gamma_{t-1}^{G,FCY} + (1 - c_1^{\gamma^{G,FCY}}) \cdot (\gamma^{G,FCY} + c_2^{\gamma^{G,FCY}} \cdot (B_t^Y - B^{Y,SS})) \\ & + \varepsilon_t^{\gamma^{G,FCY}}\end{aligned} \tag{91}$$

Higher public debt level, B_t^Y, contributes to higher borrowing costs for the government through elevated $\gamma^{G,FCY}$.

Equations (92)-(94) present similar formulations for the interest rate on local currency-denominated debt:

$$r_t^{G,LCY} = r_t^{G,Comp,LCY} + \gamma_t^{G,LCY} + \gamma_t^{G,FCY} + \varepsilon_t^{r^{G,LCY}} \tag{92}$$

$$r_t^{G,Comp,LCY} = IN^{LCY} \cdot r_t + (1 - IN^{LCY}) \cdot r_{t+1}^{G,Comp,LCY} \tag{93}$$

$$\begin{aligned}\gamma_t^{G,LCY} = {} & c_1^{\gamma^{G,LCY}} \cdot \gamma_{t-1}^{G,LCY} + (1 - c_1^{\gamma^{G,LCY}}) \cdot (\gamma^{G,LCY} + c_2^{\gamma^{G,LCY}} \cdot (B_t^Y - B^{Y,SS})) \\ & + \varepsilon_t^{\gamma^{G,LCY}}\end{aligned} \tag{94}$$

The difference between (89) and (92) (beyond the different underlying short-term interest rates used for compounding) is that the equation for $r_t^{G,LCY}$ contains both local and foreign-currency term premia ($\gamma^{G,LCY}$ and $\gamma^{G,FCY}$).[68] These considerations and tradeoffs make the decision about public debt currency composition an additional important fiscal policy choice.

[67] Average maturity of the compounded rate $r_t^{G,Comp,FCY}$ is $IN^{FCY} \cdot \sum_{j=1,2,\ldots} \left(1 - IN^{FCY}\right)^{j-1} \cdot j = \frac{1}{IN^{FCY}}$.

[68] This reflects a stylized fact that the local currency government bond yields are typically steeper than the foreign currency-denominated ones (even if the short end of the two yield curves are similar). And this fact, in turn, may reflect the idea that the factors that drive foreign currency risk (for example the political situation, fiscal sustainability) are also likely to drive local currency risk. On top of that, exchange rate uncertainty adds to local currency risk.

Fiscal targets and reaction functions

Here we describe the targets of fiscal policy and how they are operationalized through specific reaction functions.

Debt targets as policy anchors

Fiscal policy has two debt targets, one for the public debt-to-GDP ratio, and another for the share of foreign currency-denominated debt in total public debt. In each case, the target consists of a steady-state value ($B^{Y,SS}$ and $B^{FCY,B,SS}$, respectively), and also a trend that converges towards this value ($\overline{B}_t^Y$ and $\overline{B}_t^{FCY,B}$).

The targets for the public debt-to-GDP ratio and the foreign-currency-denominated debt share evolve as follows, where the shocks represent policy changes to cause the targets to deviate temporarily but persistently from their steady-state values:[69]

$$\overline{B}_t^Y = c_1^{\overline{B}^Y} \cdot \overline{B}_{t-1}^Y + (1 - c_1^{\overline{B}^Y}) \cdot B^{Y,SS} + \varepsilon_t^{\overline{B}^Y} \tag{95}$$

$$\overline{B}_t^{FCY,B} = c_1^{\overline{B}^{FCY,B}} \cdot \overline{B}_{t-1}^{FCY,B} + (1 - c_1^{\overline{B}^{FCY,B}}) \cdot B^{FCY,B,SS} + \varepsilon_t^{\overline{B}^{FCY,B}} \tag{96}$$

In addition, a pair of identities serve to determine the share of foreign-currency-denominated and local-currency-denominated debt in GDP:

$$\overline{B}_t^Y = \overline{B}_t^{FCY,Y} + \overline{B}_t^{LCY,Y} \tag{97}$$

$$\overline{B}_t^{FCY,Y} = \overline{B}_t^{FCY,B}/100 \cdot \overline{B}_t^Y \tag{98}$$

Fiscal reaction functions

The authorities adjust fiscal policy systematically to bring debt ratios towards these targets. With two targets, there are two reaction functions: one for the overall structural fiscal deficit as a share of GDP, and one for foreign currency financing as a share of GDP. We now take each of these reaction functions in turn.

First, some preliminaries. We define the fiscal deficit (GD_t^Y) as government expenditures minus revenues in (99) and divide it into cyclical and structural components in (100):

$$GD_t^Y = GE_t^Y - GR_t^Y \tag{99}$$

[69] The model also supports a random-walk formulation for both equations (i.e., with AR(1) coefficients equal to 1), where the public debt ratio and the share of foreign currency-denominated debt could deviate permanently from their steady state calibrations.

$$GD_t^Y = GD_t^{S,Y} + GD_t^{C,Y} \tag{100}$$

Revenues such as income taxes move with the tax base, while some categories of expenditure such as unemployment benefits may be statutorily linked to activity. Equation (101) determines the cyclical component of the deficit as the sum of the cyclical component of revenues and a term $(-c_1^{GD^{C,Y}} \cdot \hat{y}_t^R)$ meant to capture cyclically-linked spending.

$$GD_t^{C,Y} = -\widehat{GR}_t^Y - c_1^{GD^{C,Y}} \cdot \hat{y}_t^R \tag{101}$$

The government has a choice of borrowing in local currency and/or foreign currency (102), which leads to local currency- and foreign currency-denominated debt accumulation equations (103) and (104).[70]

$$GD_t^Y = GF_t^{LCY,Y} + GF_t^{FCY,Y} \tag{102}$$

$$B_t^{LCY,Y} = GF_t^{LCY,Y} + B_{t-1}^{LCY,Y}/(1 + \Delta y_t/100) + \varepsilon_t^{B^{LCY,Y}} \tag{103}$$

$$B_t^{FCY,Y} = GF_t^{FCY,Y} + B_{t-1}^{FCY,Y} \cdot (1 + \Delta s_t^{US}/100)/(1 + \Delta y_t/100) + \varepsilon_t^{B^{FCY,Y}} \tag{104}$$

We now define the paths for trend structural deficit, $\overline{GD}_t^{S,Y}$, and for trend foreign currency-denominated deficit financing, $\overline{GF}_t^{FCY,Y}$ to be consistent with the target paths for the debt-to-GDP ratio, $\overline{B}_t^Y$, and for foreign currency-denominated debt, $\overline{B}_t^{FCY,Y}$. The former is defined implicitly in equation (105) and the latter in equation (106):

$$\overline{B}_t^Y = \overline{GD}_t^{S,Y} + (\overline{B}_t^{FCY,Y} \cdot (1 + (\Delta \overline{z}^{SS,US} - \pi^{C,US,SS} + \overline{\pi}_t^C)/100) + \overline{B}_t^{LCY,Y})/(1 + \Delta \overline{y}_t/100) \tag{105}$$

$$\overline{GF}_t^{FCY,Y} = (1 - (1 + (\Delta \overline{z}^{SS,US} - \pi^{C,US,SS} + \overline{\pi}_t^C)/100)/(1 + \Delta \overline{y}_t/100)) \cdot \overline{B}_t^{FCY,Y} \tag{106}$$

Now we turn to the reaction functions themselves.

[70] For simplicity, we assume that deficits are funded by treasury notes in local currency and foreign currency with average maturity $\frac{1}{IN^{LCY}} = 8$ and $\frac{1}{IN^{FCY}} = 8$ years, respectively. The issued notes are automatically refinanced every year. A more detailed maturity structure could be easily added as an extension following, for example, Kamenik et al. (2013). This could allow the user to incorporate liquidity considerations into the analysis of fiscal risks.

The reaction function for the overall structural deficit, equation (107), says that the fiscal authorities adjust the structural deficit $GD_t^{S,Y}$ so that it returns to the target structural deficit path, $\overline{GD}_t^{S,Y}$, with a speed of convergence determined by $c_1^{GD^{S,Y}}$:

$$GD_t^{S,Y} = c_1^{GD^{S,Y}} \cdot GD_{t-1}^{S,Y} + (1 - c_1^{GD^{S,Y}}) \cdot \overline{GD}_t^{S,Y} - c_2^{GD^{S,Y}} \cdot \hat{B}_t^Y + c_3^{GD^{S,Y}} \cdot \hat{y}_t^R + \varepsilon_t^{GD^{S,Y}} \tag{107}$$

The structural deficit also responds directly to expected deviations of debt from the target path through the term $(-c_2^{GD^{S,Y}} \cdot \hat{B}_t^Y)$, where $\hat{B}_t^Y$ is defined in (108) to have a forward-looking component, if $c_1^{\hat{B}^Y}$ is positive.

$$\hat{B}_t^Y = (1 - c_1^{\hat{B}^Y}) \cdot (B_t^Y - \overline{B}_t^Y) + c_1^{\hat{B}^Y} \cdot \hat{B}_{t+1}^Y \tag{108}$$

The last two terms in the fiscal reaction function (107) reflect other factors that influence the structural fiscal deficit. The term $c_3^{GD^{S,Y}} \cdot \hat{y}_t^R$ allows for the structural deficit to react countercyclically, if $c_3^{GD^{S,Y}} < 0$. And finally, the trajectory of the structural deficit can be idiosyncratically adjusted by the fiscal authorities by the means of ad hoc structural deficit shock $\varepsilon_t^{GD^{S,Y}}$.

The second reaction function, equation (109), says that the fiscal authorities adjust foreign currency-denominated deficit financing, $GF_t^{FCY,Y}$, so that it returns to the target $\overline{GF}_t^{FCY,Y}$ defined in equation (106). Again, they do so gradually, with the pace of convergence determined by the value of the policy parameter $c_1^{GF^{FCY,Y}}$.

$$\begin{aligned} GF_t^{FCY,Y} = c_1^{GF^{FCY,Y}} \cdot GF_{t-1}^{FCY,Y} &+ (1 - c_1^{GF^{FCY,Y}}) \cdot (\overline{GF}_t^{FCY,Y} \\ &- c_2^{GF^{FCY,Y}} \cdot (100 \cdot B_{t+1}^{FCY,Y} / B_{t+1}^Y - \overline{B}_t^{FCY,B})) \\ &+ c_3^{GF^{FCY,Y}} \cdot (GD_t^Y - \overline{GD}_t^{S,Y}) + \varepsilon_t^{GF^{FCY,Y}} \end{aligned} \tag{109}$$

In addition, the larger is the deviation of expected foreign currency-denominated debt share from the target path, the lower is the foreign currency financing share of the new deficits. This is captured by the term $(-c_2^{GF^{FCY,Y}} \cdot (100 \cdot B_{t+1}^{FCY,Y} / B_{t+1}^Y - \overline{B}_t^{FCY,B}))$ in (109).

The fiscal authorities may also increase foreign currency financing if the overall deficit is above its structural target path as defined in (105), so that the overshoot of the deficit does not fall entirely on domestic financing. This policy is captured by the term $(c_3^{GF^{FCY,Y}} \cdot (GD_t^Y - \overline{GD}_t^{S,Y}))$ in (109).

Finally, any idiosyncratic deviations from the reaction function (109) are captured by the shock $\varepsilon_t^{GF^{FCY,Y}}$.

The targets and reaction functions described in this section allow for a rich menu of possibilities for how fiscal policy works to keep total and foreign currency-denominated debt stable and more broadly to preserve fiscal sustainability. In particular, there are many possible configurations of the parameters that determine the debt targets in equations (95) and (96) and in the reaction functions (107) and (109).

These different reaction functions will lead to differing probabilities of adherence to fiscal rules, and to different macroeconomic outcomes, depending on the nature of the shocks and of the economy, and on the monetary policy regime. The linkages are rich, including through the implications for the countercyclicality of fiscal policy and interactions between foreign currency financing, exchange rate volatility, and fiscal sustainability. For example, this model could explore the conjecture in Kaminsky et al. (2005) that fiscal policy may be procyclical because global risk-off shocks or country UIP premia are negatively correlated with GDP, such that fiscal financing is most costly when it is most needed.[71] Country applications of FINEX are exploring some of these issues.

4 FINEX in Action

FINEX is fundamentally a forecasting model. In Box 4, and much more so in the companion paper Remo et al., we demonstrate its use for this purpose, showing how the model can provide a structural interpretation of the historical data and help make policy-contingent forecasts and risk assessments.

This section takes a preliminary step by presenting the workings of the model more directly, showing how it can make sense of a wide range of shocks and policy interactions. Section 4.1 consider the implications of a fiscal expansion for a range of policy regimes and country characteristics. Section 4.2 analyzes the effects of public investment vs consumption with various initial debt levels. Section 4.3, studies the implications of using additional policy instruments (foreign exchange intervention and and pre-emptive CFMs) in response to shocks to foreign risk appetite. Section 4.4 highlight the benefits and costs of pre-emptive CFMs when private external debt is high. Section 4.5 concludes by highlighting differences in the response to real and financial external shocks.[72]

The baseline calibration assumes an EMDEs with a pure float IT regime; fiscal policy targets a predefined level of public debt using public investment expenditures as the fiscal instrument. It further assumes: (i) strong persistence in the Phillips

[71] The model could potentially capture the flavor of Bianchi et al. (2019), who find that highly-indebted countries tend to run pro-cyclical fiscal policy.

[72] The Figures show simulation results relative to the steady-state BGP: a value of zero implies that it is equal to its initial steady-state value along the BGP.

curve, to capture weakly anchored inflation expectations; (ii) substantial pass-through from imported prices to inflation; (iii) a relatively active monetary policy response; and (iv) imperfect capital mobility. Box 5 describes the calibration strategy we use in applying FINEX.[73]

In all these simulations, the policy reaction function parameters are not optimized. We could optimize the reaction functions with respect to a loss function. Of course, the results would depend on the calibration of the economy, the distribution of shocks, and the nature of the policy regime—for example the magnitude of the interest rate reaction to inflation would depend on the strength of the FXI response to the exchange rate. We do not do this here partly for simplicity, and partly because policymakers understand that all models are at best crude approximations; they often prefer to impose their preferred reaction functions and then use the resulting model forecasts as one (important) tool to judge the stance of policy.

4.1 Effects of a fiscal expansion

The analysis of a fiscal expansion illustrates the power of the model to make sense of a rich range of economic characteristics and policy interactions. Here we consider the implications of a fiscal expansion under different assumptions about monetary policy, the exchange rate regime, capital mobility, and financing sources.

In all these scenarios, shown in Figure 7, the government raises transfers to households by five percent of GDP in the first two years, while relaxing its long-term fiscal objectives to allow the debt-to-GDP ratio to increase permanently by ten percentage points. Starting from the third year of the simulation, the government adjusts its consumption spending, while keeping investment spending-to-GDP ratio fixed, to steer the debt level towards its debt objective.[74] Until the last scenario, we assume increased spending is financed through domestic debt issuance.

We consider six cases:

1. *Baseline: solid black line.* Real GDP increases in response to higher aggregate demand, while the current account deficit increases with higher imports. Higher financial capital inflows, attracted by a small rise in the the UIP premium, finance the current account deficit. Higher demand pushes up inflation, inducing the central bank to raise interest rates, leading to an exchange rate appreciation.

[73] The calibration for the baseline and other cases are presented in Annex A.III. Adrian et al. (2021) calibrates an EMDEs along the lines of points (i)-(iv) and Box 5.

[74] In the standard setup, government investment, not transfers, adjust to achieve the fiscal target, on the grounds of realism. Here we want to isolate the effects of government demand injections and debt accumulation; the next section discusses the implications of changes in public investment.

2. *High capital mobility* $\left(c_1^{FA^{O,Y}} = 1000\right)$*: solid green line*. Real GDP increases with higher aggregate demand. The current account deficit increases, more than in case (1) because the current account deficit is more easily financed by higher financial capital inflows, with no increase in the UIP premium. Higher demand also pushes up inflation slightly; the resulting interest rate response appreciates the exchange rate. With the unchanged UIP premium, compared to case (1) there is a slightly larger real exchange rate appreciation, lower inflation, and thus a smaller increase in the nominal interest rate. The story here is about internal balance and policy only; with full capital mobility, the balance of payments is a side-show in the short run.

   An important difference with respect to case (1) emerges in the longer run. As in case (1), the long-run effect of the fiscal expansion is a higher public debt ratio, to which foreign investors respond by increasing their required rate of return on domestic assets. In case (1), the resulting long-run reduction in the current account and financial inflows offsets this effect and keeps long-run real interest rates stable—see (59). With much higher capital mobility, the higher premium associated with higher public debt translates directly into higher long-term real interest rates. This decreases steady-state investment, reducing long-term real GDP.

3. *IT with limited capital mobility* $\left(c_1^{FA^{O,Y}} = 0.1\right)$*: solid blue line.* Both the short- and the long-run are now different. Higher aggregate demand still raises output and inflation. However, foreigners are reluctant to finance the demand-driven increase in imports, so the UIP premium increases. Interest rates rise to fight inflation, but not enough to generate the required UIP premium increase, so the exchange rate depreciates instead of appreciating as in case (1).[75] With the weaker exchange rate, inflation is higher—and interest rates respond more—than in case (1). The higher interest and weaker exchange rates have off-setting implications for GDP in the short run. The higher interest rates result in a larger fiscal deficit, but the higher inflation increases nominal GDP more, such that the debt-to-GDP ratio is lower.

   In the long run, real GDP now barely falls. Capital flows are much less sensitive to the UIP premium, so the debt-related-premium increase no longer leads to substantial financial outflows. The long-run current account balance no longer changes much and thus is not associated with lower investment and GDP. A closed capital account thus insulates the economy from the long-run costs of a higher UIP premium. Of course, it would also insulate from the

[75] Thus, whether the exchange rate appreciates or depreciates in response to a fiscal expansion depends on the degree of capital mobility. This is analogous to the IS-MP-BP result in box (1) that what matters for the sign of the exchange rate response is the slope of the MP curve relative to the BP curve, i.e., the strength of the monetary policy response relative to the openness of the capital account.

benefits of a fiscal consolidation.

4. *IT with managed exchange rate, limited capital mobility: solid red line.* The authorities in case (3) may be tempted to intervene in the foreign exchange market to alleviate pressure on the exchange rate. Thus, the only difference from the previous case is that here the authorities follow the foreign exchange intervention rule (72) and sell reserves to reduce demand for financial inflows, thus mitigating the increase in the UIP premium, thereby helping stabilize the exchange rate, inflation, and the policy rate.[76] The cost is a bigger current account deficit, financed not as in case (1) by financial capital inflows but by selling foreign exchange reserves. The effect on GDP in the short-run is about the same as in case (3): the depreciated real exchange rate in case (3) stimulates exports more than in case (4), but the higher interest rate offsets.

5. *IT with managed exchange rate, limited capital mobility, low level of foreign exchange reserves and high public debt: dotted red line.* We extend case (4) to a situation in which the central bank has a low level of reserves and high levels of public debt.[77] As discussed in section 3.2, when reserves are well above some minimum lower bound, a decrease in the stock of reserves has a small effect on γ_t. However, if the initial stock of reserves is low, then a decline increases γ_t much more (Figure 5). Similarly, when public debt is low, the effects from an increase in its level have a small impact on the UIP premium, but the effects are higher with higher initial levels of debt (Figure 4). Starting with low reserves and high debt, the benefits from managing the exchange rate are lost, as the UIP premium increases firmly in response to the depletion of foreign reserves and the rise in government debt. The increase in the premium induces a weaker exchange rate (even more than in case (3)), driving inflation up and requiring a more contractionary monetary policy that reduces the positive impact of the fiscal expansion on private consumption.

   In the short run, the weaker exchange rate more than offsets the effects of higher real interest rates on real GDP. In the long run, however, real GDP declines much more, because the permanently higher UIP premium increases interest rates, depressing private investment and potential output; meanwhile, the weak real exchange rate drives the large increase in the current account balance.

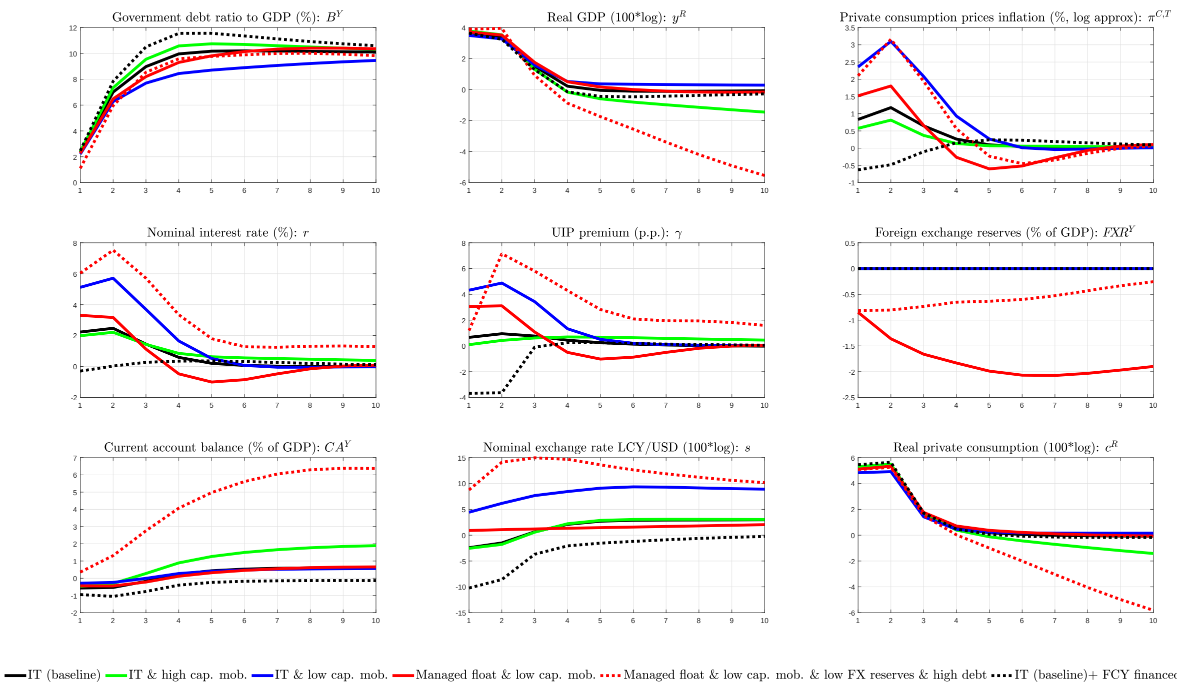
6. *Foreign currency-financed deficit: dotted black line.* We now return the baseline (case (1)), except that now the increase in government spending is financed by dollar-denominated foreign borrowing, treated as part of exogenous capital flows in the balance of payments. The official inflows over-finance

[76] We assume for simplicity that the authorities do not rebuild reserves over time.

[77] The reserves-to-GDP is 6 percent here, compared to 13 percent in case (4), just above the FXR lower bound of 5 percent where the central bank stops intervening. The debt-to-GDP ratio is 80 percent here, compared to 50 percent in case (4). See Annex A.III

the imports generated by the higher aggregate demand, such that the exchange rate appreciates significantly, much more than even with an open capital account (case (2)), resulting in endogenous capital outflows and drops in the UIP premium and inflation. Real GDP growth is lower because the appreciation compresses net exports, but consumption is higher.[78]

Figure 7. Fiscal expansion



4.2 Fiscal expansions: public consumption vs investment

The government now expands current or investment spending, rather than transfers as in section 4.1. This yields an interesting range of demand and supply-side effects, particularly when interacted with different levels of initial public debt. As in section 4.1, government spending (here absorption, i.e. consumption or investment) increases during the first two periods, financed by local-currency debt. The government adjusts its long-run government debt-to-GDP target permanently to accommodate the increased spending; after the first two years, government consumption adjusts endogenously to steer the debt level towards its target.

[78] We assume no intervention and thus that all the foreign borrowing flows are sold into the market; a policy of reserve accumulation would change the results again. Aiyar et al. (2007) and related papers examine the implications of various combinations of fiscal policy and reserves management in the face of aid inflows; this model addresses these issues almost as an afterthought.

Figure 8 compares the effects of expansion in government consumption (solid red line) and investment (solid blue line) for the baseline specification. In both scenarios, the output gap increases, as government demand is partially offset by the crowding out of private investment (as the central bank hikes the policy rate in response to the resulting inflationary pressures) and an increasing current account deficit.

Both are different from the results observed in the previous section. Most notably, the nominal exchange rate now depreciates in response to the fiscal expansion, instead of appreciating in the same baseline calibration (case (1) in section 4.1). The difference lies in how the fiscal expansion affects private consumption and inflation. Increased transfers directly increase private consumption, significantly impacting consumer price inflation. When instead the government increases absorption, the increase in private consumption is indirectly generated by the increase in the output gap, producing a smaller impact on the CPI and hence a smaller increase in the policy interest rate.[79] For the baseline level of capital account mobility, the negative effect of the larger current account on the exchange rate outweighs the positive impact of the policy rate.

The big difference between the consumption and investment simulations lies in the implications for potential GDP, which is higher in the case of investment spending because of the rise in the public capital stock.

A higher initial public debt (30 percentage points of GDP above the baseline), can make a big difference to some of these results (dashed lines). The UIP premium increases much more, (remembering (56)), even in the short run, resulting in higher depreciation, inflation, and interest rates.

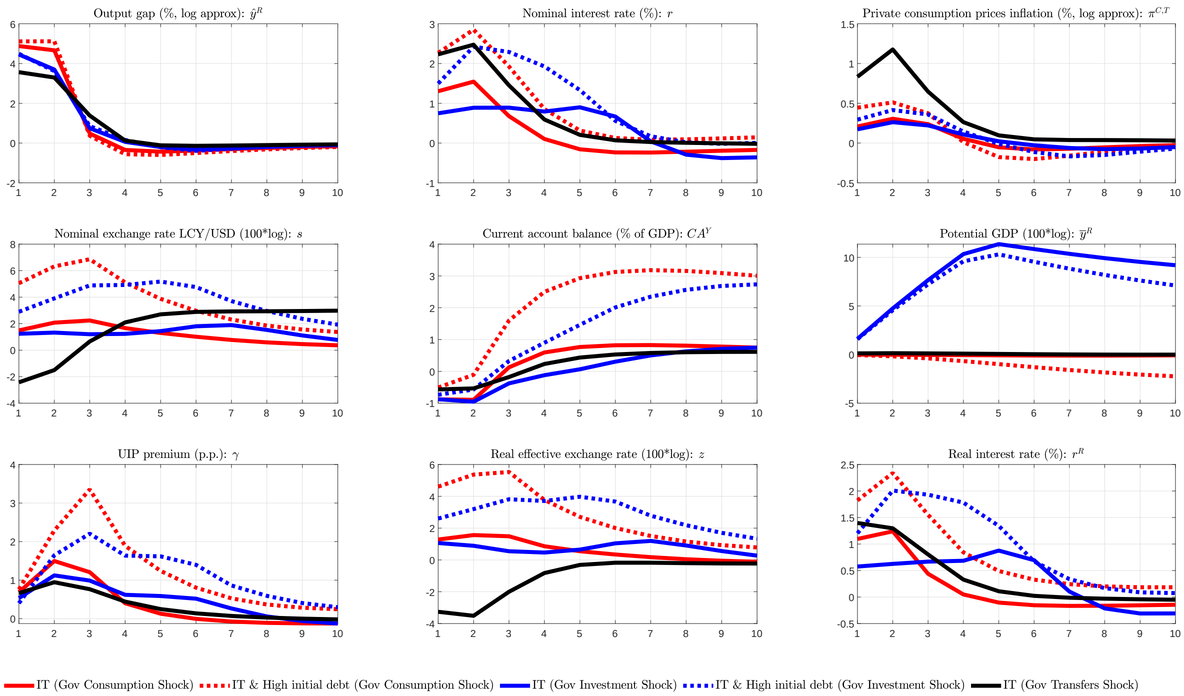
The long-run implications of higher initial debt stocks are more dramatic. The current account surplus increases in response to the higher interest rates, helping bring the UIP premium back down. However, the permanently higher real interest rates and lower capital inflows drive lower private investment and hence lower output relative to the low-debt case. The long-run fiscal multiplier is still positive for investment but is negative for government consumption.[80]

A fiscal contraction would reverse the results here and in section 4.1, with some potentially interesting implications. For example, a fiscal consolidation, particularly one that avoids a reduction in government investment, could increase long-run GDP, the more so the higher the initial debt stock, but it would present short-run demand-management challenges.

[79] The calibration assumes that government absorption falls on substantially different basket of goods than does private consumption.

[80] The long-term marginal rate of return on public investment in the model is 0.1 for the baseline calibration given by parameter $c_2^{\Delta\overline{y}^R}$ in (36). It would be straightforward to add a parameter to control for the efficiency of government investment expenditures.

Figure 8. Fiscal policy instruments



4.3 Policy responses to risk appetite shocks

We now examine the implications of using different monetary policy instruments in response to an unanticipated risk appetite shock. We compare the exclusive use of the nominal interest rate as a policy instrument (the baseline) to the addition of FXI and ex-ante administrative CFMs. We compare the results for a typical advanced economy (AE) and EMDEs (baseline) calibration.

Figure 9 presents the effects of a one-time negative five percentage-point shock to risk appetite ($\varepsilon^{\hat{\gamma}}$ in (54)).[81] In the baseline (solid black line), the shock reduces the supply of financial flows, requiring an increase in the UIP premium. Reflecting typical EMDEs features, the resulting nominal exchange rate depreciation increases inflation sharply. In response, the central bank raises policy interest rates, while the real exchange rate depreciation stimulates exports and discourages imports resulting in an increased current account surplus, somewhat mitigating the increase in the UIP premium. As in Adrian et al. (2021) and for similar reasons, the same risk-off shock is, in contrast, expansionary in a representative advanced economy (black dotted line). With better-anchored expectations and less exchange rate pass-through, expenditure switching dominates the smaller increase in the pol-

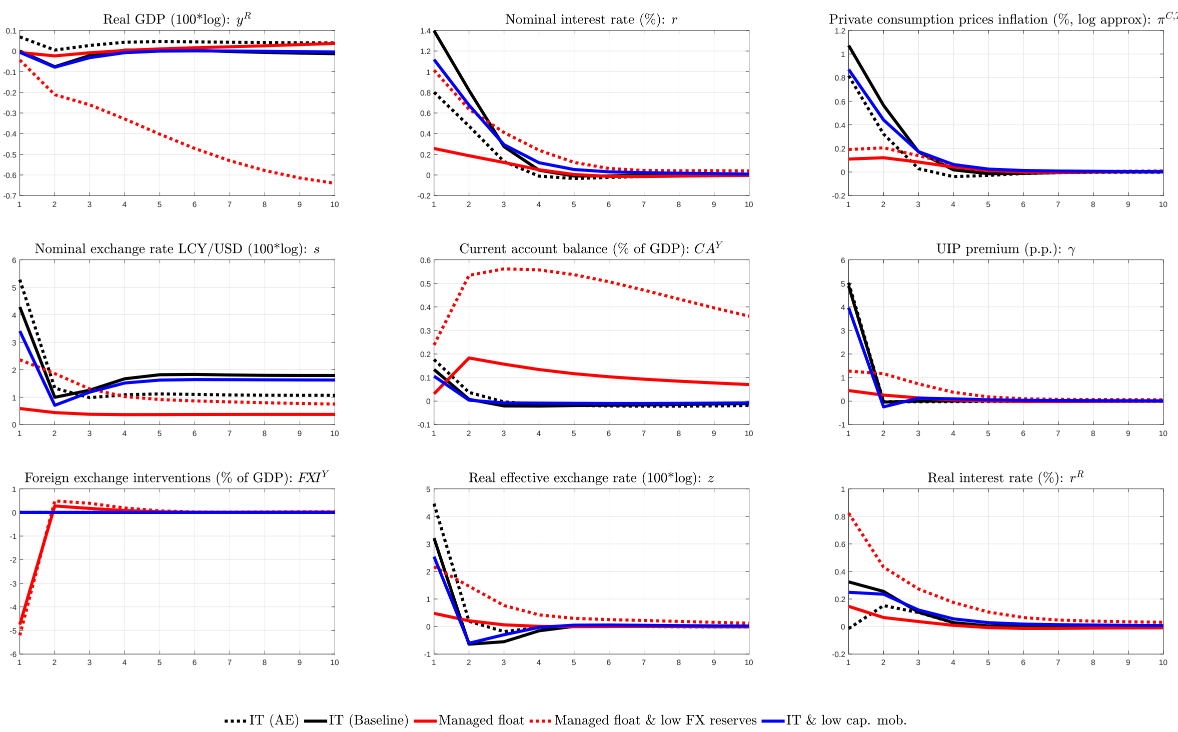
[81] As in the previous simulations, the government adjusts its consumption spending, while keeping investment spending-to-GDP ratio fixed, to steer the debt level towards its debt objective.

icy rate, and output increases.[82]

EMDEs monetary authorities may be tempted to use FXI to stabilize the exchange rate and thus avoid the contractionary monetary policy response (solid red line). Following the same FXI rule (72) as in section 4.1, the authorities sell reserves to reduce demand for financial inflows and thus defend the exchange rate.[83] This reduces the negative macroeconomic effects of the shock by allowing the central bank to conduct a less restrictive monetary policy.

FXI can clearly help, but what if reserves are low (dotted red line)? The fall in reserves leads to an increase in the UIP premium that at least partially offsets the benefits of the intervention on inflation and exchange rate. The persistently higher premium translates into a higher real interest rate leading to lower investment activity and an associated decline in potential output. Correspondingly, it also discourages risk-sensitive net financial inflows causing a permanent weakening of the exchange rate that increases the current account surplus in the long run.

Figure 9. Risk appetite shock



Finally, the authorities may consider implementing ex ante administrative CFMs to

[82] The AE IT regime has (i) reduced nominal price rigidity; (ii) lower exchange rate pass-through; (iii) increased persistence in the monetary policy response and thus a smaller initial reaction; and (iv) deeper foreign exchange markets (Annex A.III).

[83] As in section 4.1, we assume that the authorities do not rebuild reserves over time.

reduce the effective degree of capital mobility (solid blue line). Because of the reduced sensitivity of capital flows to the UIP premium, the same risk-off shock has a reduced impact: it takes a smaller adjustment of the current account, and thus other variables, to offset the effects on the UIP premium. Along the same lines, these administrative CFMs would also mean that a smaller volume of intervention would be needed to implement the managed float.

Ex ante administrative CFMs work very differently in the face of a quantity-based capital account shock, such as to an exogenous component of capital flows $\overline{FA}_t^{O,Y}$ in (49) (not shown). They would exacerbate rather than mitigate the impact, because they imply the need for a larger adjustment to the UIP premium and exchange rate to close the BoP.

4.4 Temporary drop in remittances and capital inflow taxes

Shocks to the BoP come in many forms. We have emphasized the role of financial flows, which respond to the UIP premium, and looked in section 4.3 at shocks to investors' required rate of return on those flows. This section explores the implications of a temporary drop in remittances, noting that similar outcomes emerge for other quantity shocks to the BoP. We illustrate the extent to which preemptive price-based CFMs can blunt the impact of this type of shock. We also look at some of the long-run implications of this policy.

The solid black line in Figure 10 shows the impact of a one-year one-percentage point fall in remittances as a share of GDP, in the baseline calibration. This fall directly increases the current account deficit and, through the effect of remittances on disposable income in (26), private consumption and thus aggregate demand. Inflation and output move in opposite directions, forcing a difficult trade-off on the central bank, which raises interest rates pro-cyclically.

When the private NFA position is negative and large, the impact is greater (solid blue line), because the increase in the current account deficit, financed by the same private financial inflow and thus fall in NFA, induces a larger increase in investors' required rate of return (58).[84] The result is a larger depreciation, higher inflation and interest rates, and thus a bigger drop in output. Valuation effects amplify the impact, because ratios of NFA and foreign-currency-denominated public debt to GDP, and thus the UIP premium, increase more with the larger depreciation.

These results generalize to other capital outflow shocks, such as a temporary negative shock to the exogenous component of financial flows in (48) (except for the di-

[84] For the this scenario, we calibrate the equilibrium ratio of private NFA to GDP to be 60 percentage points more negative than in the baseline.

rect effect of remittances on consumption.)[85]. FINEX thus captures one of the main mechanisms in the IPF: large negative NFA positions can increase vulnerability to BoP shocks.

As emphasized in Basu et al. (2020), preemptive price-based CFMs reduce incentives to accumulate foreign liabilities, reducing this vulnerability. To see this here, we simulate a permanent increase in the capital-inflow tax (τ^{FA^O} in (55)) of one percentage point well before the same one-year drop in remittances of one percentage point.[86] We compare the implications of this policy when the ratio of NFA-GDP was at the baseline steady-state (dashed black line) and when it was 60 percentage points below this level before the application of the tax (dashed blue line).

The preemptive capital inflows tax increases the level of NFA at t=0. The effect is much bigger when the initial level was higher in the first place, because of the nonlinearity of the $\tilde{\gamma}$ function (58). Thus, the use of preemptive capital inflow taxes (dashed black line) in the baseline calibration does not have significant effects on the response to the shocks. When the NFA position is initially weak, however, applying the capital inflow taxes as a precautionary measure substantially reduces the adverse effects of the subsequent remittances shock, mitigating the negative impact on output and inflation.

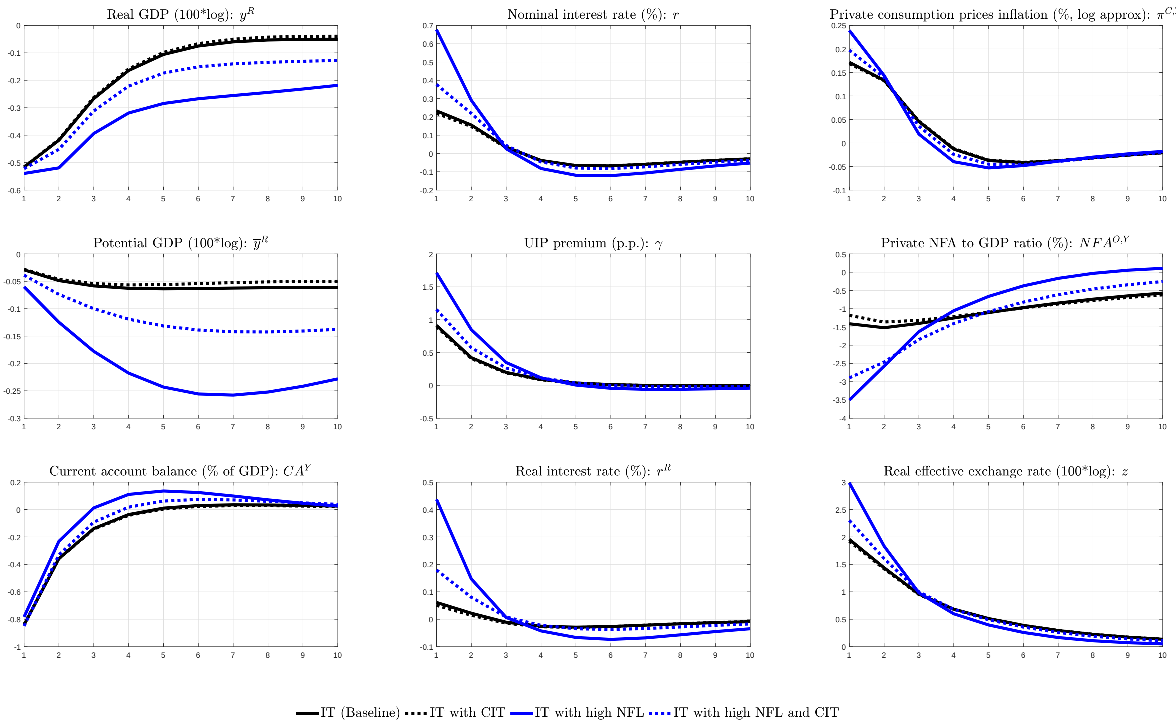
A preemptive capital inflow tax would also reduce vulnerability to the risk appetite shock discussed in 4.3 above (not shown). The interaction with capital account openness is very different, however. The risk appetite shock is expressed in terms of the change in foreign investors' required rate of return, such as might result from an increase in global risk aversion or an increase in foreign interest rates. It directly affects the UIP premium even with a fully open capital account. The adjustment in the BoP will be easy, because endogenous capital flows will respond readily to fill the gap. However, higher interest rates (see (62)) will affect internal balance, for example investment. The remittance shock analyzed in this section, in contrast, is characterized in terms of quantities. Thus, the more open the balance of payments, the *smaller* the adjustment in the UIP premium required to restore equilibrium, and the smaller the impact on internal balance.

We now examine *long-run* implications of pre-emptive capital-inflows taxes. Figure 11 shows the effects of the same one-percentage-point increase in the tax as above, now happening at time t=0 (and for simplicity abstracting from the temporary fall in remittances). In the baseline (solid black line) this leads to an initial increase in the trend level of the UIP premium ($\overline{\gamma}$ in (55)) and the real interest rate. The high interest rates and premium discourage foreign borrowing and produce a positive current account balance, which increases the NFA position and thus

[85]The latter is analogous to a negative 'noisy trader' capital account shock in Basu et al. (2020)

[86]In Figures 10 and 11, $t = 0$ corresponds to the remittances shock; the increase in the capital-inflows tax occurred at $t - 100$.

Figure 10. Transitory drop in remittances and pre-emptive capital inflow tax



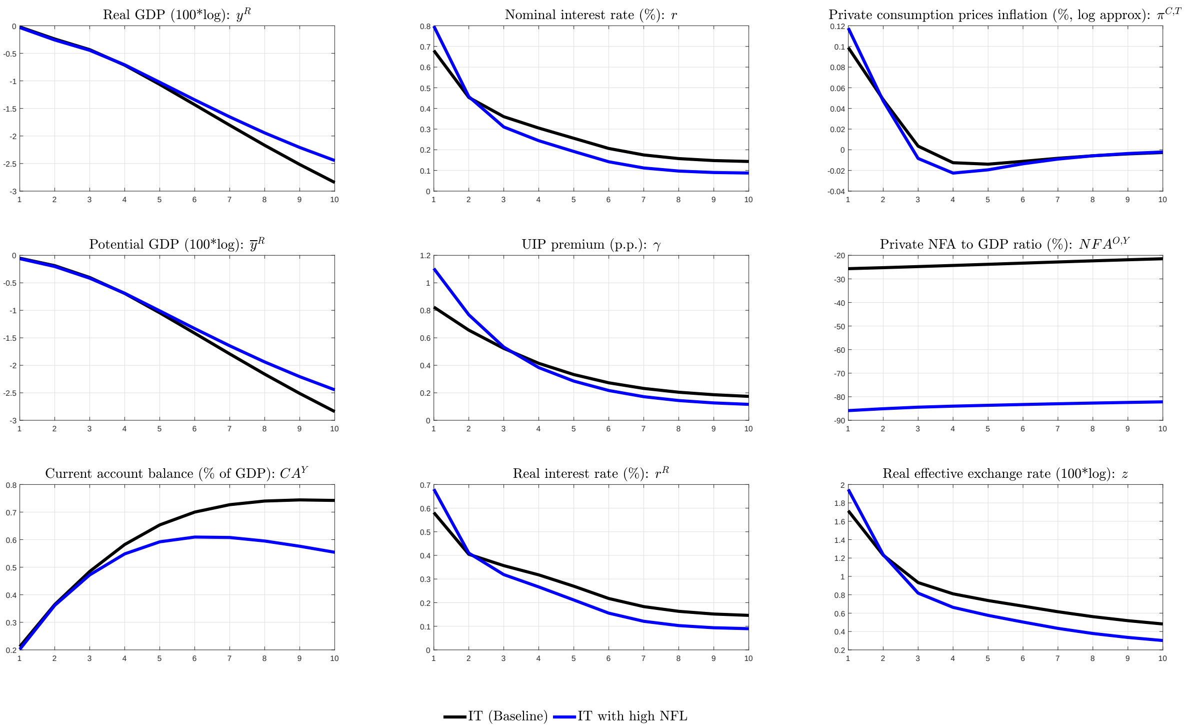
over time mitigates the effect on the premium and the real interest rate. The cost is a smaller private capital stock and hence lower potential GDP growth. When the (pre-tax) NFA position is much more negative (solid blue line), the mitigating effect of a stronger NFA position is larger, again because of the disproportionally large effect on the UIP premium, such that in the long run the negative effects on real GDP is smaller.

4.5 Monetary policy instruments: drop in external demand

We saw in sections 4.3 and 4.4 that a managed float can demonstrate less volatility in the face of various BoP shocks, as long as reserve levels are adequate. We also saw that administrative CFMs can blunt the impact of price-based capital account shocks and reduce required size of FXI interventions, though they exacerbate quantity-based BoP shocks. Here, we examine how the situation changes when the shock is to external demand.

Figure 12 presents the effects of a 2 percent transitory drop in external demand for exports, under various policy configurations. In all cases, the reduction in external demand generates a contraction in the output gap and an increase in the current

Figure 11. Capital inflow taxes in the long run

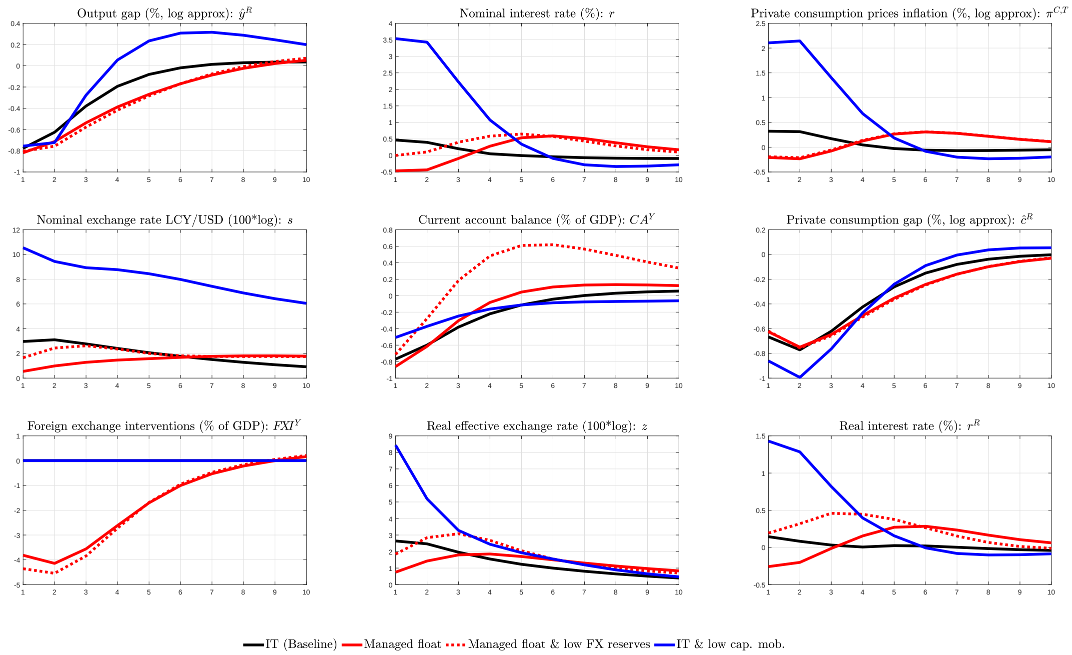


account deficit, which calls for a real exchange rate depreciation to activate expenditure switching and restore external equilibrium.

For the baseline calibration with a fully flexible exchange rate (solid black line), the pass-through of the exchange rate depreciation to inflation induces the central bank to raise the policy interest rate, despite the fall in output. A managed exchange-rate regime (solid red line) reduces the size of the depreciation and allows the central bank to pursue a countercyclical policy. However, the smaller expenditure-switching effect outweighs, and the fall in the output gap is somewhat larger. If reserves are low, such that a further decline raises investors' required return (dotted red line), the managed float looks worse still, as the persistently higher UIP premium induces a decline in investment and potential GDP.

Closing the capital account through ex ante administrative CFMs (solid blue line) helps with price-based capital account shocks, as we saw above, but not so here. It reduces the sensitivity of endogenous financial flows to changes in the UIP premium, such that a larger exchange rate depreciation, and hence higher inflation and a higher interest rate, are required to attract financial flows to replace foreign export demand and close the BoP. In the end, more of the adjustment falls to the current account. The greater expenditure switching buffers the impact on the output gap, but the lack of countercyclical capital inflows makes consumption more volatile.

Figure 12. Transitory drop in external demand



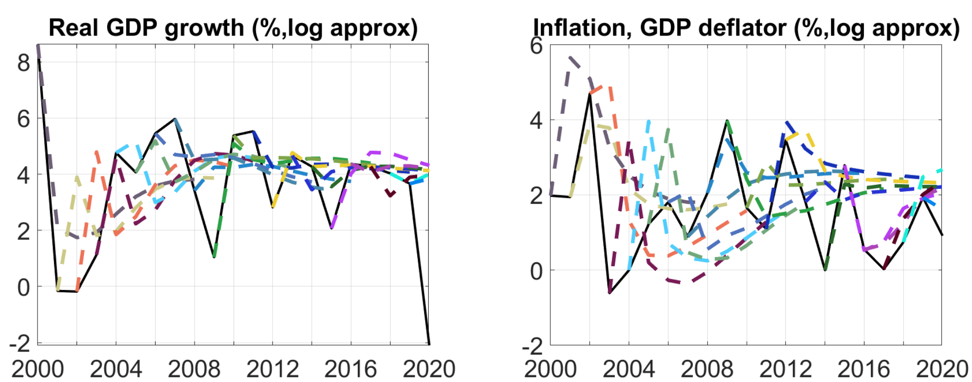
Box 4. FINEX in action: an Israel example

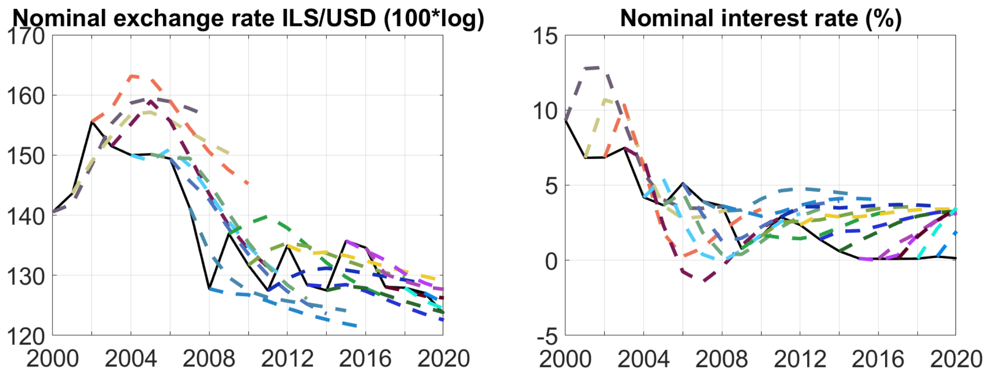
The first application of FINEX—the Israel Forecasting Model (IFM)—was developed with the Chief Economist Division of the Ministry of Finance of Israel (Remo et al.(forthcoming)). The IFM's purpose is to serve as a forecasting model, while an accompanying DSGE model serves for more structural policy simulations. The model has been used to prepare macroeconomic forecasts at the Chief Economist Division.

IFM is a somewhat modified version of the canonical FINEX model, with a focus on short- and long-run fiscal issues. Country applications will typically, as here, eliminate some parts of the canonical structure while adding other features, depending on country-specific circumstances. The IFM, in particular, does not feature FXI, CFM, commodity blocks, or NFA effects on the UIP premium. On the other hand, it includes CPI-linked debt, which represents about half of Israel government debt and which can significantly affect the dynamics of the model.

The model was calibrated to replicate Israeli data, using a variety of methods. In-sample forecasting performance served as an important validation check (Figure 13). The model's impulse response functions (IRFs) were compared to outside evidence and staff judgment. In addition, the model was used with the Kalman smoother to identify gaps and their drivers in terms of structural shocks, and the trends, for historical data. These results, like the IRFs, served both as outputs and as tests of the calibration.

Figure 13. In-sample forecasting performance





Once calibrated, the model-based analysis of historical developments forms the foundation for the forecast. Figure 14 top panel decomposes the output gap into its components. Taking the long view, the output gap went from 5 percent in 2000 to around -4 percent in 2003, driven initially by export demand and later also by consumption and investment declines in response to the dot-com bubble and the second intifada. Fiscal policy during this period was expansionary, led by government absorption. Government debt reached 90 percent of GDP in 2003 (see Figure 15). Export demand recovered after 2003, but starting from 2004 the government embarked on a set of fiscal reforms which would eventually bring the government debt down to around 60 percent of GDP over the next 12 years. The decline in government absorption had a persistent negative effect on output gap over the 2005-2008 period.

Fast-forwarding to 2020, the COVID-19 shock drove down private consumption and investment, and hence the output gap. Government absorption responded counter-cyclically. In addition, the fiscal response involved a sizable increase in transfers, which spurred private consumption. The lower charts in Figure 14 show, using model-based estimates, that the whole 'COVID-19' fiscal package significantly mitigated the impact of the shock on output and consumer price index (CPI) inflation.

We can get the flavor of a forecasting exercise by using the IFM to present alternative scenarios reflecting the impact of fiscal reforms that took place during 2004-2019. These reforms consisted of a steady reduction of government debt, from about 90 percent to 60 percent of GDP. Current government spending fell, while capital spending stabilized and eventually grew. An income tax reduction spurred growth by encouraging private investment, while higher import duties made up for some of the revenues losses.

Figure 14. Model-based data decompositions

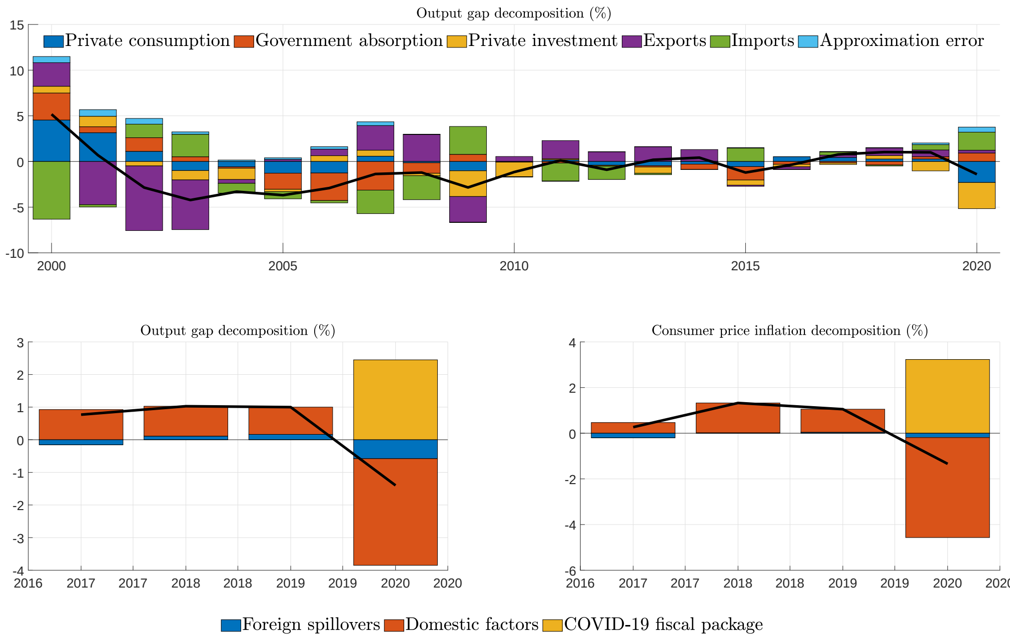
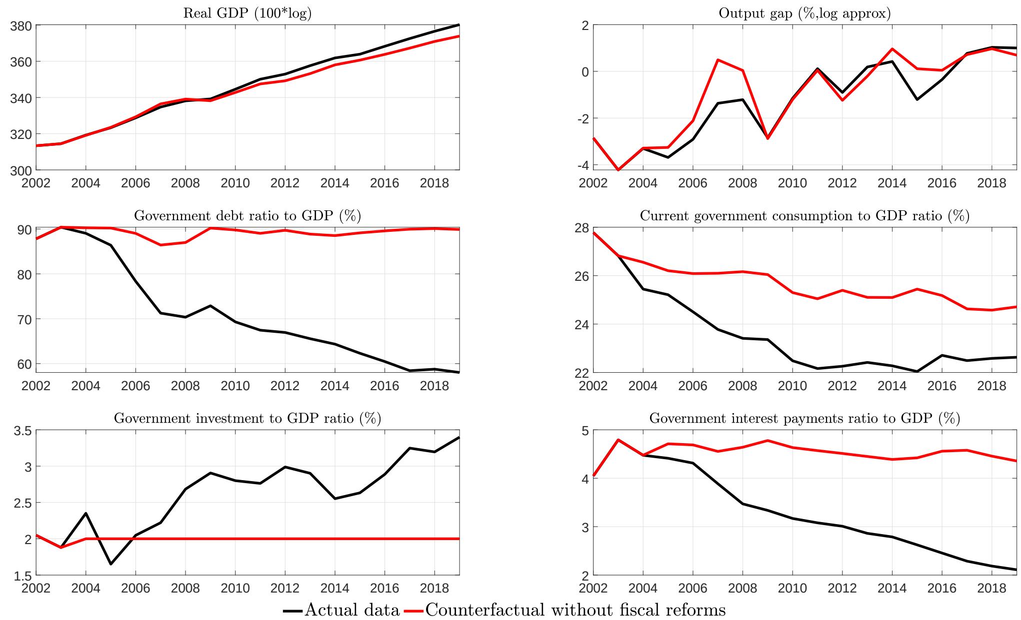


Figure 15 compares the historical data (solid black lines) against a counterfactual scenario without the fiscal reforms (solid red lines). The reforms initially reduced demand and thus growth during 2005-2008 and again during 2014-2016, when the debt consolidation was strongest, as evinced by the estimate that the actual output gap during these periods is below the output gap in the no-reform scenario. However, the long-term impact of the reforms has been strongly positive for growth. Real GDP would have been consistently lower from 2009 onwards—by about 6 percent in 2019—absent the reforms. The positive long-term impacts are driven mainly by the increase in public investment and a decrease in the UIP premium in response to the government debt consolidation.

Figure 15. Effect of fiscal reforms



Box 5. The calibration of FINEX

Calibration should be more of an art than a science, requiring expertise, intuition, and judgment to strike the right balance between theoretical assumptions and empirical evidence. No model can fully capture all aspects of the economy, and the data contain breaks and mismeasurement. Calibration thus involves (or rather should involve) making informed decisions about parameter values that align with economic intuition and evidence in the broadest sense.

More concretely, to calibrate FINEX, we follow the approach used in IMF technical assistance projects to calibrate similar semi-structural models in policy institutions that use such models for policy analysis and forecasting. We do not generally use methods that maximize the likelihood function, such as Bayesian methods that estimate the model's parameters to maximize the probability of observing the data, given priors on parameter values. Rather, in FINEX, we calibrate the parameters parsimoniously and gradually. This approach allows for a deeper understanding of the model's properties, acknowledges that no model can capture all the characteristics of the economy, and reduces biases in parameters generated by breaks in time series, including in the policy regime.

In some cases, a DSGE model may accompany the FINEX. Besides being useful for policy and welfare analysis, a DSGE model could help provide guidance for the calibration (or for priors for Bayesian estimation), including because it would suggest cross-equation restrictions and constraints on the parameter values. For example, the parameter in front of lagged inflation in the Phillips curve for private consumption $c_1^{\pi^C}$ in a DSGE model is a function of a discount factor β such that $c_1^{\pi^C} = \frac{1}{1+\beta}$. Because discount factor must be smaller than one, $c_1^{\pi^C}$ must be less than $1/2$. Of course, caution is warranted, because DSGE-derived restrictions may be rejected by the data.

In this box, we describe the general approach. We followed this approach for the generic calibration described in this paper, with the critical caveat that we lack the concrete country application to motivate and inform the full iterative approach. Remo et al. provides a full concrete example.

During the calibration process, we defined different criteria to ensure that the model produced accurate and reliable results. The criteria used to calibrate FINEX include empirical fit, forecasting performance, economic coherence, the ability to explain historical data, and consistency of parameter values with econometric estimates. We also ensure that the assessments of trends, cyclical components, and economic shocks are consistent with economic intuition and common wisdom. The calibration process is iterative and involves the following stages:

- Definition of the FINEX structure.
- Data collection.
- Determination of parameters to be calibrated.
- Modification of parameter values to meet the previously-defined criteria.

The structure and characteristics of FINEX imply that the data used to calibrate the model come from various sources. For domestic variables (national accounts, fiscal accounts, prices, and balance of payments), the data would typically come from the Statistical Office, the Central Bank, and the Ministry of Finance of each country. Data used for external variables (GDP of trading partners, interest rates, exchange rates, price index, and commodity prices) would come from external sources such as the IMF's WEO, Consensus Forecast, and the World Bank 'Pink-Sheet.'

The obtained data need to be transformed to be consistent with the structure of FINEX. For example, if the model is used with an annual frequency, the data frequency needs to be adjusted considering the nature of the variables (i.e., flows and stocks). The transformed data is used for model filtering and computing the long-term relationships of the economy that determine the calibration of parameters.

The calibration of the model considers the type of parameters and their implications for model application. Parameters are divided into three types (Annex A.III shows the value of all FINEX parameters):

- Parameters determining the steady state.
- Parameters determining the decomposition between gaps and trends.
- Parameters governing transmission mechanisms and policy responses.

In FINEX, the steady state refers to a situation in which the economy is in long-term equilibrium, and economic variables stay on their balanced growth path. It represents a stable and balanced state of the economy without significant changes or fluctuations. The search for the steady state in FINEX requires employing numerical methods to solve the system of equations and obtain the steady-state values for each variable.

The parameters determining the steady state of FINEX are calibrated so that the long-term values to which FINEX converges, once the effect of initial conditions and shocks disappears, are in line with the observed data. In this way, we calibrate the parameters determining the steady state for the growth rate of the economy, growth in price levels and relative prices, interest rates and risk premium, depreciation of the real exchange rate, and the GDP ratios of the components of aggregate demand, fiscal variables (revenue, expenditure, and debt), and the balance of payments. Although parameter values are generally selected to replicate historical means in the data, they also incorporated knowledge and expert judgment about the economy's long-term prospects.

Because the steady-state values for variables of the model are obtained by solving the system of equations, it is only possible to adjust some long-term relationships of the model to the data. For example, the steady state value of the fiscal deficit is determined endogenously based on the steady-state calibration for the debt target, inflation, output growth, interest rates, and exchange rates.

The Kalman smoother is used to estimate unobserved variables (e.g., the cyclical and trend decomposition of model variables) and make predictions about their future values. To do this, we defined the state-space representation using the FINEX structure as the state equation and a subset of the available variables in the database as the measurement equation, assuming zero measurement noise.

The cyclical and trend decomposition obtained from a gap model like FINEX is a function of the relative variances of disturbances in the cyclical and trend components of the model. In the calibration of FINEX, we follow the usual practice used in calibrating gap models, where the assumed variance of shocks affecting cyclical components is greater than that of shocks affecting trend components.

The cyclical and trend decomposition also depends on the parameters governing persistence in the gap and trend equations. The parameters determining persistence are calibrated so that the half-life of cyclical processes are shorter than the half-life of trend processes. For example, for private investment, the variance of the investment gap disturbance is four times greater than the variance of the trend component disturbance in the trend growth of private investment. Similarly, the persistence of the cyclical component of private investment has a half-life of less than a year, while the half-life of the trend component of real private investment growth is close to 1.5 years.

In FINEX, the equation for the trend growth rate of each aggregate demand component incorporates a correction mechanism that ensures the level of the trend component converges to the steady state characterized by a constant share of nominal expenditure in GDP. When calibrating the parameters governing this correction mechanism, we follow a similar approach to the persistence parameters, choosing values that guarantee a faster convergence of variables in levels than that of the trend variables.

The last set of calibrated parameters corresponds to the parameters influencing the transmission mechanisms of the model. Within this set of parameters, we calibrate the parameters determining the substitution between domestic and foreign assets and determining the degree of capital mobility. We also calibrate the parameters for monetary policy and fiscal rules, the sensitivity of exports and imports to the real exchange rate, the import content in the components of aggregate demand, and the parameters governing the transmission of economic activity and relative prices to inflation.

In this case, the calibration seeks to reflect specific characteristics of each economy. Thus, as discussed in section 4.3, the parameter that determines the degree of capital mobility is adjusted to illustrate the degree of depth of the FX market, the persistence of the curve in the Phillips curve reflects the degree of anchoring of inflation expectations, the persistence of nominal interest rates and the coefficient affecting the monetary policy response to deviations of inflation from the target in the monetary policy rule reflect the operation of the central bank, and the parameters of the fiscal rule reflect the degree of aversion of fiscal policy to deviations of debt from its fiscal target. We also look to produce a reasonable and empirically plausible set of fiscal multipliers.

Finally, for parameters governing the dynamics of the external block, we used external data sources to construct multivariate estimates of the coefficients determining persistence and standard deviations.

The calibration of a model is an iterative process that requires careful attention to detail. This involves adjusting the model's parameters to ensure that it accurately represents real-world data and meets specific criteria. Calibration is a complex task and generally demands a hands-on case-by-case approach.

During calibration, various criteria must be met to ensure the model produces reliable and accurate results. These criteria may include empirical fit, forecast performance, economic consistency, ability to explain historical data, and comparison against previous econometric estimates. Each measure is a benchmark for evaluating the model's performance and validity.

Despite—or perhaps because of—its inherent challenges, calibration is crucial in developing robust macroeconomic models. By refining and adjusting the parameters iteratively, researchers can better understand the model, enhance its ability to replicate real-world dynamics, and generate meaningful insights for policy analysis and forecasting.

5 Conclusion

FINEX emphasizes the interaction of three elements: internal balance, external balance, and policy. It is designed for forecasting in policy institutions, and for this reason has a semi-structural gap-trend structure. At the same time, it embodies the lessons of the recent DSGE literature, including the insights from the portfolio-balance approach to the UIP premium and the foundational papers of the IMF's integrated policy framework. It thus supports the analysis of FXI and CFMs, as well as more traditional monetary and fiscal instruments.

The paper does not attempt to establish any broad policy lessons. This is partly because we do not want to assume that the model captures all the channels important for a complete welfare analysis. More importantly, the implications of different policy mixes in the FINEX depend in a complex way on the nature of shocks, country characteristics, and initial conditions. Thus, the goal is to help policymakers interpret recent data in terms of structural shocks and policy responses, produce forecasts that support a sensible and data-coherent economic narrative, and consider alternative scenarios that embody different shocks, assumptions about the economy, and policy responses.

There is a clear trade-off here. More complex models, notably closer to or in the DSGE tradition, lend themselves to welfare analysis and to direct analysis of a wider range of structural issues, but they can be more difficult to take to the data for purposes of understanding particular episodes or making forecasts. And even the richest state-of-the-art models, such as Basu et al. (2020), do not capture all the channels that may be relevant to normative analysis, such as the role of heterogeneous agents, deviations from rational expectations, or long-term feedback from system performance to model parameters such as the depth of financial markets.

Based on practical experience, FINEX is designed for application to countries with imperfect capital mobility and hybrid monetary policy regimes, and where monetary/fiscal/reserves interactions are of primary importance. Existing semi-structural quarterly projection models are typically narrowly focused on monetary policy and thus poorly equipped to address this wider range of issues. FINEX is thus well-suited to address the typical concerns of economists in a wide range of policy institutions and countries. These same features lend themselves to use by IMF country economists.[87]

This model is of course not the one size that fits all. FINEX is substantially more complicated than traditional gap-trend models used in central banks. Our expec-

[87] Versions and components of FINEX are being applied in technical assistance projects with several central banks and ministries of finance, including to inform updates to their existing quarterly projection models (for example the Philippines and Jordan). In addition, the model was used to prepare an alternative scenario for the 2022 Finland Article IV review (IMF (2022)).

tation and early experience is that the ability to address the most pressing issues and to capture more realistic policy regimes compensates for this complexity. However simpler formulations—subsets of this model—will often be more useful. For example, the traditional 'four-equation' QPM will remain ideal for central banks with simple policy regimes or where capacity is low. Ministries of finance in a pegged exchange rate regime may wish to concentrate on a small subset of issues and of this model.[88]

Beyond semi-structural models, micro-founded models such as Basu et al. (2020) and Adrian et al. (2021) are the reference point for quantitative macroeconomic policy analysis. They permit a richer analysis of transmission mechanisms and of optimal policy. A forecasting model such as FINEX is their natural complement; ideally policy institutions would, capacity allowing, have access to both. Some institutions may choose to use such a model for forecasting as well.

Important extensions and new applications are on the agenda. A clear priority is the inclusion of a financial sector, including to incorporate macro-prudential policy as in Basu et al. (2020), drawing on related DSGE modeling for foundations.

The role of semi-structural forecasting models in finance ministries is not as well-developed as in central banks. Caselli et al. (2022) highlights the importance of risk-based medium-term fiscal frameworks that strike a balance between the credibility of fiscal rules and the flexibility to respond to shocks effectively. This suggests an analogy with the adoption of inflation forecast targeting, which also aimed to establish credibility while maintaining a flexible response to supply shocks. Consequently, this suggests a potential role for semi-structural models like the one presented here. Just as transparent and credible forecasts have been found to be crucial for the success of inflation forecast targeting, the kinds of forecasts that the FINEX can help produce should enhance the credibility and flexibility of risk-based medium-term fiscal frameworks.

[88] Adapting to Finland (IMF (2022)) required calibrating the model as a currency peg with fully open capital account, such that domestic monetary policy is completely subjugated to the Eurozone monetary policy. The Finland variant does not feature FXI, CFM, or a natural resource block. It was implemented within the "'Integrated Macro Forecasting Environment (IMFE)"', an experimental tool designed to facilitate the use of macro-frameworks, including embedded models, in the work of IMF country teams.

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Glossary

AE advanced economy. 61, 62

BGP balanced growth path. 23, 55

BoP balance of payments. 9–13, 15–17, 20, 31, 33, 36, 37, 45–47, 63–66

CAB current account balance. 14, 21

CFM capital flow management measure. 7–11, 13–17, 29, 33, 37–39, 43, 44, 46, 55, 61–66, 68, 76, 77

CPI consumer price index. 69

DCP dominant currency pricing. 24

DSGE dynamic stochastic general equilibrium. 5–7, 18, 31, 36, 68, 72, 76, 77

ELB effective lower bound. 8, 40, 42

EMDEs emerging markets and developing economies. 6, 8, 9, 14, 23, 40, 42, 44, 45, 55, 56, 61, 62

FCY foreign currency. 15

FINEX Forecasting Model of Internal and External Balance. 4, 6–11, 14–18, 20, 21, 23, 24, 26, 33, 39, 41, 44, 47, 48, 55, 56, 64, 68, 72–74, 76, 77

FXA foreign exchange accumulation. 42

FXI foreign exchange intervention. 7–17, 29, 36, 41, 42, 44–47, 56, 61, 62, 65, 68, 76, 77

FXR foreign exchange reserves. 17, 35, 41, 42, 58

GDP gross domestic product. 11, 14, 15, 18–23, 26–31, 35, 41, 47–49, 52, 53, 55–61, 63–66, 69, 70

IFM Israel Forecasting Model. 68, 69

IMF International Monetary Fund. 7, 8, 35, 42, 43, 72, 73

IPF integrated policy framework. 7, 8, 64

IRF impulse response function. 68

IT inflation targeting. 7, 14, 39, 44, 45, 55, 62

LCP local currency pricing. 24

LCY local currency. 15

NFA net foreign assets. 7–11, 14, 29, 31, 32, 34, 36, 37, 63–65, 68

NK New Keynesian. 24

NNR non-natural resource. 27, 28

NOIL non-oil. 28, 29

NR natural resource. 48

PCP producer currency pricing. 24

QPM quarterly projection model. 5–7, 21, 25, 76, 77

REER real effective exchange rate. 27, 40, 41, 45

RER real exchange rate. 24

TFP total factor productivity. 29, 30

UIP uncovered interest parity. 4, 7, 9–15, 17, 20, 21, 29, 30, 32–38, 40, 41, 43, 45, 46, 55–66, 68, 70, 76

A Model description

A.I Variables

Table 1. Variables

Variable	Model name	Description	Steady-state
K^R	K	Private capital (level)	–
k^R	L_K	Private capital (100*log)	–
Δk^R	DL_K	Private capital growth (%, log approx)	2.15
Y^R	GDP	Real GDP (level)	–
y^R	L_GDP	Real GDP (100*log)	–
$\overline{Y}^R$	GDP_BAR	Potential GDP (level)	–
$\Delta\overline{y}^R$	DL_GDP_BAR	Potential real GDP growth (%, log approx)	3.00
$\overline{y}^R$	L_GDP_BAR	Potential GDP (100*log)	–
Δy^R	DL_GDP	Real GDP growth (%, log approx)	3.00
$\tilde{A}^R$	TFP_BAR	Potential quasi total factor productivity (level)	–
$\tilde{a}^R$	L_TFP_BAR	Potential quasi total factor productivity (100*log)	–
$\Delta\tilde{a}^{R,g}$	DL_GTFP_BAR	Persistent component of potential quasi TFP growth (%, log approx)	3.00
$\Delta\tilde{a}^R$	DL_TFP_BAR	Potential quasi TFP growth (%, log approx)	3.00
$\hat{y}^R$	L_GDP_GAP	Output gap (%, log approx)	0.00
C^R	CONS	Real private consumption (level)	–
c^R	L_CONS	Real private consumption (100*log)	–
$\hat{c}^R$	L_CONS_GAP	Private consumption gap (%, log approx)	0.00
$\hat{c}^{R,E}$	E_L_CONS_GAP	Expected private consumption gap (%, log approx)	0.00
Δc^R	DL_CONS	Real private consumption growth (%, log approx)	3.15
$\overline{C}^R$	CONS_BAR	Potential real private consumption (level)	–
$\overline{c}^R$	L_CONS_BAR	Potential real private consumption (100*log)	–
$\Delta\overline{c}^R$	DL_CONS_BAR	Potential real private consumption growth (%, log approx)	3.15
C^Y	CONS_RAT	Private consumption to GDP ratio (%)	60.00
$\overline{C}^Y$	CONS_RAT_BAR	Equilibrium private consumption to GDP ratio (%)	60.00
I^R	INV	Real private investment (level)	–
i^R	L_INV	Real private investment (100*log)	–
$\hat{i}^R$	L_INV_GAP	Private investment gap (%, log approx)	-0.00
$\hat{i}^{R,E}$	E_L_INV_GAP	Expected private investment gap (%, log approx)	-0.00
Δi^R	DL_INV	Real private investment growth (%, log approx)	2.15
$\overline{I}^R$	INV_BAR	Potential real private investment (level)	–
$\overline{i}^R$	L_INV_BAR	Potential real private investment(100*log)	–
$\Delta\overline{i}^R$	DL_INV_BAR	Potential real private investment growth (%, log approx)	2.15
I^Y	INV_RAT	Private investment to GDP ratio (%)	20.00
$\overline{I}^Y$	INV_RAT_BAR	Equilibrium private investment to GDP ratio (%)	20.00
X^Y	EXP_RAT	Total exports to GDP ratio (%)	30.10
$\overline{X}^Y$	EXP_RAT_BAR	Equilibrium total exports to GDP ratio (%)	30.10
$X^{R,NNR}$	EXP_NNR	Real NNR exports (level)	–
$x^{R,NNR}$	L_EXP_NNR	Real NNR exports (100*log)	–
$\hat{x}^{R,NNR}$	L_EXP_NNR_GAP	NNR exports gap (%, log approx)	-0.00
$\hat{x}^{R,NNR,E}$	E_L_EXP_NNR_GAP	Expected NNR exports gap (%, log approx)	-0.00
$\Delta x^{R,NNR}$	DL_EXP_NNR	Real NNR exports growth (%, log approx)	3.65

Table continues on the next page.

Variable	Model name	Description	Steady-state
$\overline{X}^{R,NNR}$	EXP_NNR_BAR	Potential real NNR exports (level)	–
$\overline{x}^{R,NNR}$	L_EXP_NNR_BAR	Potential real NNR exports(100*log)	–
$\Delta\overline{x}^{R,NNR}$	DL_EXP_NNR_BAR	Potential real NNR exports growth (%, log approx)	3.65
$X^{NNR,Y}$	EXP_NNR_RAT	NNR exports to GDP ratio (%)	30.00
$\overline{X}^{NNR,Y}$	EXP_NNR_RAT_BAR	Equilibrium NNR exports to GDP ratio (%)	30.00
$\overline{X}^{R,NNR,S}$	EXP_NNR_SUP_BAR	Proxy for equilibrium NNR exports supply changes (100*log)	0.00
$X^{R,NR}$	EXP_NR	Real NR exports (level)	–
$x^{R,NR}$	L_EXP_NR	Real NR exports (100*log)	–
$\hat{x}^{R,NR}$	L_EXP_NR_GAP	NR exports gap (%, log approx)	-0.00
$\Delta x^{R,NR}$	DL_EXP_NR	Real NR exports growth (%, log approx)	3.15
$\overline{X}^{R,NR}$	EXP_NR_BAR	Potential real NR exports (level)	–
$\overline{x}^{R,NR}$	L_EXP_NR_BAR	Potential real NR exports(100*log)	–
$\Delta\overline{x}^{R,NR}$	DL_EXP_NR_BAR	Potential real NR exports growth (%, log approx)	3.15
$\overline{X}^{R,NR,S}$	EXP_NR_SUP_BAR	Proxy for equilibrium NR exports supply changes (100*log)	0.00
$X^{NR,Y}$	EXP_NR_RAT	NR exports to GDP ratio (%)	0.10
$\overline{X}^{NR,Y}$	EXP_NR_RAT_BAR	Equilibrium NR exports to GDP ratio (%)	0.10
$G^{NR,Y}$	EXP_NR_PROF_RAT	NR exports producers profit to GDP ratio (%)	0.05
$\overline{G}^{NR,Y}$	EXP_NR_PROF_RAT_BAR	Equilibrium NR exports producers profit to GDP ratio (%)	0.05
M^{Y}	IMP_RAT	Total imports to GDP ratio (%)	30.86
$M^{R,NOIL}$	IMP_NOIL	Real non-oil imports (level)	–
$m^{R,NOIL}$	L_IMP_NOIL	Real non-oil imports (100*log)	–
$\hat{m}^{R,NOIL}$	L_IMP_NOIL_GAP	Non-oil imports gap (%, log approx)	0.00
$\hat{m}^{R,NOIL,E}$	E_L_IMP_NOIL_GAP	Expected non-oil imports gap (%, log approx)	0.00
$\Delta m^{R,NOIL}$	DL_IMP_NOIL	Real non-oil imports growth (%, log approx)	4.15
$\overline{M}^{R,NOIL}$	IMP_NOIL_BAR	Potential real non-oil imports (level)	–
$\overline{m}^{R,NOIL}$	L_IMP_NOIL_BAR	Potential real non-oil imports (100*log)	–
$\Delta\overline{m}^{R,NOIL}$	DL_IMP_NOIL_BAR	Potential real non-oil imports growth (%, log approx)	4.15
$M^{NOIL,Y}$	IMP_NOIL_RAT	Non-oil imports to GDP ratio (%)	23.86
$\overline{M}^{NOIL,Y}$	IMP_NOIL_RAT_BAR	Equilibrium non-oil imports to GDP ratio (%)	23.86
$M^{NOIL,Y,SS}$	IMP_NOIL_RAT_SS	Non-oil imports to GDP ratio in steady state (%)	23.86
$\overline{M}^{R,NOIL,D}$	IMP_NOIL_DEM_BAR	Proxy for equilibrium non-oil imports demand (100*log)	0.00
$M^{R,OIL}$	IMP_OIL	Real oil imports (level)	–
$m^{R,OIL}$	L_IMP_OIL	Real oil imports (100*log)	–
$\hat{m}^{R,OIL}$	L_IMP_OIL_GAP	Oil imports gap (%, log approx)	0.00
$\hat{m}^{R,OIL,E}$	E_L_IMP_OIL_GAP	Expected oil imports gap (%, log approx)	0.00
$\Delta m^{R,OIL}$	DL_IMP_OIL	Real oil imports growth (%, log approx)	1.15
$\overline{M}^{R,OIL}$	IMP_OIL_BAR	Potential real oil imports (level)	–
$\overline{m}^{R,OIL}$	L_IMP_OIL_BAR	Potential real oil imports (100*log)	–
$\Delta\overline{m}^{R,OIL}$	DL_IMP_OIL_BAR	Potential real oil imports growth (%, log approx)	1.15
$M^{OIL,Y}$	IMP_OIL_RAT	Oil imports to GDP ratio (%)	7.00
$\overline{M}^{OIL,Y}$	IMP_OIL_RAT_BAR	Equilibrium oil imports to GDP ratio (%)	7.00
$\overline{M}^{R,OIL,D}$	IMP_OIL_DEM_BAR	Proxy for equilibrium oil imports demand (100*log)	0.00
G^{R}	GOV	Real government absorption (level)	–
g^{R}	L_GOV	Real government absorption (100*log, level)	–
$\hat{g}^{R}$	L_GOV_GAP	Government absorption gap (%, log approx)	0.00
$\hat{g}^{R,E}$	E_L_GOV_GAP	Expected government absorption gap (%, log approx)	0.00
Δg^{R}	DL_GOV	Real government absorption growth (%, log approx)	3.15
$\overline{G}^{R}$	GOV_BAR	Potential real government absorption (level)	–
$\overline{g}^{R}$	L_GOV_BAR	Potential real government absorption (100*log)	–
$\Delta\overline{g}^{R}$	DL_GOV_BAR	Potential real government absorption growth (%, log approx)	3.15
Y	NGDP	Nominal GDP (level)	–
y	L_NGDP	Nominal GDP (100*log)	–

Table continues on the next page.

Variable	Model name	Description	Steady-state
Δy	DL_NGDP	Nominal GDP growth (%, log approx)	5.13
$\Delta\overline{y}$	DL_NGDP_BAR	Nominal GDP trend growth (%, log approx)	5.13
P^{Y}	P_GDP	GDP deflator (level)	–
p^{Y}	L_P_GDP	GDP deflator (100*log)	–
π^{Y}	DL_P_GDP	GDP deflator inflation (%, log approx)	2.13
$\overline{P}^{R,Y}$	RP_GDP_BAR	Equilibrium relative price of GDP to cons. (%)	–
$\overline{p}^{R,Y}$	L_RP_GDP_BAR	Equilibrium relative price of GDP to cons. (100*log)	–
$\Delta\overline{p}^{R,Y}$	DL_RP_GDP_BAR	Equilibrium relative price inflation of GDP to cons. (%, log approx)	0.15
P^{C}	P_CONS	Private consumption prices before tax (level)	–
$P^{C,T}$	P_CONS_TAX	Private consumption prices (level)	–
π^{C}	DL_P_CONS	Private consumption prices inflation before tax (%, log approx)	1.98
$\pi^{C,T}$	DL_P_CONS_TAX	Private consumption prices inflation (%, log approx)	1.98
$\pi^{C,E}$	E_DL_P_CONS	Expected private consumption prices inflation before tax (%, log approx)	1.98
p^{C}	L_P_CONS	Private consumption prices before tax (100*log)	–
$p^{C,T}$	L_P_CONS_TAX	Private consumption prices (100*log)	–
P^{I}	P_INV	Private investment prices (level)	–
p^{I}	L_P_INV	Private investment prices (100*log)	–
π^{I}	DL_P_INV	Private investment prices inflation (%, log approx)	2.98
$\pi^{I,E}$	E_DL_P_INV	Expected private investment prices inflation (%, log approx)	2.98
$p^{R,I}$	L_RP_INV	Relative price of investment to consumption (100*log)	–
$\overline{p}^{R,I}$	L_RP_INV_BAR	Equilibrium relative price of investment to consumption (100*log)	–
$P^{R,I}$	RP_INV_BAR	Equilibrium relative price of investment to consumption (%)	–
$\hat{p}^{R,I}$	L_RP_INV_GAP	Relative price of investment to consumption gap (%, log approx)	-0.00
$\Delta\overline{p}^{R,I}$	DL_RP_INV_BAR	Equilibrium relative price inflation of invest. to cons. (%, log approx)	1.00
$P^{X^{NNR}}$	P_EXP_NNR	NNR export prices (level)	–
$p^{X^{NNR}}$	L_P_EXP_NNR	NNR export prices (100*log)	–
$\pi^{X^{NNR}}$	DL_P_EXP_NNR	NNR export prices inflation (%, log approx)	1.48
$pi^{X^{NNR},E}$	E_DL_P_EXP_NNR	Expected NNR export prices inflation (%, log approx)	1.48
$p^{R,X^{NNR}}$	L_RP_EXP_NNR	Relative price of NNR export to consumption (100*log)	–
$\overline{p}^{R,X^{NNR}}$	L_RP_EXP_NNR_BAR	Equilibrium relative price of NNR export to consumption (100*log)	–
$\overline{P}^{R,X^{NNR}}$	RP_EXP_NNR_BAR	Equilibrium relative price of NNR export to consumption (%)	–
$\hat{p}^{R,X^{NNR}}$	L_RP_EXP_NNR_GAP	Relative price of NNR export to consumption gap (%, log approx)	-0.00
$\hat{p}^{R,X^{NNR},E}$	E_L_RP_EXP_NNR_GAP	Expected relative price of NNR export to consumption gap (%, log approx)	-0.00
$\Delta\overline{p}^{R,X^{NNR}}$	DL_RP_EXP_NNR_BAR	Equilibrium relative price infaltion of NNR exp. to cons. (%, log approx)	-0.50
$P^{X^{NR}}$	P_EXP_NR	NR export prices (level)	–
$p^{X^{NR}}$	L_P_EXP_NR	NR export prices (100*log)	–
$\pi^{X^{NR}}$	DL_P_EXP_NR	NR export prices inflation (%, log approx)	1.98
$P^{x^{NR},MAVG}$	L_P_EXP_NR_MAVG	NR export prices moving average (100*log)	–
$P^{X^{NR},MAVG}$	P_EXP_NR_MAVG	NR export prices moving average (level)	–
$p^{R,X^{NR}}$	L_RP_EXP_NR	Relative price of NR export to consumption (100*log)	-228.90
$\overline{p}^{R,X^{NR}}$	L_RP_EXP_NR_BAR	Equilibrium relative price of NR export to consumption (100*log)	-228.90
$\overline{P}^{R,X^{NR}}$	RP_EXP_NR_BAR	Equilibrium relative price of NR export to consumption (%)	–
$\hat{p}^{R,X^{NR}}$	L_RP_EXP_NR_GAP	Relative price of NR export to consumption gap (%, log approx)	-0.00
$\hat{p}^{R,X^{NR},E}$	E_L_RP_EXP_NR_GAP	Expected relative price of NR export to consumption gap (%, log approx)	-0.00
$\Delta\overline{p}^{R,X^{NR}}$	DL_RP_EXP_NR_BAR	Equilibrium relative price infaltion of NR exp. to cons. (%, log approx)	0.00
$P^{M^{NOIL}}$	P_IMP_NOIL	Non-oil import prices before tax (level)	–
$P^{M^{NOIL},T}$	P_IMP_NOIL_TAX	Non-oil import prices (level)	–

Table continues on the next page.

Variable	Model name	Description	Steady-state
$p^{M^{NOIL}}$	L_P_IMP_NOIL	Non-oil import prices before tax (100*log)	–
$\pi^{M^{NOIL}}$	DL_P_IMP_NOIL	Non-oil import prices inflation before tax (%, log approx)	0.98
$\pi^{M^{NOIL},E}$	E_DL_P_IMP_NOIL	Expected non-oil import prices inflation before tax (%, log approx)	0.98
$p^{M^{NOIL},T}$	L_P_IMP_NOIL_TAX	Non-oil import prices (100*log)	–
$\pi^{M^{NOIL},T}$	DL_P_IMP_NOIL_TAX	Non-oil import prices inflation (%, log approx)	0.98
$p^{R,M^{NOIL}}$	L_RP_IMP_NOIL	Relative price of non-oil imports to consumption (100*log)	–
$\overline{p}^{R,M^{NOIL}}$	L_RP_IMP_NOIL_BAR	Equilibrium relative price of non-oil imports to consumption (100*log)	–
$\overline{P}^{R,M^{NOIL}}$	RP_IMP_NOIL_BAR	Equilibrium relative price of non-oil imports to consumption (%)	–
$\hat{p}^{R,M^{NOIL}}$	L_RP_IMP_NOIL_GAP	Relative price of non-oil imports to consumption gap (%, log approx)	0.00
$\hat{p}^{R,M^{NOIL},E}$	E_L_RP_IMP_NOIL_GAP	Expected relative price of non-oil imports to consumption gap (%, log approx)	0.00
$\Delta\overline{p}^{R,M^{NOIL}}$	DL_RP_IMP_NOIL_BAR	Equilibrium relative price inflation of non-oil imp. to cons. (%, log approx)	-1.00
$P^{M^{OIL}}$	P_IMP_OIL	Oil import prices before tax (level)	–
$P^{M^{OIL},T}$	P_IMP_OIL_TAX	Oil import prices (level)	–
$p^{M^{OIL}}$	L_P_IMP_OIL	Oil import prices before tax (100*log)	–
$\pi^{M^{OIL}}$	DL_P_IMP_OIL	Oil import prices inflation before tax (%, log approx)	3.98
$\pi^{M^{OIL},E}$	E_DL_P_IMP_OIL	Expected oil import prices inflation before tax (%, log approx)	3.98
$p^{M^{OIL},T}$	L_P_IMP_OIL_TAX	Oil import prices (100*log)	–
$\pi^{M^{OIL},T}$	DL_P_IMP_OIL_TAX	Oil import prices inflation (%, log approx)	3.98
$p^{R,M^{OIL}}$	L_RP_IMP_OIL	Relative price of oil imports to consumption (100*log)	–
$\overline{p}^{R,M^{OIL}}$	L_RP_IMP_OIL_BAR	Equilibrium relative price of oil imports to consumption (100*log)	–
$\overline{P}^{R,M^{OIL}}$	RP_IMP_OIL_BAR	Equilibrium relative price of oil imports to consumption (%)	–
$\hat{p}^{R,M^{OIL}}$	L_RP_IMP_OIL_GAP	Relative price of oil imports to consumption gap (%, log approx)	0.00
$\hat{p}^{R,M^{OIL},E}$	E_L_RP_IMP_OIL_GAP	Expected relative price of oil imports to consumption gap (%, log approx)	0.00
$\Delta\overline{p}^{R,M^{OIL}}$	DL_RP_IMP_OIL_BAR	Equilibrium relative price inflation of oil imp. to cons. (%, log approx)	2.00
P^G	P_GOV	Government absorption prices (level)	–
p^G	L_P_GOV	Government absorption prices inflation (%, log approx)	–
π^G	DL_P_GOV	Government absorption prices inflation (%, log approx)	1.98
$\pi^{G,E}$	E_DL_P_GOV	Expected government absorption prices inflation (%, log approx)	1.98
$p^{R,G}$	L_RP_GOV	Relative price of government absorption to consumption (100*log)	1.00
$\hat{p}^{R,G}$	L_RP_GOV_GAP	Relative price of government absorption to consumption gap (%, log approx)	0.00
$\overline{P}^{R,G}$	RP_GOV_BAR	Relative price of government absorption to consumption (%)	–
$\Delta\overline{P}^{R,G}$	DL_RP_GOV_BAR	Equilibrium relative price inflation of gov. to cons. (%, log approx)	0.00
$\overline{p}^{R,G}$	L_RP_GOV_BAR	Equilibrium relative price of gov. to consumption (100*log)	1.00
CA^Y	CA_RAT	Current account balance (% of GDP)	-2.24
$\overline{CA}^Y$	CA_RAT_BAR	Potential current account balance (% of GDP)	-2.24
REM^Y	REMIT_RAT	Net remittances inflows to GDP ratio (%)	2.00
$R\hat{E}M^Y$	REMIT_RAT_GAP	Net remittances gap (% of GDP)	0.00
$\overline{REM}^Y$	REMIT_RAT_BAR	Net remittances trend (% of GDP)	2.00
$CA^{O,Y}$	OCA_RAT	Net other current account inflows to GDP ratio (%)	-3.50
$\overline{CA}^{O,Y}$	OCA_RAT_BAR	Net potential other current account inflows to GDP ratio (%)	-3.50
FA^Y	FA_RAT	Net financial account inflows to GDP ratio (%)	2.24
$\overline{FA}^Y$	FA_RAT_BAR	Net potential financial account inflows to GDP ratio (%)	2.24
$FA^{O,Y}$	OFA_RAT	Net other financial account inflows to GDP ratio (%)	1.61
$\overline{FA}^{O,Y}$	OFA_RAT_BAR	Net potential other financial account inflows to GDP ratio (%)	1.61
$I^{NFA^O,Y}$	ONFA_INT_RAT	Interest on private NFA to GDP ratio (%)	-0.83

Table continues on the next page.

Variable	Model name	Description	Steady-state
$\overline{I}^{NFA^O,Y}$	ONFA_INT_RAT_BAR	Equilibrium interest on private NFA to GDP ratio (%)	-0.83
$NFA^{O,Y}$	ONFA_RAT	Private NFA to GDP ratio (%)	-25.44
τ^{FA^O}	TAU_OFA	Capital inflow tax rate (%)	0.00
$\overline{FA}^{O,Exo,Y}$	EXO_OFA_RAT_BAR	(Semi-)Exogenous financial account inflows to GDP ratio (%)	0.00
S^{US}	NER	Nominal exchange rate LCY/USD (LCY per 1USD)	–
s^{US}	L_NER	Nominal exchange rate LCY/USD (100*log)	–
$s^{E,US}$	E_L_NER	Expected nominal exchnage rate LCY/USD (100*log)	–
Δs^{US}	DL_NER	Nominal exchange rate LCY/USD depreciation(%, log approx)	-1.52
γ	RR_PREM	UIP premium (p.p.)	3.50
$\overline{\gamma}$	RR_PREM_BAR	Equilibrium UIP premium (p.p.)	3.50
$\hat{\gamma}$	RR_PREM_GAP	UIP premium gap (p.p.)	-0.00
γ^B	DEB_PREM	Public debt contribution to the UIP premium (p.p.)	-0.00
γ^{NFA^O}	ONFA_PREM	Private NFA contribution to the UIP premium (p.p.)	-0.00
r^{unc}	RS_UNCON	Nominal interest rate (%)	5.48
r	RS	Nominal interest rate (%)	5.48
r^R	RR	Real interest rate (%)	3.50
$\overline{r}^R$	RR_BAR	Equilibrium real interest rate (%)	3.50
$\hat{r}^R$	RR_GAP	Real interest rate gap (p.p.)	-0.00
$\overline{\pi}^C$	DL_P_CONS_TAR	Consumer Price Inflation target (%, log approx)	1.98
$r^{G,LCY}$	RS_GOV_LCY	Nominal sovereign LCY interest rate (%)	8.48
$\gamma^{G,LCY}$	RR_PREM_GOV_LCY	Sovereign LCY premium (p.p.)	0.50
$\overline{r}^{R,G,LCY}$	RR_GOV_LCY_BAR	Equilibrium real sovereign LCY interest rate (%)	6.50
$r^{G,Comp,LCY}$	RS_GOV_LCY_COMP	Compounded short-term sovereign LCY interest rate (%)	5.48
$r^{R,G,Comp,LCY}$	RR_GOV_LCY_COMP	Compounded equilibrium real sovereign short term LCY interest rate (%)	3.50
$r^{G,FCY}$	RS_GOV_FCY	Nominal sovereign FCY interest rate (%)	6.00
$\gamma^{G,FCY}$	RR_PREM_GOV_FCY	Sovereign FCY premium (p.p.)	2.50
$\overline{r}^{R,G,FCY}$	RR_GOV_FCY_BAR	Equilibrium real sovereign FCY interest rate (%)	3.50
$r^{G,Comp,FCY}$	RS_GOV_FCY_COMP	Compounded short-term sovereign FCY interest rate (%)	3.50
$r^{R,G,Comp,FCY}$	RR_GOV_FCY_COMP	Compounded equilibrium real sovereign short term FCY interest rate (%)	1.00
r^{NFA^O}	RS_ONFA	Nominal private NFA interest rate (%)	3.50
γ^{NFA^O}	RR_PREM_ONFA	Private NFA premium (p.p.)	0.00
$r^{NFA^O,Comp}$	RS_ONFA_COMP	Compounded short-term private NFA interest rate (%)	3.50
$\overline{FXR}^Y$	FX_RES_RAT_TAR	Foreign exchange reserves target (% of GDP)	0.00
FXR^Y	FX_RES_RAT	Foreign exchange reserves (% of GDP)	0.00
FXI^Y	FXI_RAT	Foreign exchange interventions (% of GDP)	0.00
$FXI^{Y,unc}$	FXI_RAT_UNCON	Foreign exchange interventions (% of GDP)	0.00
$\overline{FXA}^Y$	FXA_RAT_TAR	Foreign exchange accumulation target (% of GDP)	0.00
FXA^Y	FXA_RAT	Foreign exchange accumulation(% of GDP)	0.00
$\widehat{FXR}^Y$	FX_RES_RAT_GAP	Foreign exchange reserves gap (% of GDP)	-0.00
γ^{FXR}	FX_RES_PREM	FX reserves position contribution to the UIP premium (p.p.)	-0.00
τ^Y	TAU_Y	Income tax rate	10.00
τ^C	TAU_C	Consumption tax rate	20.00
$\tau^{M^{NOIL}}$	TAU_M_NOIL	Non-oil import tax rate	5.00
$\tau^{M^{OIL}}$	TAU_M_OIL	Oil import tax rate	5.00
τ^{NR}	TAU_NR	Natural resource royalty rate	0.00
$\tau^{C,E}$	E_TAU_C	Expected consumption tax rate	20.00
$\tau^{M^{NOIL},E}$	E_TAU_M_NOIL	Expected non-oil import tax rate	5.00
$\tau^{M^{OIL},E}$	E_TAU_M_OIL	Expected oil import tax rate	5.00
GR^Y	GREV_RAT	Total revenue to GDP ratio	24.47
$GR^{C,Y}$	GREV_CONS_RAT	Consumption taxes to GDP ratio	10.00
$GR^{Y,Y}$	GREV_INC_RAT	Income taxes to GDP ratio	10.00

Table continues on the next page.

Variable	Model name	Description	Steady-state
$GR^{M^{NOIL},Y}$	GREV_IMP_NOIL_RAT	Non-oil import taxes to GDP ratio	1.14
$GR^{M^{OIL},Y}$	GREV_IMP_OIL_RAT	Oil import taxes to GDP ratio	0.33
$GR^{NR,Y}$	GREV_NR_RAT	National resource royalty to GDP ratio	0.00
$\overline{GR}^{NR,Y}$	GREV_NR_RAT_BAR	Equilibrium NR royalty to GDP ratio	0.00
$\overline{GR}^{Y}$	GREV_RAT_BAR	Equilibrium total revenue to GDP ratio	24.47
$\widehat{GR}^{Y}$	GREV_RAT_GAP	Government total revenues ratio to GDP gap (%)	0.00
$GR^{O,Y}$	GREV_OTH_RAT	Other government revenues ratio to GDP (%)	3.00
$\overline{GR}^{O,Y}$	GREV_OTH_RAT_BAR	Other government revenues ratio to GDP in equilibrium (%)	3.00
G^{Y}	GOV_RAT	Government absorption to GDP ratio (%)	20.76
$\overline{G}^{Y}$	GOV_RAT_BAR	Equilibrium government absorption to GDP ratio (%)	20.76
$GE^{C,Y}$	GEXP_CONS_RAT	Current Government consumption to GDP ratio (%)	20.00
GE^{Y}	GEXP_RAT	Government expenditure to GDP ratio, including interest payments (%)	27.05
$GE^{O,Y}$	GEXP_OTH_RAT	Other Government expenditure to GDP ratio (%)	1.50
$GE^{Tr,Y}$	GEXP_TRF_RAT	Government transfers to GDP ratio (%)	1.00
$\overline{GE}^{Tr,Y}$	GEXP_TRF_RAT_BAR	Equilibrium gvernment transfers to GDP ratio (%)	1.00
$\widehat{GE}^{Tr,Y}$	GEXP_TRF_RAT_GAP	Government transfers ratio to GDP gap (%)	0.00
$GE^{Tr,Y_{-5}}$	GEXP_TRF_RAT_LBASE	Government transfers relative to nominal GDP 5 periods ago (adjusted by BGP growth)	1.00
$GE^{B,Y}$	GEXP_INT_RAT	Government interest payments ratio to GDP (%)	3.79
$GE^{B^{LCY},Y}$	GEXP_INT_LCY_RAT	Government LCY interest payments ratio to GDP (%)	3.23
$GE^{B^{FCY},Y}$	GEXP_INT_FCY_RAT	Government FCY interest payments ratio to GDP (%)	0.56
$\overline{GE}^{B,Y}$	GEXP_INT_RAT_BAR	Equilibrium government interest payments ratio to GDP (%)	3.79
$\overline{GE}^{B^{LCY},Y}$	GEXP_INT_LCY_RAT_BAR	Equilibrium government LCY interest payments ratio to GDP (%)	3.23
$\overline{GE}^{B^{FCY},Y}$	GEXP_INT_FCY_RAT_BAR	Equilibrium government FCY interest payments ratio to GDP (%)	0.56
$\hat{G}^{Y}$	GOV_RAT_GAP	Government absorption to GDP ratio gap (%)	0.00
$GE^{I^{G},Y}$	GEXP_INV_RAT	Government investment to GDP ratio (%)	0.76
$GE^{R,I^{G}}$	GEXP_INV	Government investment (level)	–
$K^{R,G}$	K_PUB	Government Capital (level)	–
$k^{R,G}$	L_K_PUB	Government Capital (100*log)	–
$\Delta k^{R,G}$	DL_K_PUB	Government Capital growth, (approximately percent)	3.15
GD^{Y}	DEF_O_RAT	Government overall deficit ratio to GDP (%)	2.58
$GD^{P,Y}$	DEF_P_RAT	Government primary deficit ratio to GDP (%)	-1.20
$GD^{C,Y}$	DEF_C_RAT	Government cyclical deficit ratio to GDP (%)	-0.00
$GF^{LCY,Y}$	FIN_LCY_RAT	Deficit financing in LCY (% of GDP)	1.95
$GF^{FCY,Y}$	FIN_FCY_RAT	Deficit financing in FCY (% of GDP)	0.63
$\overline{GF}^{FCY,Y}$	FIN_FCY_RAT_TAR	Deficit financing target in FCY (% of GDP)	0.63
$GD^{S,Y}$	DEF_S_RAT	Government structural deficit ratio to GDP (%)	2.58
$\overline{GD}^{S,Y}$	DEF_S_RAT_TAR	Government structural deficit target ratio to GDP (%)	2.58
$\overline{B}^{Y}$	DEB_RAT_TAR	Government debt target ratio to GDP (%)	50.00
B^{Y}	DEB_RAT	Government debt ratio to GDP (%)	50.00
$\hat{B}^{Y}$	DEB_DEV_RAT	Government debt deviation from the target to GDP ratio (p.p)	-0.00
$\overline{B}^{LCY,Y}$	DEB_LCY_RAT_TAR	Government LCY debt target ratio to GDP (%)	40.00
$\overline{B}^{FCY,Y}$	DEB_FCY_RAT_TAR	Government FCY debt target ratio to GDP (%)	10.00
$\overline{B}^{FCY,B}$	DEB_FCY_SHARE_TAR	Target share of FCY debt in total debt (%)	20.00
$B^{FCY,Y}$	DEB_FCY_RAT	Government FCY debt to GDP ratio (%)	10.00
$B^{LCY,Y}$	DEB_LCY_RAT	Government LCY debt to GDP ratio (%)	40.00
r^{US}	US_RS	US nominal interest rate (%)	3.50
$\overline{r}^{R,US}$	US_RR_BAR	US equilibrium real interest rate (%)	1.00
$r^{R,US}$	US_RR	US real interest rate (%)	1.00
$\hat{y}^{R,US}$	US_L_GDP_GAP	Output gap - US (%, log approx)	0.00

Table continues on the next page.

Variable	Model name	Description	Steady-state
$y^{R,US}$	US_L_GDP	Real GDP - US (100*log)	–
$\Delta y^{R,US}$	US_DL_GDP	Real GDP growth - US (QoQ %, ann)	2.00
$\overline{y}^{R,US}$	US_L_GDP_BAR	Real potential output - US (100*log)	–
$\Delta \overline{y}^{R,US}$	US_DL_GDP_BAR	Real potential output growth - US (QoQ %, ann)	2.00
$\pi^{C,US}$	US_DL_P_CONS	Inflation - US (QoQ %, annualized)	2.50
$p^{C,US}$	US_L_P_CONS	CPI - US (100*log)	–
z^{US}	US_L_RER	Real exchange rate - US (100*log)	–
Δz^{US}	US_DL_RER	RER appreciation - US (QoQ %, annualized)	-1.00
$\hat{z}^{US}$	US_L_RER_GAP	Real exchange rate gap - US (%, log approx)	-0.00
$\overline{Z}^{US}$	US_RER_BAR	Real exchange rate trend - US (level)	–
$\overline{z}^{US}$	US_L_RER_BAR	Real exchange rate trend - US (100*log)	–
$\Delta \overline{z}^{US}$	US_DL_RER_BAR	Eq. RER appreciation - US (QoQ %, annualized)	-1.00
$\hat{y}^{R,EZ}$	EZ_L_GDP_GAP	Output gap - EZ (%, log approx)	0.00
$y^{R,EZ}$	EZ_L_GDP	Real GDP - EZ (100*log)	–
$\Delta y^{R,EZ}$	EZ_DL_GDP	Real GDP growth - EZ (QoQ %, ann)	1.50
$\overline{y}^{R,EZ}$	EZ_L_GDP_BAR	Real potential output - EZ (100*log)	–
$\Delta \overline{y}^{R,EZ}$	EZ_DL_GDP_BAR	Real potential output growth - EZ (QoQ %, ann)	1.50
$\pi^{C,EZ}$	EZ_DL_P_CONS	Inflation - EZ (QoQ %, annualized)	1.90
$p^{C,EZ}$	EZ_L_P_CONS	CPI - EZ (100*log)	–
s^{EZ}	EZ_L_NER	Nominal exchange rate - EZ (LCY per USD, 100*log)	–
Δs^{EZ}	EZ_DL_NER	Nominal ER Depreciation - EZ (QoQ ann, LCY per USD)	-0.60
z^{EZ}	EZ_L_RER	Real exchange rate - EZ (100*log)	1.00
Δz^{EZ}	EZ_DL_RER	RER appreciation - EZ (QoQ %, annualized)	0.00
$\hat{z}^{EZ}$	EZ_L_RER_GAP	Real exchange rate gap - EZ (%, log approx)	0.00
$\overline{Z}^{EZ}$	EZ_RER_BAR	Real exchange rate trend - EZ (level)	–
$\overline{z}^{EZ}$	EZ_L_RER_BAR	Real exchange rate trend - EZ (100*log)	1.00
$\Delta \overline{z}^{EZ}$	EZ_DL_RER_BAR	Eq. RER appreciation - EZ (QoQ %, annualized)	0.00
$\Delta \overline{z}^{G,EZ}$	EZ_DL_RER_BAR_G	Underlying eq. RER appreciation - EZ (QoQ %, annualized)	0.00
$\hat{y}^{R,*}$	F_L_GDP_GAP	Effective foreign output gap (%, log approx)	0.00
$y^{R,*}$	F_L_GDP	Effective foreign output (100*log)	–
$\overline{y}^{R,*}$	F_L_GDP_BAR	Effective foreign potential output (100*log)	–
$\Delta \overline{y}^{R,*}$	F_DL_GDP_BAR	Effective foreign potential output growth (%, log approx)	1.86
$p^{C,*}$	F_L_P_CONS	Effective foreign price level (100*log)	–
$\pi^{C,*}$	F_DL_P_CONS	Effective foreign price inflation (%, log approx)	2.50
$p^{C,Xw,*}$	F_EXP_L_P_CONS	Effective export countries price level (100*log)	–
$\pi^{C,Xw,*}$	F_EXP_DL_P_CONS	Effective export countries price inflation (%, log approx)	2.50
$p^{C,Mw,*}$	F_IMP_L_P_CONS	Effective import countries price level (100*log)	–
$\pi^{C,Mw,*}$	F_IMP_DL_P_CONS	Effective import countries price inflation (%, log approx)	2.50
Z	REER	Real effective exchange rate (level)	–
z	L_REER	Real effective exchange rate (100*log)	–
Δz	DL_REER	REER depreciation (%, log approx)	-1.00
$\hat{z}$	L_REER_GAP	REER gap (%, log approx)	-0.00
$\overline{z}$	L_REER_BAR	Equilibrium REER (100*log)	–
$\Delta \overline{z}$	DL_REER_BAR	Equilibrium real exchange rate depreciation (%, log approx)	-1.00
z^{Xw}	F_EXP_L_REER	Effective export countries real exchange rate (100*log)	–
$\overline{z}^{Xw}$	F_EXP_L_REER_BAR	Effective eq. export countries real exchange rate (100*log)	–
$\Delta \overline{z}^{Xw}$	F_EXP_DL_REER_BAR	Effective export countries real exchange rate depreciation (%, log approx)	-1.00
$\hat{z}^{Xw}$	F_EXP_L_REER_GAP	Effective export countries real exchange rate gap (%, log approx)	-0.00
z^{Mw}	F_IMP_L_REER	Effective import countries real exchange rate (100*log)	–
$\overline{z}^{Mw}$	F_IMP_L_REER_BAR	Effective eq. import countries real exchange rate (100*log)	–
$\Delta \overline{z}^{Mw}$	F_IMP_DL_REER_BAR	Effective import countries real exchange rate depreciation (%, log approx)	-1.00
$\hat{z}^{Mw}$	F_IMP_L_REER_GAP	Effective import countries real exchange rate gap (%, log approx)	-0.00
$p^{oil,*}$	L_P_OIL	International oil price (100*log)	–

Table continues on the next page.

Variable	Model name	Description	Steady-state
$p^{R,oil,*}$	L_RP_OIL	Real oil price (100*log)	–
$\Delta p^{R,oil,*}$	DL_RP_OIL	Real oil price inflation (100*log)	5.00
$\overline{p}^{R,oil,*}$	L_RP_OIL_BAR	Real oil price trend (100*log)	–
$\hat{p}^{R,oil,*}$	L_RP_OIL_GAP	Real oil price gap (percent)	0.00
$\Delta\overline{p}^{R,oil,*}$	DL_RP_OIL_BAR	Eq. real oil price growth (percent, QoQ annualized)	5.00
$\pi^{oil,*}$	DL_P_OIL	International oil price inflation (percent)	7.50
$P^{NR,*}$	P_NR	International natural resource price (level)	–
$p^{NR,*}$	L_P_NR	International natural resource price (100*log)	–
$\overline{P}^{R,NR,*}$	RP_NR_BAR	Real natural resource price trend (level)	–
$p^{R,NR,*}$	L_RP_NR	Real natural resource price (100*log)	1.00
$\Delta p^{R,NR,*}$	DL_RP_NR	Real natural resource price inflation (100*log)	0.00
$\overline{p}^{R,NR,*}$	L_RP_NR_BAR	Real natural resource price trend (100*log)	1.00
$\hat{p}^{R,NR,*}$	L_RP_NR_GAP	Real natural resource price gap (percent)	0.00
$\Delta\overline{p}^{R,NR,*}$	DL_RP_NR_BAR	Eq. real natural resource price growth (percent, QoQ annualized)	0.00
$\pi^{NR,*}$	DL_P_NR	International natural resource price inflation (percent)	2.50

A.II Shocks

Table 2. Shocks

Shock	Model name	Description
$\varepsilon^{\Delta\tilde{a}^R}$	RES_L_TFP_BAR	Shock to potential quasi TFP
$\varepsilon^{\Delta\tilde{a}^{R,g}}$	RES_DL_GTFP_BAR	Shock to potential quasi TFP growth
$\varepsilon^{\hat{c}^R}$	RES_L_CONS_GAP	Shock to private consumption gap (p.p.)
$\varepsilon^{\Delta\overline{c}^R}$	RES_DL_CONS_BAR	Shock to potential real private consumption growth (p.p.)
$\varepsilon^{\hat{i}^R}$	RES_L_INV_GAP	Shock to investment gap (p.p.)
$\varepsilon^{\Delta\overline{i}^R}$	RES_DL_INV_BAR	Shock to potential real investment growth (p.p.)
$\varepsilon^{\hat{x}^{R,NNR}}$	RES_L_EXP_NNR_GAP	Shock to NNR exports gap (p.p.)
$\varepsilon^{\Delta\overline{x}^{R,NNR}}$	RES_DL_EXP_NNR_BAR	Shock to potential real NNR exports growth (p.p.)
$\varepsilon^{\overline{X}^{R,NNR,S}}$	RES_EXP_NNR_SUP_BAR	Shock to proxy for equilibrium NNR exports supply (p.p.)
$\varepsilon^{\hat{x}^{R,NR}}$	RES_L_EXP_NR_GAP	Shock to NR exports gap (p.p.)
$\varepsilon^{\Delta\overline{x}^{R,NR}}$	RES_DL_EXP_NR_BAR	Shock to potential real NR exports growth (p.p.)
$\varepsilon^{\overline{X}^{R,NR,S}}$	RES_EXP_NR_SUP_BAR	Shock to proxy for equilibrium NR exports supply (p.p.)
$\varepsilon^{\hat{m}^{R,NOIL}}$	RES_L_IMP_NOIL_GAP	Shock to non-oil imports gap (p.p.)
$\varepsilon^{\Delta\overline{m}^{R,NOIL}}$	RES_DL_IMP_NOIL_BAR	Shock to potential real non-oil imports growth (p.p.)
$\varepsilon^{\overline{M}^{R,NOIL,D}}$	RES_IMP_NOIL_DEM_BAR	Shock to proxy for equilibrium non-oil imports demand (p.p.)
$\varepsilon^{\hat{m}^{R,NOIL}}$	RES_L_IMP_OIL_GAP	Shock to oil imports gap (p.p.)
$\varepsilon^{\Delta\overline{m}^{R,NOIL}}$	RES_DL_IMP_OIL_BAR	Shock to potential real oil imports growth (p.p.)
$\varepsilon^{\overline{M}^{R,NOIL,D}}$	RES_IMP_OIL_DEM_BAR	Shock to proxy for equilibrium oil imports demand (p.p.)
ε^{π^C}	RES_DL_P_CONS	Shock to consumption prices (p.p.)
ε^{π^I}	RES_DL_P_INV	Shock to investment prices (p.p.)
$\varepsilon^{\Delta\overline{p}^{R,I}}$	RES_DL_RP_INV_BAR	Shock to eq. growth of relative price of investment (p.p.)

Table continues on the next page.

Shock	Model name	Description
$\varepsilon^{\pi^{X^{NNR}}}$	RES_DL_P_EXP_NNR	Shock to NNR export prices (p.p.)
$\varepsilon^{\Delta\overline{p}^{R,X^{NNR}}}$	RES_DL_RP_EXP_NNR_BAR	Shock to eq. growth of relative price of NNR export(p.p.)
$\varepsilon^{\pi^{X^{NR}}}$	RES_DL_P_EXP_NR	Shock to NR export prices (p.p.)
$\varepsilon^{\Delta\overline{p}^{R,X^{NR}}}$	RES_DL_RP_EXP_NR_BAR	Shock to eq. growth of relative price of NR export(p.p.)
$\varepsilon^{\pi^{M^{NOIL}}}$	RES_DL_P_IMP_NOIL	Shock to non-oil import prices (p.p.)
$\varepsilon^{\Delta\overline{p}^{R,M^{NOIL}}}$	RES_DL_RP_IMP_NOIL_BAR	Shock to eq. growth of relative price of non-oil import(p.p.)
$\varepsilon^{\pi^{M^{OIL}}}$	RES_DL_P_IMP_OIL	Shock to oil import prices (p.p.)
$\varepsilon^{\Delta\overline{p}^{R,M^{OIL}}}$	RES_DL_RP_IMP_OIL_BAR	Shock to eq. growth of relative price of oil import(p.p.)
$\varepsilon^{\pi^{G}}$	RES_DL_P_GOV	Shock to government absorption prices (p.p.)
$\varepsilon^{\Delta\overline{p}^{R,G}}$	RES_DL_RP_GOV_BAR	Shock to eq. growth of relative price of gov.absorb. (p.p.)
$\varepsilon^{R\hat{E}M^{Y}}$	RES_REMIT_RAT_GAP	Shock to net remittances inflows gap (% of GDP)
$\varepsilon^{\overline{REM}^{Y}}$	RES_REMIT_RAT_BAR	Shock to net remittances inflows trend (% of GDP)
$\varepsilon^{CA^{O,Y}}$	RES_OCA_RAT	Shock to other net current account inflows to GDP ratio (%)
$\varepsilon^{\overline{CA}^{O,Y}}$	RES_OCA_RAT_BAR	Shock to potential other net current account inflows to GDP ratio (%)
$\varepsilon^{\overline{\gamma}}$	RES_RR_PREM_BAR	Equilibrium UIP premium shock (p.p.)
$\varepsilon^{\hat{\gamma}}$	RES_RR_PREM_GAP	Transitory UIP premium shock (p.p.)
$\varepsilon^{\tau^{FA^{O}}}$	RES_TAU_OFA	Shock to capital inflow tax rate (p.p.)
$\varepsilon^{\overline{FA}^{O,Exo,Y}}$	RES_EXO_OFA_RAT_BAR	Shock to (semi-)exogenous financial account inflows to GDP ratio (%)
ε^{r}	RES_RS	Monetary policy interest shock (p.p.)
$\varepsilon^{\overline{\pi}^{C}}$	RES_DL_P_CONS_TAR	Inflation target shock (p.p.)
$\varepsilon^{r^{G,LCY}}$	RES_RS_GOV_LCY	Shock to the nominal sovereign LCY interest rate (p.p.)
$\varepsilon^{\gamma^{G,LCY}}$	RES_RR_PREM_GOV_LCY	Shock to the real sovereign LCY premium (p.p.)
$\varepsilon^{r^{G,FCY}}$	RES_RS_GOV_FCY	Shock to the nominal sovereign FCY interest rate (p.p.)
$\varepsilon^{\gamma^{G,FCY}}$	RES_RR_PREM_GOV_FCY	Shock to the real sovereign FCY premium (p.p.)
$\varepsilon^{r^{NFA^{O}}}$	RES_RS_ONFA	Shock to the nominal private NFA interest rate (p.p.)
$\varepsilon^{\gamma^{NFA^{O}}}$	RES_RR_PREM_ONFA	Shock to the real private NFA premium (p.p.)
$\varepsilon^{\overline{FXR}^{Y}}$	RES_FX_RES_RAT_TAR	Shock to foreign exchange reserves target (% of GDP)
$\varepsilon^{FXI^{Y}}$	RES_FXI_RAT	Foreign exchange intervention shock (% of GDP)
$\varepsilon^{FXA^{Y}}$	RES_FXA_RAT	Foreign exchange reserves accumulation shock (% of GDP)
$\varepsilon^{FXR^{Y}}$	RES_FX_RES_RAT	Discrepancy in foreign exchange reserves identity (% of GDP)
$\varepsilon^{\tau^{Y}}$	RES_TAU_Y	Shock to the income tax rate
$\varepsilon^{\tau^{C}}$	RES_TAU_C	Shock to the consumption tax rate
$\varepsilon^{\tau^{M^{NOIL}}}$	RES_TAU_M_NOIL	Shock to the non-oil import tax rate
$\varepsilon^{\tau^{M^{OIL}}}$	RES_TAU_M_OIL	Shock to the oil import tax rate
$\varepsilon^{\tau^{NR}}$	RES_TAU_NR	Shock to the natural resource royalty rate
$\varepsilon^{GD^{S,Y}}$	RES_DEF_S_RAT	Shock to the structural deficit ratio to GDP
$\varepsilon^{GF^{FCY,Y}}$	RES_FIN_FCY_RAT	Shock to deficit financing in FCY (% of GDP)
$\varepsilon^{\overline{B}^{Y}}$	RES_DEB_RAT_TAR	Shock to the debt ratio to GDP target
$\varepsilon^{\overline{B}^{FCY,B}}$	RES_DEB_FCY_SHARE_TAR	Shock to target share of FCY debt (% of total debt)
$\varepsilon^{B^{FCY,Y}}$	RES_DEB_FCY_RAT	Shock to FCY debt accumulation (% of GDP)

Table continues on the next page.

Shock	Model name	Description
$\varepsilon^{B^{LCY,Y}}$	RES_DEB_LCY_RAT	Shock to LCY debt accumulation (% of GDP)
$\varepsilon^{GR^{O,Y}}$	RES_GREV_OTH_RAT	Shock to the other government revenues ratio to GDP
$\varepsilon^{\overline{GR}^{O,Y}}$	RES_GREV_OTH_RAT_BAR	Shock to the EQ. other government revenues ratio to GDP
$\varepsilon^{GE^{C,Y}}$	RES_GEXP_CONS_RAT	Shock to the government consumption ratio to GDP
$\varepsilon^{GE^{O,Y}}$	RES_GEXP_OTH_RAT	Shock to other government expenditure ratio to GDP
$\varepsilon^{GE^{Tr,Y}}$	RES_GEXP_TRF_RAT	Shock to Government transfers to GDP ratio
$\varepsilon^{\overline{GE^{Tr,Y}}}$	RES_GEXP_TRF_RAT_BAR	Shock to equilibrium Government transfers to GDP ratio
$\varepsilon^{r^{US}}$	RES_ABS_US_RS	US interest rate shock
$\varepsilon^{\overline{r}^{R,US}}$	RES_ABS_US_RR_BAR	US equilibrium interest rate shock
$\varepsilon^{\hat{y}^{R,US}}$	RES_ABS_US_L_GDP_GAP	Demand shock - US (p.p.)
$\varepsilon^{\Delta\overline{y}^{R,US}}$	RES_ABS_US_DL_GDP_BAR	Potential output growth shock - US (p.p.)
$\varepsilon^{\pi^{C,US}}$	RES_ABS_US_DL_P_CONS	Supply shock - US (p.p.)
$\varepsilon^{\hat{y}^{R,EZ}}$	RES_ABS_EZ_L_GDP_GAP	Demand shock - EZ (p.p.)
$\varepsilon^{\Delta\overline{y}^{R,EZ}}$	RES_ABS_EZ_DL_GDP_BAR	Potential output growth shock - EZ (p.p.)
$\varepsilon^{\pi^{C,EZ}}$	RES_ABS_EZ_DL_P_CONS	Supply shock - EZ (p.p.)
$\varepsilon^{\hat{z}^{EZ}}$	RES_ABS_EZ_L_RER_GAP	Transitory exchange rate shock - EZ (p.p.)
$\varepsilon^{\overline{z}^{EZ}}$	RES_ABS_EZ_L_RER_BAR	Eq. exchange rate level shock - EZ (p.p.)
$\varepsilon^{\Delta\overline{z}^{EZ}}$	RES_ABS_EZ_DL_RER_BAR	Eq. exchange rate appreciation shock - EZ (p.p.)
$\varepsilon^{\hat{p}^{R,oil,*}}$	RES_ABS_L_RP_OIL_GAP	Real oil price gap shock
$\varepsilon^{\Delta\overline{p}^{R,oil,*}}$	RES_ABS_DL_RP_OIL_BAR	Eq. real oil price growth shock
$\varepsilon^{\hat{p}^{R,NR,*}}$	RES_ABS_L_RP_NR_GAP	Real natural resource price gap shock
$\varepsilon^{\Delta\overline{p}^{R,NR,*}}$	RES_ABS_DL_RP_NR_BAR	Eq. real natural resource price growth shock

A.III Parameters

Table 3. Alternative model calibrations

Parameter	Description	IT (Baseline)	IT (AE)	IT & high cap. mob.	IT & low cap. mob.	Managed float	Managed float & low cap. mob.
${c_1^{\pi}}^C$	Persistence of private consumption price inflation	0.80	0.40	$=$	$=$	$=$	$=$
${c_2^{\pi}}^C$	Pass-through from non-oil import prices to consumption prices	0.30	0.10	$=$	$=$	$=$	$=$
${c_1^{FA}}^{O,Y}$	Short-term degree of cross-border capital mobility	1.00	1000.00	1000.00	0.10	$=$	0.10
${c_1^{\overline{FA}}}^{O,Y}$	Long-term degree of cross-border capital mobility	1.00	1000.00	1000.00	$=$	$=$	$=$
c_1^r	Policy interest rate smoothing	0.15	0.30	$=$	$=$	$=$	$=$
${c_2^{FXI}}^Y$	Intensity of FX management	0.00	$=$	$=$	$=$	10.00	10.00
$\overline{FXR}^{Y,SS}$	Steady state foreign exchange reserves (% of GDP)	0.00	$=$	$=$	$=$	13.00	13.00
$\gamma^{FXR,max}$	Maximum of the FX reserves contribution to the UIP premium	0.00	$=$	$=$	$=$	2.00	2.00
FXR^{min}	Point of reaching maximum FX reserves contribution to the UIP premium	0.00	$=$	$=$	$=$	5.00	5.00
${c_2^{\gamma}}^{FXR}$	Curvature of the FX reserves contribution to the UIP premium	0.05	$=$	$=$	$=$	0.50	0.50
${c_1^{\gamma}}^{FXR}$	Intercept in FXR contribution to the UIP premium	-0.00	$=$	$=$	$=$	-0.04	-0.04
${c_3^{\gamma}}^{FXR}$	Slope of FXR contribution to the UIP premium	0.00	$=$	$=$	$=$	24.82	24.82

'=' means that the value of the parameter is the same as in IT (Baseline) parametrization.

Table 4. Parameters

Parameter	Model name	Description	Calibration
$\Delta\tilde{a}^{R,SS}$	DL_TFP_SS	Steady state real GDP Growth (%, log approx)	3.00
${\delta^K}^R$	C1_K	Depreciation rate of private capital	0.09
${c_1^{\Delta\overline{y}}}^R$	C1_DL_GDP_BAR	Response of potential GDP growth to private capital	0.50
${c_2^{\Delta\overline{y}}}^R$	C2_DL_GDP_BAR	Response of potential GDP growth to public capital	0.10
${c_1^{\Delta\tilde{a}}}^{R,g}$	C1_DL_GTFP_BAR	Persistency of potential quasi TFP growth	0.50
$\Delta\overline{z}^{SS,US}$	US_DL_RER_BAR_SS	Steady state RER depreciation (%, log approx)	-1.00
${c_1^{\hat{c}}}^R$	C1_L_CONS_GAP		0.25
${c_2^{\hat{c}}}^R$	C2_L_CONS_GAP		0.30
${c_3^{\hat{c}}}^R$	C3_L_CONS_GAP		0.10
${c_4^{\hat{c}}}^R$	C4_L_CONS_GAP		0.10
${c_5^{\hat{c}}}^R$	C5_L_CONS_GAP		0.05
${c_6^{\hat{c}}}^R$	C6_L_CONS_GAP		0.70
${c_7^{\hat{c}}}^R$	C7_L_CONS_GAP		0.70
${c_1^{\Delta\overline{c}}}^R$	C1_DL_CONS_BAR		0.50
${c_2^{\Delta\overline{c}}}^R$	C2_DL_CONS_BAR		0.50
${c_3^{\Delta\overline{c}}}^R$	C3_DL_CONS_BAR		0.20
${c_4^{\Delta\overline{c}}}^R$	C4_DL_CONS_BAR		1.00
${c_5^{\Delta\overline{c}}}^R$	C5_DL_CONS_BAR		0.30
$C^{Y,SS}$	CONS_RAT_SS		60.00
${c_1^{\hat{i}}}^R$	C1_L_INV_GAP		0.15
${c_2^{\hat{i}}}^R$	C2_L_INV_GAP		0.60

Table continues on the next page.

Parameter	Model name	Description	Calibration
$c_3^{\hat{i}^R}$	C3_L_INV_GAP		0.30
$c_4^{\hat{i}^R}$	C4_L_INV_GAP		0.50
$c_5^{\hat{i}^R}$	C5_L_INV_GAP		0.00
$c_6^{\hat{i}^R}$	C6_L_INV_GAP		0.50
$c_1^{\Delta\bar{i}^R}$	C1_DL_INV_BAR		0.40
$c_2^{\Delta\bar{i}^R}$	C2_DL_INV_BAR		0.75
$c_3^{\Delta\bar{i}^R}$	C3_DL_INV_BAR		2.00
$c_4^{\Delta\bar{i}^R}$	C4_DL_INV_BAR		0.05
$I^{Y,SS}$	INV_RAT_SS		20.00
$c_1^{\hat{x}^{R,NNR}}$	C1_L_EXP_NNR_GAP		0.15
$c_2^{\hat{x}^{R,NNR}}$	C2_L_EXP_NNR_GAP		0.00
$c_3^{\hat{x}^{R,NNR}}$	C3_L_EXP_NNR_GAP		0.25
$c_4^{\hat{x}^{R,NNR}}$	C4_L_EXP_NNR_GAP		0.90
$c_1^{\Delta\overline{x}^{R,NNR}}$	C1_DL_EXP_NNR_BAR		0.40
$c_2^{\Delta\overline{x}^{R,NNR}}$	C2_DL_EXP_NNR_BAR		0.50
$c_3^{\Delta\overline{x}^{R,NNR}}$	C3_DL_EXP_NNR_BAR		1.00
$X^{NNR,Y,SS}$	EXP_NNR_RAT_SS		30.00
$c_1^{\overline{X}^{R,NNR,S}}$	C1_EXP_NNR_SUP_BAR		1.00
$c_2^{\overline{X}^{R,NNR,S}}$	C2_EXP_NNR_SUP_BAR		0.70
$c_1^{\hat{x}^{R,NR}}$	C1_L_EXP_NR_GAP		0.15
$c_2^{\hat{x}^{R,NR}}$	C2_L_EXP_NR_GAP		0.25
$c_1^{\Delta\overline{x}^{R,NR}}$	C1_DL_EXP_NR_BAR		0.20
$c_2^{\Delta\overline{x}^{R,NR}}$	C2_DL_EXP_NR_BAR		0.50
$c_3^{\Delta\overline{x}^{R,NR}}$	C3_DL_EXP_NR_BAR		0.00
$X^{NR,Y,SS}$	EXP_NR_RAT_SS		0.10
$c_4^{\Delta\overline{x}^{R,NR}}$	C4_DL_EXP_NR_BAR		0.10
$c_1^{\overline{X}^{R,NR,S}}$	C1_EXP_NR_SUP_BAR		1.00
$c_1^{G^{NR,Y}}$	C1_EXP_NR_PROF_RAT		0.50
$c_1^{\hat{m}^{R,NOIL}}$	C1_L_IMP_NOIL_GAP		0.15
$c_2^{\hat{m}^{R,NOIL}}$	C2_L_IMP_NOIL_GAP		0.30
$c_3^{\hat{m}^{R,NOIL}}$	C3_L_IMP_NOIL_GAP		0.15
$c_4^{\hat{m}^{R,NOIL}}$	C4_L_IMP_NOIL_GAP		0.25
$c_5^{\hat{m}^{R,NOIL}}$	C5_L_IMP_NOIL_GAP		0.04
$c_6^{\hat{m}^{R,NOIL}}$	C6_L_IMP_NOIL_GAP		0.01
$c_7^{\hat{m}^{R,NOIL}}$	C7_L_IMP_NOIL_GAP		0.15
$c_8^{\hat{m}^{R,NOIL}}$	C8_L_IMP_NOIL_GAP		0.05
$c_1^{\Delta\overline{m}^{R,NOIL}}$	C1_DL_IMP_NOIL_BAR		0.30
$c_2^{\Delta\overline{m}^{R,NOIL}}$	C2_DL_IMP_NOIL_BAR		0.80
$c_3^{\Delta\overline{m}^{R,NOIL}}$	C3_DL_IMP_NOIL_BAR		0.15
$c_4^{\Delta\overline{m}^{R,NOIL}}$	C4_DL_IMP_NOIL_BAR		0.25
$c_5^{\Delta\overline{m}^{R,NOIL}}$	C5_DL_IMP_NOIL_BAR		0.15
$c_6^{\Delta\overline{m}^{R,NOIL}}$	C6_DL_IMP_NOIL_BAR		0.30
$c_7^{\Delta\overline{m}^{R,NOIL}}$	C7_DL_IMP_NOIL_BAR		0.00

Table continues on the next page.

Parameter	Model name	Description	Calibration
$c_8^{\Delta\overline{m}^{R,NOIL}}$	C8_DL_IMP_NOIL_BAR		0.90
$c_9^{\Delta\overline{m}^{R,NOIL}}$	C9_DL_IMP_NOIL_BAR		0.15
$c_1^{\overline{M}^{R,NOIL,D}}$	C1_IMP_NOIL_DEM_BAR		1.00
$c_1^{\hat{m}^{R,OIL}}$	C1_L_IMP_OIL_GAP		0.15
$c_2^{\hat{m}^{R,OIL}}$	C2_L_IMP_OIL_GAP		0.10
$c_3^{\hat{m}^{R,OIL}}$	C3_L_IMP_OIL_GAP		0.10
$c_4^{\hat{m}^{R,OIL}}$	C4_L_IMP_OIL_GAP		0.10
$c_5^{\hat{m}^{R,OIL}}$	C5_L_IMP_OIL_GAP		0.04
$c_6^{\hat{m}^{R,OIL}}$	C6_L_IMP_OIL_GAP		0.02
$c_7^{\hat{m}^{R,OIL}}$	C7_L_IMP_OIL_GAP		0.07
$c_8^{\hat{m}^{R,OIL}}$	C8_L_IMP_OIL_GAP		0.10
$c_1^{\Delta\overline{m}^{R,OIL}}$	C1_DL_IMP_OIL_BAR		0.30
$c_2^{\Delta\overline{m}^{R,OIL}}$	C2_DL_IMP_OIL_BAR		0.80
$c_3^{\Delta\overline{m}^{R,OIL}}$	C3_DL_IMP_OIL_BAR		0.10
$c_4^{\Delta\overline{m}^{R,OIL}}$	C4_DL_IMP_OIL_BAR		0.15
$c_5^{\Delta\overline{m}^{R,OIL}}$	C5_DL_IMP_OIL_BAR		0.15
$c_6^{\Delta\overline{m}^{R,OIL}}$	C6_DL_IMP_OIL_BAR		0.15
$c_7^{\Delta\overline{m}^{R,OIL}}$	C7_DL_IMP_OIL_BAR		0.00
$c_8^{\Delta\overline{m}^{R,OIL}}$	C8_DL_IMP_OIL_BAR		0.10
$c_9^{\Delta\overline{m}^{R,OIL}}$	C9_DL_IMP_OIL_BAR		0.15
$M^{OIL,Y,SS}$	IMP_OIL_RAT_SS	Oil imports to GDP ratio in steady state (%)	7.00
$c_1^{\overline{M}^{R,OIL,D}}$	C1_IMP_OIL_DEM_BAR		1.00
$c_1^{\pi^C}$	C1_DL_P_CONS	Persistence of private consumption price inflation	0.80
$c_2^{\pi^C}$	C2_DL_P_CONS	Pass-through from non-oil import prices to consumption prices	0.30
$c_3^{\pi^C}$	C3_DL_P_CONS		0.05
$c_4^{\pi^C}$	C4_DL_P_CONS		0.30
$c_5^{\pi^C}$	C5_DL_P_CONS		0.40
$c_1^{\pi^I}$	C1_DL_P_INV		0.10
$c_2^{\pi^I}$	C2_DL_P_INV		0.15
$c_3^{\pi^I}$	C3_DL_P_INV		0.07
$c_4^{\pi^I}$	C4_DL_P_INV		0.30
$c_5^{\pi^I}$	C5_DL_P_INV		0.00
$c_1^{\Delta\overline{p}^{R,I}}$	C1_DL_RP_INV_BAR		0.50
$\Delta\overline{p}^{R,G,SS}$	DL_RP_INV_SS		1.00
$c_1^{\pi^{X^{NNR}}}$	C1_DL_P_EXP_NNR		1.00
$c_2^{\pi^{X^{NNR}}}$	C2_DL_P_EXP_NNR		0.30
$c_3^{\pi^{X^{NNR}}}$	C3_DL_P_EXP_NNR		0.80
$c_1^{\Delta\overline{p}^{R,X^{NNR}}}$	C1_DL_RP_EXP_NNR_BAR		0.50
$\Delta\overline{p}^{R,X^{NNR},SS}$	DL_RP_EXP_NNR_SS		-0.50
$c_1^{\pi^{X^{NR}}}$	C1_DL_P_EXP_NR		1.00
$c_2^{\pi^{X^{NR}}}$	C2_DL_P_EXP_NR		0.60

Table continues on the next page.

Parameter	Model name	Description	Calibration
$c_1^{\Delta\overline{p}^{R,X^{NR}}}$	C1_DL_RP_EXP_NR_BAR		0.00
$\Delta\overline{p}^{R,X^{NNR},SS}$	DL_RP_EXP_NR_SS		0.00
$c_1^{\pi^{M^{NOIL}}}$	C1_DL_P_IMP_NOIL		0.90
$c_2^{\pi^{M^{NOIL}}}$	C2_DL_P_IMP_NOIL		0.80
$c_1^{\Delta\overline{p}^{R,M^{NOIL}}}$	C1_DL_RP_IMP_NOIL_BAR		1.00
$\Delta\overline{p}^{R,M^{NOIL},SS}$	DL_RP_IMP_NOIL_SS		-1.00
$c_1^{\pi^{M^{OIL}}}$	C1_DL_P_IMP_OIL		0.90
$c_2^{\pi^{M^{OIL}}}$	C2_DL_P_IMP_OIL		0.80
$c_1^{\Delta\overline{p}^{R,M^{OIL}}}$	C1_DL_RP_IMP_OIL_BAR		0.00
$\Delta\overline{p}^{R,M^{OIL},SS}$	DL_RP_IMP_OIL_SS		2.00
$c_1^{\pi^G}$	C1_DL_P_GOV		0.20
$c_2^{\pi^G}$	C2_DL_P_GOV		0.20
$c_3^{\pi^G}$	C3_DL_P_GOV		0.05
$c_4^{\pi^G}$	C4_DL_P_GOV		0.10
$c_5^{\pi^G}$	C5_DL_P_GOV		0.10
$\Delta\overline{p}^{R,G,SS}$	DL_RP_GOV_SS		0.00
$c_1^{\Delta\overline{P}^{R,G}}$	C1_DL_RP_GOV_BAR		0.50
$c_1^{R\hat{E}M^Y}$	C1_REMIT_RAT_GAP		0.50
$c_2^{R\hat{E}M^Y}$	C2_REMIT_RAT_GAP		0.25
$c_1^{\overline{REM}^Y}$	C1_REMIT_RAT_BAR		0.60
$REM^{Y,SS}$	REMIT_RAT_SS	Net remittances inflows to GDP ratio in steady state (%)	2.00
$CA^{O,Y,SS}$	OCA_RAT_SS	Other net current account inflows to GDP ratio in steady state (%)	-3.50
$c_1^{CA^{O,Y}}$	C1_OCA_RAT		0.20
$c_1^{\overline{CA}^{O,Y}}$	C1_OCA_RAT_BAR		0.50
$c_1^{FA^{O,Y}}$	C1_OFA_RAT	Short-term degree of cross-border capital mobility	1.00
$c_1^{\overline{FA}^{O,Y}}$	C1_OFA_RAT_BAR	Long-term degree of cross-border capital mobility	1.00
$\tau^{FA^O,SS}$	TAU_OFA_SS	Capital inflow tax rate in steady state (%)	0.00
$c_1^{\tau^{FA^O}}$	C1_TAU_OFA		1.00
$\tau^{FA^O,adm}$	C1_TAU_OFA_ADMIN	Parameter reflecting administrative restrictions on capital flows	0.00
$c_1^{\overline{FA}^{O,Exo,Y}}$	C1_EXO_OFA_RAT_BAR		1.00
$c_1^{s^{E,US}}$	C1_E_L_NER	Forward lookinness in expected NER	0.80
γ^{SS}	RR_PREM_SS	Steady state UIP premium (%)	3.50
$c_1^{\gamma^B}$	C1_DEB_PREM		0.05
$c_1^{\gamma^{NFA^O}}$	C1_ONFA_PREM		0.03
$\underline{r}$	RS_ELB	Effective lower bound for policy rate (%)	0.00
c_1^r	C1_RS	Policy interest rate smoothing	0.15
c_2^r	C2_RS	Wight on inflation gap in MP interest rule	1.00
c_3^r	C3_RS	Wight on output gap in MP interest rule	0.20
$c_1^{\overline{\pi}^C}$	C1_DL_P_CONS_TAR	Persistency of inflation target	1.00
$\overline{\pi}^{C,SS}$	DL_P_CONS_TAR_SS	Consumer Price Inflation target (%, log approx)	1.98
$\gamma^{G,LCY}$	RR_PREM_GOV_LCY_SS	Steady state of sovereign LCY premium (p.p.)	0.50
$c_1^{\gamma^{G,LCY}}$	C1_RR_PREM_GOV_LCY		0.60

Table continues on the next page.

Parameter	Model name	Description	Calibration
$c_2^{\gamma^{G,LCY}}$	C2_RR_PREM_GOV_LCY		0.05
$\gamma^{G,FCY}$	RR_PREM_GOV_FCY_SS	Steady state of sovereign FCY premium (p.p.)	2.50
$c_1^{\gamma^{G,FCY}}$	C1_RR_PREM_GOV_FCY		0.60
$c_2^{\gamma^{G,FCY}}$	C2_RR_PREM_GOV_FCY		0.02
γ^{NFA^O}	RR_PREM_ONFA_SS	Steady state of private NFA premium (p.p.)	0.00
$c_1^{\gamma^{NFA^O}}$	C1_RR_PREM_ONFA		0.60
IN^{LCY}	INVMAT_LCY	Inverse of average maturity of government LCY debt	0.12
IN^{FCY}	INVMAT_FCY	Inverse of average maturity of government FCY debt	0.12
IN^{NFA^O}	INVMAT_ONFA	Inverse of average maturity of private NFA	0.20
$c_1^{\overline{FXR}^Y}$	C1_FX_RES_RAT_TAR		1.00
$c_1^{FXI^Y}$	C1_FXI_RAT		0.00
$c_2^{FXI^Y}$	C2_FXI_RAT	Intensity of FX management	0.00
$\overline{FXR}^{Y,SS}$	FX_RES_RAT_TAR_SS	Steady state foreign exchange reserves (% of GDP)	0.00
$\gamma^{FXR,max}$	FX_RES_PREM_MAX	Maximum of the FX reserves contribution to the UIP premium	0.00
FXR^{min}	FX_RES_RAT_FLOOR	Point of reaching maximum FX reserves contribution to the UIP premium	0.00
$c_2^{\gamma^{FXR}}$	C2_FX_RES_PREM	Curvature of the FX reserves contribution to the UIP premium	0.05
$c_1^{FXA^Y}$	C1_FXA_RAT		0.00
$c_2^{FXA^Y}$	C2_FXA_RAT		1.00
$c_1^{\widehat{FXR}^Y}$	C1_FX_RES_RAT_GAP		0.50
$c_1^{\gamma^{FXR}}$	C1_FX_RES_PREM	Intercept in FXR contribution to the UIP premium	0.00
$c_3^{\gamma^{FXR}}$	C3_FX_RES_PREM	Slope of FXR contribution to the UIP premium	0.00
$c_4^{\gamma^{FXR}}$	C4_FX_RES_PREM		1.00
$c_1^{\tau^Y}$	C1_TAU_Y		1.00
$c_1^{\tau^C}$	C1_TAU_C		1.00
$c_1^{\tau^{M^{NOIL}}}$	C1_TAU_M_NOIL		1.00
$c_1^{\tau^{M^{OIL}}}$	C1_TAU_M_OIL		1.00
$c_1^{\tau^{NR}}$	C1_TAU_NR		1.00
$c_1^{GR^Y}$	C1_GREV_RAT		1.10
$B^{Y,SS}$	DEB_RAT_SS		50.00
$\tau^{Y,SS}$	TAU_Y_SS	Effective income tax rate (%)	10.00
$\tau^{C,SS}$	TAU_C_SS	Effective consumption tax rate (%)	20.00
$\tau^{M^{NOIL},SS}$	TAU_M_NOIL_SS	Effective non-oil import tax rate (%)	5.00
$\tau^{M^{OIL},SS}$	TAU_M_OIL_SS	Effective oil import tax rate (%)	5.00
$\tau^{NR,SS}$	TAU_NR_SS	Effective natural resource royalty rate (%)	0.00
$GR^{O,Y,SS}$	GREV_OTH_RAT_SS	Other tax revenues in steady-state (ratio to GDP)	3.00
$GE^{C,Y,SS}$	GEXP_CONS_RAT_SS	Government current consumption in steady-state (ratio to GDP)	20.00
$GE^{O,Y,SS}$	GEXP_OTH_RAT_SS	Other government expenditure ratio to GDP (ratio to GDP)	1.50
$\overline{GE^{Tr,Y,SS}}$	GEXP_TRF_RAT_BAR_SS	Government transfers ratio to GDP (ratio to GDP)	1.00
$c_1^{GD^{C,Y}}$	C1_DEF_C_RAT		0.10
$c_1^{GD^{S,Y}}$	C1_DEF_S_RAT		0.30
$c_2^{GD^{S,Y}}$	C2_DEF_S_RAT		0.20
$c_3^{GD^{S,Y}}$	C3_DEF_S_RAT		-0.25
$c_1^{\overline{B}^Y}$	C1_DEB_RAT_TAR		1.00
$c_1^{\hat{B}^Y}$	C1_DEB_DEV_RAT		0.50

Table continues on the next page.

Parameter	Model name	Description	Calibration
$c_1^{\overline{G}^{Y}}$	C1_GOV_RAT_BAR		0.50
$c_1^{\overline{GR}^{O,Y}}$	C1_GREV_OTH_RAT_BAR		0.90
$c_1^{GR^{O,Y}}$	C1_GREV_OTH_RAT		0.70
$\delta^{K^{R,G}}$	C1_K_PUB	Depreciation rate of public capital	0.06
$c_2^{K^{R,G}}$	C2_K_PUB		0.25
$c_3^{K^{R,G}}$	C3_K_PUB		0.25
$c_4^{K^{R,G}}$	C4_K_PUB		0.25
$c_1^{GE^{C,Y}}$	C1_GEXP_CONS_RAT		0.70
$c_1^{GE^{O,Y}}$	C1_GEXP_OTH_RAT		0.60
$c_1^{GE^{Tr,Y}}$	C1_GEXP_TRF_RAT		0.60
$c_1^{\overline{GE}^{Tr,Y}}$	C1_GEXP_TRF_RAT_BAR		0.90
$c_1^{\overline{B}^{FCY,B}}$	C1_DEB_FCY_SHARE_TAR		1.00
$B^{FCY,B,SS}$	DEB_FCY_SHARE_TAR_SS	Steady state share of FCY debt (% of total debt)	20.00
$c_1^{GF^{FCY,Y}}$	C1_FIN_FCY_RAT		0.00
$c_2^{GF^{FCY,Y}}$	C2_FIN_FCY_RAT		0.20
$c_3^{GF^{FCY,Y}}$	C3_FIN_FCY_RAT		0.10
$c_1^{r^{US}}$	C1_US_RS		0.50
$c_1^{\overline{r}^{R,US}}$	C1_US_RR_BAR		0.50
$\overline{r}^{R,US,SS}$	US_RR_BAR_SS	US steady state real interest rate (%)	1.00
$w^{X,EZ}$	EZ_EX	Percent share of EZ in exports	20.00
$w^{X,US}$	US_EX	Percent share of US in exports	50.00
$w^{X,ALL}$	EX_ALL		70.00
$w^{M,EZ}$	EZ_IM		30.00
$w^{M,US}$	US_IM		30.00
$w^{M,ALL}$	IM_ALL		60.00
$w^{TR,EZ}$	EZ_TR		50.00
$w^{TR,US}$	US_TR		80.00
$w^{TR,ALL}$	TR_ALL		130.00
$\omega^{TR,US}$	US_W_TR		0.62
$\omega^{X,US}$	US_W_EX		0.71
$\omega^{M,US}$	US_W_IM		0.50
$\omega^{TR,EZ}$	EZ_W_TR		0.38
$\omega^{X,EZ}$	EZ_W_EX		0.29
$\omega^{M,EZ}$	EZ_W_IM		0.50
$c_1^{\hat{y}^{R,EZ}}$	C1_EZ_L_GDP_GAP		0.50
$c_1^{\Delta\overline{y}^{R,EZ}}$	C1_EZ_DL_GDP_BAR		0.60
$c_1^{\pi^{C,EZ}}$	C1_EZ_DL_P_CONS		0.40
$c_1^{\hat{z}^{EZ}}$	C1_EZ_L_RER_GAP		0.50
$c_1^{\Delta\overline{z}^{EZ}}$	C1_EZ_DL_RER_BAR		0.10
$c_1^{\hat{y}^{R,US}}$	C1_US_L_GDP_GAP		0.50
$c_1^{\Delta\overline{y}^{R,US}}$	C1_US_DL_GDP_BAR		0.60
$c_1^{\pi^{C,US}}$	C1_US_DL_P_CONS		0.40
$\Delta\overline{z}^{EZ,SS}$	EZ_DL_RER_BAR_SS		0.00
$\pi^{C,EZ,SS}$	EZ_DL_P_CONS_SS		1.90
$\pi^{C,US,SS}$	US_DL_P_CONS_SS		2.50
$\Delta\overline{y}^{EZ,SS}$	EZ_DL_GDP_BAR_SS		1.50

Table continues on the next page.

Parameter	Model name	Description	Calibration
$\Delta\overline{y}^{US,SS}$	US_DL_GDP_BAR_SS		2.00
$\Delta p^{R,oil,*,SS}$	DL_RP_OIL_SS	International oil price inflation in steady state	5.00
$c_1^{\hat{p}^{R,oil,*}}$	C1_L_RP_OIL_GAP		0.30
$c_1^{\Delta\overline{p}^{R,oil,*}}$	C1_DL_RP_OIL_BAR		0.50
$\Delta p^{R,NR,*,SS}$	DL_RP_NR_SS	International natural resource price inflation in steady state	0.00
$c_1^{\hat{p}^{R,NR,*}}$	C1_L_RP_NR_GAP		0.30
$c_1^{\Delta\overline{p}^{R,NR,*}}$	C1_DL_RP_NR_BAR		0.50

A.IV Equations

Table 5. Equations

Private capital accumulation
$$I_t^R = K_t^R - (1-\delta^{K^R}) \cdot K_{t-1}^R \tag{1}$$

Logarithm of private capital
$$k_t^R = 100 \cdot \log(K_t^R) \tag{2}$$

Private capital growth
$$\Delta k_t^R = k_t^R - k_{t-1}^R \tag{3}$$

Logarithm of real GDP
$$y_t^R = 100 \cdot \log(Y_t^R) \tag{4}$$

Real GDP breakdown
$$y_t^R = \overline{y}_t^R + \hat{y}_t^R \tag{5}$$

Logarithm of pontetial real GDP
$$\overline{y}_t^R = 100 \cdot \log(\overline{Y}_t^R) \tag{6}$$

Potential real GDP growth
$$\Delta\overline{y}_t^R = c_1^{\Delta\overline{y}^R} \cdot (\Delta k_t^R - \mathcal{S}(\Delta k^R)) + c_2^{\Delta\overline{y}^R} \cdot (\Delta k_t^{R,G} - \mathcal{S}(\Delta k^{R,G})) + \Delta\tilde{a}_t^R \tag{7}$$

Potential real GDP growth
$$\Delta\overline{y}_t^R = \overline{y}_t^R - \overline{y}_{t-1}^R \tag{8}$$

Real GDP growth
$$\Delta y_t^R = y_t^R - y_{t-1}^R \tag{9}$$

Logarithm of quasi potential TFP
$$\tilde{a}_t^R = 100 \cdot \log(\tilde{A}_t^R) \tag{10}$$

Quasi potential TFP
$$\Delta\tilde{a}_t^R = \Delta\tilde{a}_t^{R,g} + \varepsilon_t^{\Delta\tilde{a}^R} \tag{11}$$

Persistent component of quasi potential TFP growth

Table continues on the next page.

$$\Delta\tilde{a}_t^{R,g} = c_1^{\Delta\tilde{a}^{R,g}} \cdot \Delta\tilde{a}_{t-1}^{R,g} + (1 - c_1^{\Delta\tilde{a}^{R,g}}) \cdot \Delta\tilde{a}^{R,SS} + \varepsilon_t^{\Delta\tilde{a}^{R,g}} \tag{12}$$

Quasi potential TFP growth

$$\Delta\tilde{a}_t^R = \tilde{a}_t^R - \tilde{a}_{t-1}^R \tag{13}$$

Potential market clearing condition

$$\begin{aligned}\Delta\overline{y}_t^R &= \overline{C}_{t-1}^Y/100 \cdot \Delta\overline{c}_t^R + \overline{I}_{t-1}^Y/100 \cdot \Delta\overline{i}_t^R + \overline{X}_{t-1}^{NNR,Y}/100 \cdot \Delta\overline{x}_t^{R,NNR} \\ &+ \overline{X}_{t-1}^{NR,Y}/100 \cdot \Delta\overline{x}_t^{R,NR} - \overline{M}_{t-1}^{NOIL,Y}/100 \cdot \Delta\overline{m}_t^{R,NOIL} \\ &- \overline{M}_{t-1}^{OIL,Y}/100 \cdot \Delta\overline{m}_t^{R,OIL} + \overline{G}_{t-1}^Y/100 \cdot \Delta\overline{g}_t^R\end{aligned} \tag{14}$$

GDP Gap

$$\begin{aligned}\hat{y}_t^R &= \overline{C}_t^Y/100 \cdot \hat{c}_t^R + \overline{I}_t^Y/100 \cdot \hat{i}_t^R + \overline{X}_t^{NNR,Y}/100 \cdot \hat{x}_t^{R,NNR} + \overline{X}_t^{NR,Y}/100 \cdot \hat{x}_t^{R,NR} \\ &- \overline{M}_t^{NOIL,Y}/100 \cdot \hat{m}_t^{R,NOIL} - \overline{M}_t^{OIL,Y}/100 \cdot \hat{m}_t^{R,OIL} + \overline{G}_t^Y/100 \cdot \hat{g}_t^R\end{aligned} \tag{15}$$

Private consumption gap

$$\hat{c}_t^R = c_1^{\hat{c}^R} \cdot \hat{c}_{t-1}^R + c_2^{\hat{c}^R} \cdot \hat{c}_{t+1}^R - c_3^{\hat{c}^R} \cdot \hat{r}_t^R + c_4^{\hat{c}^R} \cdot \hat{y}_t^R - c_5^{\hat{c}^R} \cdot (\tau_t^C - \tau_{t+1}^C) + c_6^{\hat{c}^R} \cdot R\hat{E}M_t^Y + c_7^{\hat{c}^R} \cdot \widehat{GE}_t^{Tr,Y} + \varepsilon_t^{\hat{c}^R} \tag{16}$$

Expected private consumption gap

$$\hat{c}_t^{R,E} = \hat{c}_{t+1}^R \tag{17}$$

Potential real private consumption growth

$$\begin{aligned}\Delta\overline{c}_t^R &= c_1^{\Delta\overline{c}^R} \cdot \Delta\overline{c}_{t-1}^R + (1 - c_1^{\Delta\overline{c}^R}) \cdot (\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^R) \\ &- c_2^{\Delta\overline{c}^R} \cdot (\overline{C}_t^Y - (C^{Y,SS} - c_3^{\Delta\overline{c}^R} \cdot (\tau_t^C - \mathcal{S}(\tau^C)) \\ &+ c_4^{\Delta\overline{c}^R} \cdot (\overline{REM}_t^Y - REM^{Y,SS}) + c_5^{\Delta\overline{c}^R} \cdot (\overline{GE}_t^{Tr,Y} - \mathcal{S}(\overline{GE}^{Tr,Y})))) + \varepsilon_t^{\Delta\overline{c}^R}\end{aligned} \tag{18}$$

Real private consumption breakdown

$$c_t^R = \hat{c}_t^R + \overline{c}_t^R \tag{19}$$

Real private consumption level

$$c_t^R = 100 \cdot \log(C_t^R) \tag{20}$$

Potential real private consumption level

$$\overline{c}_t^R = 100 \cdot \log(\overline{C}_t^R) \tag{21}$$

Real private consumption growth identity

$$\Delta c_t^R = c_t^R - c_{t-1}^R \tag{22}$$

Potential real private consumption growth identity

$$\Delta\overline{c}_t^R = \overline{c}_t^R - \overline{c}_{t-1}^R \tag{23}$$

Potential private consumption to GDP ratio

$$\begin{aligned}\overline{C}_t^Y &= 100 \cdot (1 + \tau_t^C/100) \cdot \overline{C}_t^R/((1 + \tau_t^C/100) \cdot \overline{C}_t^R + P_t^{R,I} \cdot \overline{I}_t^R + \overline{P}_t^{R,X^{NNR}} \cdot \overline{X}_t^{R,NNR} + \overline{P}_t^{R,X^{NR}} \cdot \overline{X}_t^{R,NR} - \overline{P}_t^{R,M^{NOIL}} \cdot (1 + \\ &\tau_t^{M^{NOIL}}/100) \cdot \overline{M}_t^{R,NOIL} - \overline{P}_t^{R,M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100) \cdot \overline{M}_t^{R,OIL} + \overline{P}_t^{R,G} \cdot \overline{G}_t^R)\end{aligned} \tag{24}$$

Private consumption to GDP ratio

$$C_t^Y = 100 \cdot (P_t^C \cdot (1 + \tau_t^C/100)/P_t^Y) \cdot (C_t^R/Y_t^R) \tag{25}$$

Private investment Gap

$$\hat{i}_t^R = c_1^{\hat{i}^R} \cdot \hat{i}_{t-1}^R + c_2^{\hat{i}^R} \cdot \hat{i}_{t+1}^R - c_3^{\hat{i}^R} \cdot \hat{r}_t^R + c_4^{\hat{i}^R} \cdot \hat{c}_{t+1}^R + c_6^{\hat{i}^R} \cdot \hat{x}_{t+1}^{R,NNR} - c_5^{\hat{i}^R} \cdot (\hat{z}_t^{Mw} - \hat{p}_t^{R,I}) + \varepsilon_t^{\hat{i}^R} \tag{26}$$

Expected private investment gap

$$\hat{i}_t^{R,E} = \hat{i}_{t+1}^R \tag{27}$$

Table continues on the next page.

Potential real private investment growth

$$\Delta\bar{i}_t^R = c_1^{\Delta\bar{i}^R} \cdot \Delta\bar{i}_{t-1}^R + (1 - c_1^{\Delta\bar{i}^R}) \cdot (\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^R - \Delta\overline{p}_t^{R,I}) - c_2^{\Delta\bar{i}^R} \cdot (\overline{I}_t^Y - (I^{Y,SS} - c_3^{\Delta\bar{i}^R} \cdot (\overline{r}_t^R - (\overline{r}^{R,US,SS} + \gamma^{SS} + \Delta\overline{z}^{SS,US})) - c_4^{\Delta\bar{i}^R} \cdot (\tau_t^Y - \mathcal{S}(\tau^Y)))) + \varepsilon_t^{\Delta\bar{i}^R} \tag{28}$$

Potential private investment to GDP ratio

$$\overline{I}_t^Y = 100 \cdot P_t^{R,I} \cdot \overline{I}_t^R / ((1 + \tau_t^C/100) \cdot \overline{C}_t^R + P_t^{R,I} \cdot \overline{I}_t^R + \overline{P}_t^{R,X^{NNR}} \cdot \overline{X}_t^{R,NNR} + \overline{P}_t^{R,X^{NR}} \cdot \overline{X}_t^{R,NR} - \overline{P}_t^{R,M^{NOIL}} \cdot (1 + \tau_t^{M^{NOIL}}/100) \cdot \overline{M}_t^{R,NOIL} - \overline{P}_t^{R,M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100) \cdot \overline{M}_t^{R,OIL} + \overline{P}_t^{R,G} \cdot \overline{G}_t^R) \tag{29}$$

Private investment to GDP ratio

$$I_t^Y = 100 \cdot (P_t^I / P_t^Y) \cdot (I_t^R / Y_t^R) \tag{30}$$

Real private investment breakdown

$$i_t^R = \hat{i}_t^R + \bar{i}_t^R \tag{31}$$

Real private investment growth identity

$$\Delta i_t^R = i_t^R - i_{t-1}^R \tag{32}$$

Real private investment level

$$i_t^R = 100 \cdot \log(I_t^R) \tag{33}$$

Potential real private investment growth identity

$$\Delta\bar{i}_t^R = \bar{i}_t^R - \bar{i}_{t-1}^R \tag{34}$$

Potential real private investment level

$$\bar{i}_t^R = 100 \cdot \log(\overline{I}_t^R) \tag{35}$$

Total exports to GDP ratio

$$X_t^Y = X_t^{NNR,Y} + X_t^{NR,Y} \tag{36}$$

Potential total exports to GDP ratio

$$\overline{X}_t^Y = \overline{X}_t^{NNR,Y} + \overline{X}_t^{NR,Y} \tag{37}$$

NNR export gap

$$\hat{x}_t^{R,NNR} = c_1^{\hat{x}^{R,NNR}} \cdot \hat{x}_{t-1}^{R,NNR} + c_2^{\hat{x}^{R,NNR}} \cdot \hat{x}_{t+1}^{R,NNR} + c_3^{\hat{x}^{R,NNR}} \cdot (\hat{z}_t^{Xw} - \hat{p}_t^{R,X^{NNR}}) + c_4^{\hat{x}^{R,NNR}} \cdot \hat{y}_t^{R,*} + \varepsilon_t^{\hat{x}^{R,NNR}} \tag{38}$$

Expected NNR exports gap

$$\hat{x}_t^{R,NNR,E} = \hat{x}_{t+1}^{R,NNR} \tag{39}$$

Potential real NNR exports growth

$$\Delta\overline{x}_t^{R,NNR} = c_1^{\Delta\overline{x}^{R,NNR}} \cdot \Delta\overline{x}_{t-1}^{R,NNR} + (1 - c_1^{\Delta\overline{x}^{R,NNR}}) \cdot (\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^R - \Delta\overline{p}_t^{R,X^{NNR}}) - c_2^{\Delta\overline{x}^{R,NNR}} \cdot (\overline{X}_t^{NNR,Y} - (X^{NNR,Y,SS} + c_3^{\Delta\overline{x}^{R,NNR}} \cdot \overline{X}_t^{R,NNR,S})) + \varepsilon_t^{\Delta\overline{x}^{R,NNR}} \tag{40}$$

Proxy for potential NNR exports demand

$$\overline{X}_t^{R,NNR,S} = c_1^{\overline{X}^{R,NNR,S}} \cdot \overline{X}_{t-1}^{R,NNR,S} + c_2^{\overline{X}^{R,NNR,S}} \cdot (\Delta\overline{p}_t^{R,X^{NNR}} - \mathcal{S}(\Delta\overline{p}^{R,X^{NNR}})) + (1 - c_2^{\overline{X}^{R,NNR,S}}) \cdot (\Delta\overline{y}_t^{R,*} - \mathcal{S}(\Delta\overline{y}^{R,*})) + \varepsilon_t^{\overline{X}^{R,NNR,S}} \tag{41}$$

Potential NNR exports to GDP ratio

$$\overline{X}_t^{NNR,Y} = 100 \cdot \overline{P}_t^{R,X^{NNR}} \cdot \overline{X}_t^{R,NNR} / ((1 + \tau_t^C/100) \cdot \overline{C}_t^R + P_t^{R,I} \cdot \overline{I}_t^R + \overline{P}_t^{R,X^{NNR}} \cdot \overline{X}_t^{R,NNR} + \overline{P}_t^{R,X^{NR}} \cdot \overline{X}_t^{R,NR} - \overline{P}_t^{R,M^{NOIL}} \cdot (1 + \tau_t^{M^{NOIL}}/100) \cdot \overline{M}_t^{R,NOIL} - \overline{P}_t^{R,M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100) \cdot \overline{M}_t^{R,OIL} + \overline{P}_t^{R,G} \cdot \overline{G}_t^R) \tag{42}$$

Table continues on the next page.

NNR exports to GDP ratio

$$X_t^{NNR,Y} = 100 \cdot (P_t^{X^{NNR}}/P_t^{Y}) \cdot (X_t^{R,NNR}/Y_t^{R}) \tag{43}$$

Real NNR exports breakdown

$$x_t^{R,NNR} = \hat{x}_t^{R,NNR} + \overline{x}_t^{R,NNR} \tag{44}$$

Real NNR exports growth identity

$$\Delta x_t^{R,NNR} = x_t^{R,NNR} - x_{t-1}^{R,NNR} \tag{45}$$

Real NNR exports level

$$x_t^{R,NNR} = 100 \cdot \log(X_t^{R,NNR}) \tag{46}$$

Potential real NNR exports growth identity

$$\Delta\overline{x}_t^{R,NNR} = \overline{x}_t^{R,NNR} - \overline{x}_{t-1}^{R,NNR} \tag{47}$$

Potential real NNR exports level

$$\overline{x}_t^{R,NNR} = 100 \cdot \log(\overline{X}_t^{R,NNR}) \tag{48}$$

Natural-resource real exports gap

$$\hat{x}_t^{R,NR} = c_1^{\hat{x}^{R,NR}} \cdot \hat{x}_{t-1}^{R,NR} + c_2^{\hat{x}^{R,NR}} \cdot \hat{p}_t^{R,X^{NR}} + \varepsilon_t^{\hat{x}^{R,NR}} \tag{49}$$

Potential natural-resource real exports growth

$$\Delta\overline{x}_t^{R,NR} = c_1^{\Delta\overline{x}^{R,NR}} \cdot \Delta\overline{x}_{t-1}^{R,NR} + (1 - c_1^{\Delta\overline{x}^{R,NR}}) \cdot (\Delta\overline{p}_t^{R,Y} - \Delta\overline{p}_t^{R,X^{NR}} + \Delta\overline{y}_t^{R}) - c_2^{\Delta\overline{x}^{R,NR}} \cdot (\overline{X}_t^{NR,Y} - (X^{NR,Y,SS} + c_4^{\Delta\overline{x}^{R,NR}} \cdot \overline{X}_t^{R,NR,S} - c_3^{\Delta\overline{x}^{R,NR}} \cdot (\tau_t^{NR} - \mathcal{S}(\tau^{NR})))) + \varepsilon_t^{\Delta\overline{x}^{R,NR}} \tag{50}$$

$$\overline{X}_t^{R,NR,S} = c_1^{\overline{X}^{R,NR,S}} \cdot \overline{X}_{t-1}^{R,NR,S} + (\Delta\overline{p}_t^{R,X^{NR}} - \mathcal{S}(\Delta\overline{p}^{R,X^{NR}})) + \varepsilon_t^{\overline{X}^{R,NR,S}} \tag{51}$$

Potential NR exports to GDP ratio

$$\overline{X}_t^{NR,Y} = 100 \cdot \overline{P}_t^{R,X^{NR}} \cdot \overline{X}_t^{R,NR}/((1 + \tau_t^{C}/100) \cdot \overline{C}_t^{R} + P_t^{R,I} \cdot \overline{I}_t^{R} + \overline{P}_t^{R,X^{NNR}} \cdot \overline{X}_t^{R,NNR} + \overline{P}_t^{R,X^{NR}} \cdot \overline{X}_t^{R,NR} - \overline{P}_t^{R,M^{NOIL}} \cdot (1 + \tau_t^{M^{NOIL}}/100) \cdot \overline{M}_t^{R,NOIL} - \overline{P}_t^{R,M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100) \cdot \overline{M}_t^{R,OIL} + \overline{P}_t^{R,G} \cdot \overline{G}_t^{R}) \tag{52}$$

NR exports to GDP ratio

$$X_t^{NR,Y} = 100 \cdot (P_t^{X^{NR}}/P_t^{Y}) \cdot (X_t^{R,NR}/Y_t^{R}) \tag{53}$$

Real NR exports breakdown

$$x_t^{R,NR} = \overline{x}_t^{R,NR} + \hat{x}_t^{R,NR} \tag{54}$$

Real NR exports growth identity

$$\Delta x_t^{R,NR} = x_t^{R,NR} - x_{t-1}^{R,NR} \tag{55}$$

Real NR exports level

$$x_t^{R,NR} = 100 \cdot \log(X_t^{R,NR}) \tag{56}$$

Potential real NR exports growth identity

$$\Delta\overline{x}_t^{R,NR} = \overline{x}_t^{R,NR} - \overline{x}_{t-1}^{R,NR} \tag{57}$$

Potential real NR exports level

$$\overline{x}_t^{R,NR} = 100 \cdot \log(\overline{X}_t^{R,NR}) \tag{58}$$

NR exports producers profit

$$G_t^{NR,Y} = 100 \cdot ((P_t^{X^{NR}} - c_1^{G^{NR,Y}} \cdot P_t^{X^{NR},MAVG})/P_t^{Y}) \cdot (X_t^{R,NR}/Y_t^{R}) \tag{59}$$

Table continues on the next page.

Equilibrium NR exports producers profit

$$\overline{G}_t^{NR,Y} = (1 - c_1^{G^{NR,Y}}) \cdot \overline{X}_t^{NR,Y} \tag{60}$$

Total imports to GDP ratio

$$M_t^Y = M_t^{NOIL,Y} + M_t^{OIL,Y} \tag{61}$$

Non-oil import Gap

$$\hat{m}_t^{R,NOIL} = c_1^{\hat{m}^{R,NOIL}} \cdot \hat{m}_{t-1}^{R,NOIL} + c_2^{\hat{m}^{R,NOIL}} \cdot \hat{x}_t^{R,NNR} + c_3^{\hat{m}^{R,NOIL}} \cdot \hat{i}_t^R + c_4^{\hat{m}^{R,NOIL}} \cdot \hat{c}_t^R - c_5^{\hat{m}^{R,NOIL}} \cdot \hat{p}_t^{R,M^{NOIL}} - c_6^{\hat{m}^{R,NOIL}} \cdot (\hat{p}_t^{R,M^{NOIL}} - \hat{p}_t^{R,I}) + c_7^{\hat{m}^{R,NOIL}} \cdot \hat{g}_t^R - c_8^{\hat{m}^{R,NOIL}} \cdot (\tau_t^{M^{NOIL}} - \tau_{t+1}^{M^{NOIL}}) + \varepsilon_t^{\hat{m}^{R,NOIL}} \tag{62}$$

Expected non-oil imports gap

$$\hat{m}_t^{R,NOIL,E} = \hat{m}_{t+1}^{R,NOIL} \tag{63}$$

Potential real non-oil imports growth

$$\Delta\overline{m}_t^{R,NOIL} = c_1^{\Delta\overline{m}^{R,NOIL}} \cdot \Delta\overline{m}_{t-1}^{R,NOIL} + (1 - c_1^{\Delta\overline{m}^{R,NOIL}}) \cdot (\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^R - \Delta\overline{p}_t^{R,M^{NOIL}}) - c_2^{\Delta\overline{m}^{R,NOIL}} \cdot (\overline{M}_t^{NOIL,Y} - (M_t^{NOIL,Y,SS} + c_3^{\Delta\overline{m}^{R,NOIL}} \cdot \overline{M}_t^{R,NOIL,D} + c_4^{\Delta\overline{m}^{R,NOIL}} \cdot (\overline{C}_t^Y - C^{Y,SS}) + c_5^{\Delta\overline{m}^{R,NOIL}} \cdot (\overline{I}_t^Y - I^{Y,SS}) + c_6^{\Delta\overline{m}^{R,NOIL}} \cdot (\overline{X}_t^{NNR,Y} - X^{NNR,Y,SS}) + c_7^{\Delta\overline{m}^{R,NOIL}} \cdot (\overline{X}_t^{NR,Y} - X^{NR,Y,SS}) + c_8^{\Delta\overline{m}^{R,NOIL}} \cdot (\overline{G}_t^Y - \mathcal{S}(G^Y)) - c_9^{\Delta\overline{m}^{R,NOIL}} \cdot (\tau_t^{M^{NOIL}} - \mathcal{S}(\tau^{M^{NOIL}})))) + \varepsilon_t^{\Delta\overline{m}^{R,NOIL}} \tag{64}$$

Proxy for potential non-oil imports demand

$$\overline{M}_t^{R,NOIL,D} = c_1^{\overline{M}^{R,NOIL,D}} \cdot \overline{M}_{t-1}^{R,NOIL,D} - (\Delta\overline{p}_t^{R,M^{NOIL}} - \mathcal{S}(\Delta\overline{p}^{R,M^{NOIL}})) + \varepsilon_t^{\overline{M}^{R,NOIL,D}} \tag{65}$$

Potential non-oil imports to GDP ratio

$$\overline{M}_t^{NOIL,Y} = 100 \cdot \overline{P}_t^{R,M^{NOIL}} \cdot (1 + \tau_t^{M^{NOIL}}/100) \cdot \overline{M}_t^{R,NOIL}/((1 + \tau_t^C/100) \cdot \overline{C}_t^R + P_t^{R,I} \cdot \overline{I}_t^R + \overline{P}_t^{R,X^{NNR}} \cdot \overline{X}_t^{R,NNR} + \overline{P}_t^{R,X^{NR}} \cdot \overline{X}_t^{R,NR} - \overline{P}_t^{R,M^{NOIL}} \cdot (1 + \tau_t^{M^{NOIL}}/100) \cdot \overline{M}_t^{R,NOIL} - \overline{P}_t^{R,M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100) \cdot \overline{M}_t^{R,OIL} + \overline{P}_t^{R,G} \cdot \overline{G}_t^R) \tag{66}$$

Steady state of non-oil imports to GDP ratio

$$M_t^{NOIL,Y,SS} = (C^{Y,SS} + I^{Y,SS} + \mathcal{S}(G^Y) + X^{NNR,Y,SS} + X^{NR,Y,SS} - M^{OIL,Y,SS}) - 100 \tag{67}$$

Non-oil imports to GDP ratio

$$M_t^{NOIL,Y} = 100 \cdot (P_t^{M^{NOIL}} \cdot (1 + \tau_t^{M^{NOIL}}/100)/P_t^Y) \cdot (M_t^{R,NOIL}/Y_t^R) \tag{68}$$

Real non-oil imports breakdown

$$m_t^{R,NOIL} = \hat{m}_t^{R,NOIL} + \overline{m}_t^{R,NOIL} \tag{69}$$

Real non-oil imports growth identity

$$\Delta m_t^{R,NOIL} = m_t^{R,NOIL} - m_{t-1}^{R,NOIL} \tag{70}$$

Real non-oil imports level

$$m_t^{R,NOIL} = 100 \cdot \log(M_t^{R,NOIL}) \tag{71}$$

Potential real non-oil imports growth identity

$$\Delta\overline{m}_t^{R,NOIL} = \overline{m}_t^{R,NOIL} - \overline{m}_{t-1}^{R,NOIL} \tag{72}$$

Potential real non-oil imports level

$$\overline{m}_t^{R,NOIL} = 100 \cdot \log(\overline{M}_t^{R,NOIL}) \tag{73}$$

Oil import Gap

$$\hat{m}_t^{R,OIL} = c_1^{\hat{m}^{R,OIL}} \cdot \hat{m}_{t-1}^{R,OIL} + c_2^{\hat{m}^{R,OIL}} \cdot \hat{x}_t^{R,NNR} + c_3^{\hat{m}^{R,OIL}} \cdot \hat{i}_t^R + c_4^{\hat{m}^{R,OIL}} \cdot \hat{c}_t^R - c_5^{\hat{m}^{R,OIL}} \cdot \hat{p}_t^{R,M^{OIL}} - c_6^{\hat{m}^{R,OIL}} \cdot (\hat{p}_t^{R,M^{OIL}} - \hat{p}_t^{R,I}) + c_7^{\hat{m}^{R,OIL}} \cdot \hat{g}_t^R - c_8^{\hat{m}^{R,OIL}} \cdot (\tau_t^{M^{OIL}} - \tau_{t+1}^{M^{OIL}}) + \varepsilon_t^{\hat{m}^{R,NOIL}} \tag{74}$$

Table continues on the next page.

Expected oil imports gap
$$\hat{m}_t^{R,OIL,E} = \hat{m}_{t+1}^{R,OIL} \tag{75}$$

Potential real oil imports growth
$$\Delta\overline{m}_t^{R,OIL} = c_1^{\Delta\overline{m}^{R,OIL}} \cdot \Delta\overline{m}_{t-1}^{R,OIL} + (1 - c_1^{\Delta\overline{m}^{R,OIL}}) \cdot (\Delta\overline{p}_t^{R,Y} + \Delta\overline{y}_t^{R} - \Delta\overline{p}_t^{R,M^{OIL}}) - c_2^{\Delta\overline{m}^{R,OIL}} \cdot (\overline{M}_t^{OIL,Y} - (M^{OIL,Y,SS} + c_3^{\Delta\overline{m}^{R,OIL}} \cdot \overline{M}_t^{R,OIL,D} + c_4^{\Delta\overline{m}^{R,OIL}} \cdot (\overline{C}_t^{Y} - C^{Y,SS}) + c_5^{\Delta\overline{m}^{R,OIL}} \cdot (\overline{I}_t^{Y} - I^{Y,SS}) + c_6^{\Delta\overline{m}^{R,OIL}} \cdot (\overline{X}_t^{NNR,Y} - X^{NNR,Y,SS}) + c_7^{\Delta\overline{m}^{R,OIL}} \cdot (\overline{X}_t^{NR,Y} - X^{NR,Y,SS}) + c_8^{\Delta\overline{m}^{R,OIL}} \cdot (\overline{G}_t^{Y} - \mathcal{S}(G^{Y})) - c_9^{\Delta\overline{m}^{R,OIL}} \cdot (\tau_t^{M^{OIL}} - \mathcal{S}(\tau^{M^{OIL}})))) + \varepsilon_t^{\Delta\overline{m}^{R,NOIL}} \tag{76}$$

Proxy for potential oil imports demand
$$\overline{M}_t^{R,OIL,D} = c_1^{\overline{M}^{R,OIL,D}} \cdot \overline{M}_{t-1}^{R,OIL,D} - (\Delta\overline{p}_t^{R,M^{OIL}} - \mathcal{S}(\Delta\overline{p}^{R,M^{OIL}})) + \varepsilon_t^{\overline{M}^{R,NOIL,D}} \tag{77}$$

Potential oil imports to GDP ratio
$$\overline{M}_t^{OIL,Y} = 100 \cdot \overline{P}_t^{R,M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100) \cdot \overline{M}_t^{R,OIL}/((1 + \tau_t^{C}/100) \cdot \overline{C}_t^{R} + P_t^{R,I} \cdot \overline{I}_t^{R} + \overline{P}_t^{R,X^{NNR}} \cdot \overline{X}_t^{R,NNR} + \overline{P}_t^{R,X^{NR}} \cdot \overline{X}_t^{R,NR} - \overline{P}_t^{R,M^{NOIL}} \cdot (1 + \tau_t^{M^{NOIL}}/100) \cdot \overline{M}_t^{R,NOIL} - \overline{P}_t^{R,M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100) \cdot \overline{M}_t^{R,OIL} + \overline{P}_t^{R,G} \cdot \overline{G}_t^{R}) \tag{78}$$

Oil imports to GDP ratio
$$M_t^{OIL,Y} = 100 \cdot (P_t^{M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100)/P_t^{Y}) \cdot (M_t^{R,OIL}/Y_t^{R}) \tag{79}$$

Real oil imports breakdown
$$m_t^{R,OIL} = \hat{m}_t^{R,OIL} + \overline{m}_t^{R,OIL} \tag{80}$$

Real oil imports growth identity
$$\Delta m_t^{R,OIL} = m_t^{R,OIL} - m_{t-1}^{R,OIL} \tag{81}$$

Real oil imports level
$$m_t^{R,OIL} = 100 \cdot \log(M_t^{R,OIL}) \tag{82}$$

Potential real oil imports growth identity
$$\Delta\overline{m}_t^{R,OIL} = \overline{m}_t^{R,OIL} - \overline{m}_{t-1}^{R,OIL} \tag{83}$$

Potential real oil imports level
$$\overline{m}_t^{R,OIL} = 100 \cdot \log(\overline{M}_t^{R,OIL}) \tag{84}$$

Potential government absorption to GDP ratio
$$\overline{G}_t^{Y} = 100 \cdot \overline{P}_t^{R,G} \cdot \overline{G}_t^{R}/((1 + \tau_t^{C}/100) \cdot \overline{C}_t^{R} + P_t^{R,I} \cdot \overline{I}_t^{R} + \overline{P}_t^{R,X^{NNR}} \cdot \overline{X}_t^{R,NNR} + \overline{P}_t^{R,X^{NR}} \cdot \overline{X}_t^{R,NR} - \overline{P}_t^{R,M^{NOIL}} \cdot (1 + \tau_t^{M^{NOIL}}/100) \cdot \overline{M}_t^{R,NOIL} - \overline{P}_t^{R,M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100) \cdot \overline{M}_t^{R,OIL} + \overline{P}_t^{R,G} \cdot \overline{G}_t^{R}) \tag{85}$$

Government absorption to GDP ratio
$$G_t^{Y} = 100 \cdot (P_t^{G}/P_t^{Y}) \cdot (G_t^{R}/Y_t^{R}) \tag{86}$$

Real government absorption breakdown
$$g_t^{R} = \hat{g}_t^{R} + \overline{g}_t^{R} \tag{87}$$

Expected government absorption gap
$$\hat{g}_t^{R,E} = \hat{g}_{t+1}^{R} \tag{88}$$

Real government absorption growth identity
$$\Delta g_t^{R} = g_t^{R} - g_{t-1}^{R} \tag{89}$$

Real government absorption level
$$g_t^{R} = 100 \cdot \log(G_t^{R}) \tag{90}$$

Potential real government absorption growth identity

Table continues on the next page.

$$\Delta\overline{g}_t^R = \overline{g}_t^R - \overline{g}_{t-1}^R \qquad (91)$$

Potential real government absorption level
$$\overline{g}_t^R = 100 \cdot \log(\overline{G}_t^R) \qquad (92)$$

Nominal GDP identity
$$Y_t = P_t^{C,T} \cdot C_t^R + P_t^I \cdot I_t^R + P_t^{X^{NNR}} \cdot X_t^{R,NNR} + P_t^{X^{NR}} \cdot X_t^{R,NR} - P_t^{M^{NOIL},T} \cdot M_t^{R,NOIL} - P_t^{M^{OIL},T} \cdot M_t^{R,OIL} + P_t^G \cdot G_t^R \qquad (93)$$

Nominal GDP level
$$y_t = 100 \cdot \log(Y_t) \qquad (94)$$

Nominal GDP growth
$$\Delta y_t = y_t - y_{t-1} \qquad (95)$$

Equilibrium nominal GDP growth
$$\Delta\overline{y}_t = \Delta\overline{y}_t^R + \Delta\overline{p}_t^{R,Y} + \overline{\pi}_t^C \qquad (96)$$

GDP deflator
$$Y_t = Y_t^R \cdot P_t^Y \qquad (97)$$

Log of GDP deflator
$$p_t^Y = 100 \cdot \log(P_t^Y) \qquad (98)$$

GDP deflator inflation
$$\pi_t^Y = p_t^Y - p_{t-1}^Y \qquad (99)$$

Equilibrium relative price of GDP to consumption
$$\overline{P}_t^{R,Y} \cdot \overline{Y}_t^R = \overline{C}_t^R + P_t^{R,I} \cdot \overline{I}_t^R + \overline{P}_t^{R,X^{NNR}} \cdot \overline{X}_t^{R,NNR} + \overline{P}_t^{R,X^{NR}} \cdot \overline{X}_t^{R,NR} - \overline{P}_t^{R,M^{NOIL}} \cdot \overline{M}_t^{R,NOIL} - \overline{P}_t^{R,M^{OIL}} \cdot \overline{M}_t^{R,OIL} + \overline{P}_t^{R,G} \cdot \overline{G}_t^R \qquad (100)$$

Equilibrium relative price of GDP to consumption level
$$\overline{p}_t^{R,Y} = 100 \cdot \log(\overline{P}_t^{R,Y}) \qquad (101)$$

Equilibrium relative price inflation of GDP to consumption
$$\Delta\overline{p}_t^{R,Y} = \overline{p}_t^{R,Y} - \overline{p}_{t-1}^{R,Y} \qquad (102)$$

Consumption goods Phillips Curve
$$\pi_t^C = c_1^{\pi^C} \cdot \pi_{t-1}^C + (1 - c_1^{\pi^C}) \cdot \pi_{t+1}^C + c_2^{\pi^C} \cdot \hat{p}_t^{R,M^{NOIL}} + c_3^{\pi^C} \cdot \hat{p}_t^{R,M^{OIL}} + c_4^{\pi^C} \cdot \hat{c}_t^R + c_5^{\pi^C} \cdot \hat{p}_t^{R,I} + \varepsilon_t^{\pi^C} \qquad (103)$$

Consumption inflation definition - before tax
$$\pi_t^C = p_t^C - p_{t-1}^C \qquad (104)$$

Expected consumption inflation - before tax
$$\pi_t^{C,E} = \pi_{t+1}^C \qquad (105)$$

Consumption prices level - before tax
$$p_t^C = 100 \cdot \log(P_t^C) \qquad (106)$$

Consumption inflation definition
$$\pi_t^{C,T} = p_t^{C,T} - p_{t-1}^{C,T} \qquad (107)$$

Consumption prices level
$$p_t^{C,T} = 100 \cdot \log(P_t^{C,T}) \qquad (108)$$

Consumption prices definition
$$P_t^{C,T} = P_t^C \cdot (1 + \tau_t^C/100) \qquad (109)$$

Table continues on the next page.

Investment goods Phillips Curve

$$\pi_t^I = c_1^{\pi^I} \cdot \pi_{t-1}^I + (1 - c_1^{\pi^I}) \cdot \pi_{t+1}^I + c_2^{\pi^I} \cdot (\hat{p}_t^{R,M^{NOIL}} - \hat{p}_t^{R,I}) + c_3^{\pi^I} \cdot (\hat{p}_t^{R,M^{OIL}} - \hat{p}_t^{R,I}) + c_4^{\pi^I} \cdot \hat{i}_t^R - c_5^{\pi^I} \cdot \hat{p}_{t+1}^{R,I} + \varepsilon_t^{\pi^I} \quad (110)$$

Investment inflation definition

$$\pi_t^I = p_t^I - p_{t-1}^I \quad (111)$$

Expected investment inflation

$$\pi_t^{I,E} = \pi_{t+1}^I \quad (112)$$

Investment prices level

$$p_t^I = 100 \cdot \log(P_t^I) \quad (113)$$

Relative price of investment breakdown

$$p_t^{R,I} = \hat{p}_t^{R,I} + \overline{p}_t^{R,I} \quad (114)$$

Relative price of investment definition

$$p_t^{R,I} = p_t^I - p_t^C \quad (115)$$

Equilibrium relative price of investment dynamics

$$\Delta\overline{p}_t^{R,I} = c_1^{\Delta\overline{p}^{R,I}} \cdot \Delta\overline{p}_{t-1}^{R,I} + (1 - c_1^{\Delta\overline{p}^{R,I}}) \cdot \Delta\overline{p}^{R,G,SS} + \varepsilon_t^{\Delta\overline{p}^{R,I}} \quad (116)$$

Equilibrium relative price of investment definition

$$\Delta\overline{p}_t^{R,I} = \overline{p}_t^{R,I} - \overline{p}_{t-1}^{R,I} \quad (117)$$

Equilibrium relative price of investment level

$$\overline{p}_t^{R,I} = 100 \cdot \log(P_t^{R,I}) \quad (118)$$

NNR export goods Phillips Curve

$$\pi_t^{X^{NNR}} = \Delta\overline{p}_t^{R,X^{NNR}} + \overline{\pi}_t^C + c_1^{\pi^{X^{NNR}}} \cdot (\pi_t^{C,Xw,*} + \Delta s_t^{US} - (\Delta\overline{z}_t^{Xw} + \overline{\pi}_t^C)) + c_2^{\pi^{X^{NNR}}} \cdot \hat{x}_t^{R,NNR} - c_3^{\pi^{X^{NNR}}} \cdot \hat{p}_{t+1}^{R,X^{NNR}} + \varepsilon_t^{\pi^{X^{NNR}}} \quad (119)$$

NNR exports inflation definition

$$\pi_t^{X^{NNR}} = p_t^{X^{NNR}} - p_{t-1}^{X^{NNR}} \quad (120)$$

Expected NNR exports inflation

$$pi_t^{X^{NNR},E} = \pi_{t+1}^{X^{NNR}} \quad (121)$$

NNR exports prices level

$$p_t^{X^{NNR}} = 100 \cdot \log(P_t^{X^{NNR}}) \quad (122)$$

Relative price of NNR exports definition

$$p_t^{R,X^{NNR}} = p_t^{X^{NNR}} - p_t^C \quad (123)$$

Relative price of NNR exports breakdown

$$p_t^{R,X^{NNR}} = \hat{p}_t^{R,X^{NNR}} + \overline{p}_t^{R,X^{NNR}} \quad (124)$$

Expected NNR exports relative price gap

$$\hat{p}_t^{R,X^{NNR},E} = \hat{p}_{t+1}^{R,X^{NNR}} \quad (125)$$

Equilibrium relative price of NNR exports dynamics

$$\Delta\overline{p}_t^{R,X^{NNR}} = 1 \cdot (\Delta\overline{z}_t^{Xw} - \mathcal{S}(\Delta\overline{z}^{Xw})) + \Delta\overline{p}^{R,X^{NNR},SS} + \varepsilon_t^{\Delta\overline{p}^{R,X^{NNR}}} \quad (126)$$

Equilibrium relative price of NNR exports definition

Table continues on the next page.

$$\Delta\overline{p}_t^{R,X^{NNR}} = \overline{p}_t^{R,X^{NNR}} - \overline{p}_{t-1}^{R,X^{NNR}} \tag{127}$$

Equilibrium relative price of NNR exports level

$$\overline{p}_t^{R,X^{NNR}} = 100 \cdot \log(\overline{P}_t^{R,X^{NNR}}) \tag{128}$$

NR export goods Phillips Curve

$$\pi_t^{X^{NR}} = \Delta\overline{p}_t^{R,X^{NR}} + \overline{\pi}_t^C + c_1^{\pi^{X^{NR}}} \cdot (\pi_t^{NR,*} + \Delta s_t^{US} - (\Delta p^{R,NR,*,SS} + \Delta\overline{z}_t^{US} + \overline{\pi}_t^C)) - c_2^{\pi^{X^{NR}}} \cdot \hat{p}_{t+1}^{R,X^{NR}} + \varepsilon_t^{\pi^{X^{NR}}} \tag{129}$$

NR exports inflation definition

$$\pi_t^{X^{NR}} = p_t^{X^{NR}} - p_{t-1}^{X^{NR}} \tag{130}$$

NR exports prices level

$$p_t^{X^{NR}} = 100 \cdot \log(P_t^{X^{NR}}) \tag{131}$$

Moving average of NR exports prices definition

$$P_t^{x^{NR},MAVG} = (p_{t-1}^{X^{NR}} + p_t^{X^{NR}} + p_{t+1}^{X^{NR}} + p_{t+2}^{X^{NR}})/4 - (\Delta\overline{p}_t^{R,X^{NR}} + \overline{\pi}_t^C)/2 \tag{132}$$

Moving average of NR exports prices level

$$P_t^{x^{NR},MAVG} = 100 \cdot \log(P_t^{X^{NR},MAVG}) \tag{133}$$

Relative price of NR exports definition

$$p_t^{R,X^{NR}} = p_t^{X^{NR}} - p_t^C \tag{134}$$

Relative price of NR exports breakdown

$$p_t^{R,X^{NR}} = \hat{p}_t^{R,X^{NR}} + \overline{p}_t^{R,X^{NR}} \tag{135}$$

Expected NR exports relative price gap

$$\hat{p}_t^{R,X^{NR},E} = \hat{p}_{t+1}^{R,X^{NR}} \tag{136}$$

Equilibrium relative price of NR exports dynamics

$$\Delta\overline{p}_t^{R,X^{NR}} = c_1^{\Delta\overline{p}^{R,X^{NR}}} \cdot (\Delta\overline{p}_t^{R,NR,*} + \Delta\overline{z}_t^{US} - \mathcal{S}(\Delta\overline{p}^{R,NR,*}) - \mathcal{S}(\Delta\overline{z}^{US})) + \Delta\overline{p}^{R,X^{NNR},SS} + \varepsilon_t^{\Delta\overline{p}^{R,X^{NR}}} \tag{137}$$

Equilibrium relative price of NR exports definition

$$\Delta\overline{p}_t^{R,X^{NR}} = \overline{p}_t^{R,X^{NR}} - \overline{p}_{t-1}^{R,X^{NR}} \tag{138}$$

Equilibrium relative price of NR exports level

$$\overline{p}_t^{R,X^{NR}} = 100 \cdot \log(\overline{P}_t^{R,X^{NR}}) \tag{139}$$

Non-oil import goods Phillips Curve

$$\pi_t^{M^{NOIL}} = \Delta\overline{p}_t^{R,M^{NOIL}} + \overline{\pi}_t^C + c_1^{\pi^{M^{NOIL}}} \cdot (\pi_t^{C,Mw,*} + \Delta s_t^{US} - (\Delta\overline{z}_t^{Mw} + \overline{\pi}_t^C)) - c_2^{\pi^{M^{NOIL}}} \cdot \hat{p}_{t+1}^{R,M^{NOIL}} + \varepsilon_t^{\pi^{M^{NOIL}}} \tag{140}$$

Non-oil imports inflation definition - before tax

$$\pi_t^{M^{NOIL}} = p_t^{M^{NOIL}} - p_{t-1}^{M^{NOIL}} \tag{141}$$

Expected non-oil imports inflation - before tax

$$\pi_t^{M^{NOIL},E} = \pi_{t+1}^{M^{NOIL}} \tag{142}$$

Non-oil imports prices level - before tax

$$p_t^{M^{NOIL}} = 100 \cdot \log(P_t^{M^{NOIL}}) \tag{143}$$

Table continues on the next page.

Non-oil imports inflation definition
$$\pi_t^{M^{NOIL},T} = p_t^{M^{NOIL},T} - p_{t-1}^{M^{NOIL},T} \tag{144}$$

Non-oil imports prices level
$$p_t^{M^{NOIL},T} = 100 \cdot \log(P_t^{M^{NOIL},T}) \tag{145}$$

Non-oil imports prices definition
$$P_t^{M^{NOIL},T} = P_t^{M^{NOIL}} \cdot (1 + \tau_t^{M^{NOIL}}/100) \tag{146}$$

Relative price of non-oil imports breakdown
$$P_t^{R,M^{NOIL}} = \hat{p}_t^{R,M^{NOIL}} + \overline{p}_t^{R,M^{NOIL}} \tag{147}$$

Expected non-oil imports relative price gap
$$\hat{p}_t^{R,M^{NOIL},E} = \hat{p}_{t+1}^{R,M^{NOIL}} \tag{148}$$

Relative price of non-oil imports definition
$$P_t^{R,M^{NOIL}} = p_t^{M^{NOIL}} - p_t^C \tag{149}$$

Equilibrium relative price of non-oil imports dynamics
$$\Delta\overline{p}_t^{R,M^{NOIL}} = c_1^{\Delta\overline{p}^{R,M^{NOIL}}} \cdot (\Delta\overline{z}_t^{Mw} - \mathcal{S}(\Delta\overline{z}^{Mw})) + \Delta\overline{p}^{R,M^{NOIL},SS} + \varepsilon_t^{\Delta\overline{p}^{R,M^{NOIL}}} \tag{150}$$

Equilibrium relative price of non-oil imports definition
$$\Delta\overline{p}_t^{R,M^{NOIL}} = \overline{p}_t^{R,M^{NOIL}} - \overline{p}_{t-1}^{R,M^{NOIL}} \tag{151}$$

Equilibrium relative price of non-oil imports level
$$\overline{p}_t^{R,M^{NOIL}} = 100 \cdot \log(\overline{P}_t^{R,M^{NOIL}}) \tag{152}$$

Oil import goods Phillips Curve
$$\pi_t^{M^{OIL}} = \Delta\overline{p}_t^{R,M^{OIL}} + \overline{\pi}_t^C + c_1^{\pi^{M^{OIL}}} \cdot (\pi_t^{oil,*} + \Delta s_t^{US} - (\Delta p^{R,oil,*,SS} + \Delta\overline{z}_t^{US} + \overline{\pi}_t^C)) - c_2^{\pi^{M^{OIL}}} \cdot \hat{p}_{t+1}^{R,M^{OIL}} + \varepsilon_t^{\pi^{M^{OIL}}} \tag{153}$$

Oil imports inflation definition - before tax
$$\pi_t^{M^{OIL}} = p_t^{M^{OIL}} - p_{t-1}^{M^{OIL}} \tag{154}$$

Expected oil imports inflation - before tax
$$\pi_t^{M^{OIL},E} = \pi_{t+1}^{M^{OIL}} \tag{155}$$

Oil imports prices level - before tax
$$p_t^{M^{OIL}} = 100 \cdot \log(P_t^{M^{OIL}}) \tag{156}$$

Oil imports inflation definition
$$\pi_t^{M^{OIL},T} = p_t^{M^{OIL},T} - p_{t-1}^{M^{OIL},T} \tag{157}$$

Oil imports prices level
$$p_t^{M^{OIL},T} = 100 \cdot \log(P_t^{M^{OIL},T}) \tag{158}$$

Oil imports prices definition
$$P_t^{M^{OIL},T} = P_t^{M^{OIL}} \cdot (1 + \tau_t^{M^{OIL}}/100) \tag{159}$$

Relative price of oil imports breakdown
$$P_t^{R,M^{OIL}} = \hat{p}_t^{R,M^{OIL}} + \overline{p}_t^{R,M^{OIL}} \tag{160}$$

Table continues on the next page.

Expected oil imports relative price gap $\hat{p}_t^{R,M^{OIL},E} = \hat{p}_{t+1}^{R,M^{OIL}}$	(161)
Relative price of oil imports definition $P_t^{R,M^{OIL}} = p_t^{M^{OIL}} - p_t^{C}$	(162)
Equilibrium relative price of oil imports dynamics $\Delta\overline{p}_t^{R,M^{OIL}} = c_1^{\Delta\overline{p}^{R,M^{OIL}}} \cdot (\Delta\overline{p}_t^{R,oil,*} + \Delta\overline{z}_t^{US} - \mathcal{S}(\Delta\overline{p}^{R,oil,*}) - \mathcal{S}(\Delta\overline{z}^{US})) + \Delta\overline{p}^{R,M^{OIL},SS} + \varepsilon_t^{\Delta\overline{p}^{R,M^{OIL}}}$	(163)
Equilibrium relative price of oil imports definition $\Delta\overline{p}_t^{R,M^{OIL}} = \overline{p}_t^{R,M^{OIL}} - \overline{p}_{t-1}^{R,M^{OIL}}$	(164)
Equilibrium relative price of oil imports level $\overline{p}_t^{R,M^{OIL}} = 100 \cdot \log(\overline{P}_t^{R,M^{OIL}})$	(165)
Government consuption goods Phillips Curve $\pi_t^G = c_1^{\pi^G} \cdot \pi_{t-1}^G + (1 - c_1^{\pi^G}) \cdot \pi_{t+1}^G + c_2^{\pi^G} \cdot (\hat{p}_t^{R,M^{NOIL}} - \hat{p}_t^{R,G}) + c_3^{\pi^G} \cdot (\hat{p}_t^{R,M^{OIL}} - \hat{p}_t^{R,G}) + c_4^{\pi^G} \cdot \hat{g}_t^R - c_5^{\pi^G} \cdot \hat{p}_t^{R,G} + \varepsilon_t^{\pi^G}$	(166)
Government absorption inflation definition $\pi_t^G = p_t^G - p_{t-1}^G$	(167)
Expected government absorption inflation $\pi_t^{G,E} = \pi_{t+1}^G$	(168)
Government absorption prices level $p_t^G = 100 \cdot \log(P_t^G)$	(169)
Relative price of government absorption breakdown $p_t^{R,G} = \hat{p}_t^{R,G} + \overline{p}_t^{R,G}$	(170)
Relative price of government absorption definition $p_t^{R,G} = p_t^G - p_t^C$	(171)
Equilibrium relative price of government absorption dynamics $\Delta\overline{P}_t^{R,G} = c_1^{\Delta\overline{P}^{R,G}} \cdot \Delta\overline{P}_{t-1}^{R,G} + (1 - c_1^{\Delta\overline{P}^{R,G}}) \cdot \Delta\overline{p}^{R,G,SS} + \varepsilon_t^{\Delta\overline{p}^{R,G}}$	(172)
Equilibrium relative price of government absorption definition $\Delta\overline{P}_t^{R,G} = \overline{p}_t^{R,G} - \overline{p}_{t-1}^{R,G}$	(173)
Equilibrium relative price of government absorption level $\overline{p}_t^{R,G} = 100 \cdot \log(\overline{P}_t^{R,G})$	(174)
BoP identity $0 = CA_t^Y + FA_t^Y$	(175)
Equilibrium BoP identity $0 = \overline{CA}_t^Y + \overline{FA}_t^Y$	(176)
Current account balance $CA_t^Y = X_t^Y - M_t^{NOIL,Y}/(1 + \tau_t^{M^{NOIL}}/100) - M_t^{OIL,Y}/(1 + \tau_t^{M^{OIL}}/100)$ $+ REM_t^Y - (G_t^{NR,Y} - GR_t^{NR,Y}) - GE_t^{B^{FCY},Y} + I_t^{NFA^O,Y} + CA_t^{O,Y}$	(177)
Potential current account balance	

Table continues on the next page.

$$\overline{CA}_t^{Y} = \overline{X}_t^{Y} - \overline{M}_t^{NOIL,Y}/(1+\tau_t^{M^{NOIL}}/100) - \overline{M}_t^{OIL,Y}/(1+\tau_t^{M^{OIL}}/100) + \overline{REM}_t^{Y} - (\overline{G}_t^{NR,Y} - \overline{GR}_t^{NR,Y}) - \overline{GE}_t^{B^{FCY},Y} + \overline{I}_t^{NFA^O,Y} + \overline{CA}_t^{O,Y} \tag{178}$$

Remittances breakdown

$$REM_t^{Y} = \overline{REM}_t^{Y} + R\hat{E}M_t^{Y} \tag{179}$$

Remittances gap

$$R\hat{E}M_t^{Y} = c_1^{R\hat{E}M^Y} \cdot R\hat{E}M_{t-1}^{Y} + c_2^{R\hat{E}M^Y} \cdot \hat{y}_t^{R,*} + \varepsilon_t^{R\hat{E}M^Y} \tag{180}$$

Remittances trend

$$\overline{REM}_t^{Y} = c_1^{\overline{REM}^Y} \cdot \overline{REM}_{t-1}^{Y} + (1 - c_1^{\overline{REM}^Y}) \cdot REM^{Y,SS} + \varepsilon_t^{\overline{REM}^Y} \tag{181}$$

Interest on private NFA

$$I_t^{NFA^O,Y} = r_{t-1}^{NFA^O}/100 \cdot NFA_{t-1}^{O,Y} \cdot (1+\Delta s_t^{US}/100)/(1+\Delta y_t/100) \tag{182}$$

Equilibrium interest on private NFA

$$\overline{I}_t^{NFA^O,Y} = r_{t-1}^{NFA^O}/100 \cdot NFA_{t-1}^{O,Y} \cdot (1 + (\Delta\overline{z}^{SS,US} - \pi^{C,US,SS} + \overline{\pi}_t^{C})/100)/(1+\Delta\overline{y}_t/100) \tag{183}$$

Other current account inflows

$$CA_t^{O,Y} = c_1^{CA^{O,Y}} \cdot CA_{t-1}^{O,Y} + (1 - c_1^{CA^{O,Y}}) \cdot \overline{CA}_t^{O,Y} + \varepsilon_t^{CA^{O,Y}} \tag{184}$$

Equilibrium other current account inflows

$$\overline{CA}_t^{O,Y} = c_1^{\overline{CA}^{O,Y}} \cdot \overline{CA}_{t-1}^{O,Y} + (1 - c_1^{\overline{CA}^{O,Y}}) \cdot CA^{O,Y,SS} + \varepsilon_t^{\overline{CA}^{O,Y}} \tag{185}$$

Net financial account inflows

$$FA_t^{Y} = FA_t^{O,Y} - FXI_t^{Y} - FXA_t^{Y} + (GF_t^{FCY,Y} + \varepsilon_t^{B^{FCY,Y}}) \tag{186}$$

Potential net financial account inflows

$$\overline{FA}_t^{Y} = \overline{FA}_t^{O,Y} - \overline{FXA}_t^{Y} + \overline{GF}_t^{FCY,Y} \tag{187}$$

Capital and financial account inflows

$$FA_t^{O,Y} = \overline{FA}_t^{O,Y} + c_1^{FA^{O,Y}} \cdot (1 - \tau^{FA^O,adm}) \cdot (\hat{\gamma}_t - \varepsilon_t^{\hat{\gamma}}) \tag{188}$$

Private NFA

$$NFA_t^{O,Y} = -FA_t^{O,Y} + NFA_{t-1}^{O,Y} \cdot (1+\Delta s_t^{US}/100)/(1+\Delta y_t/100) \tag{189}$$

UIP premium

$$\gamma_t = r_t - (r_t^{US} + (s_t^{E,US} - s_t^{US})) \tag{190}$$

UIP premium breakdown

$$\gamma_t = \overline{\gamma}_t + \hat{\gamma}_t \tag{191}$$

Equilibrium capital and financial account inflows

$$\overline{FA}_t^{O,Y} = \mathcal{S}(\overline{FA}^{O,Y}) + \overline{FA}_t^{O,Exo,Y} + c_1^{\overline{FA}^{O,Y}} \cdot (1 - \tau^{FA^O,adm}) \cdot (\overline{\gamma}_t - (\gamma^{SS} + \gamma_t^{B} + \gamma_t^{FXR} + \gamma_t^{NFA^O} + (\tau_t^{FA^O} - \tau^{FA^O,SS}) + \varepsilon_t^{\overline{\gamma}})) \tag{192}$$

Capital inflow tax rate

$$\tau_t^{FA^O} = c_1^{\tau^{FA^O}} \cdot \tau_{t-1}^{FA^O} + (1 - c_1^{\tau^{FA^O}}) \cdot \tau^{FA^O,SS} + \varepsilon_t^{\tau^{FA^O}} \tag{193}$$

(Semi-)Exogenous financial account inflows

$$\overline{FA}_t^{O,Exo,Y} = c_1^{\overline{FA}^{O,Exo,Y}} \cdot \overline{FA}_{t-1}^{O,Exo,Y} + \varepsilon_t^{\overline{FA}^{O,Exo,Y}} \tag{194}$$

Public debt contribution to the UIP premium

Table continues on the next page.

$$\gamma_t^B = \exp(c_1^{\gamma^B} \cdot (B_t^Y - B^{Y,SS})) - 1 \tag{195}$$

Private NFA contribution to the UIP premium
$$\gamma_t^{NFA^O} = \exp(-c_1^{\gamma^{NFA^O}} \cdot (NFA_t^{O,Y} - \mathcal{S}(NFA^{O,Y}))) - 1 \tag{196}$$

Nominal exchnage rate against USD
$$s_t^{US} = 100 \cdot \log(S_t^{US}) \tag{197}$$

Nominal exchnage rate depreciation against USD
$$\Delta s_t^{US} = ((s_t^{US}) - (s_{t-1}^{US})) \tag{198}$$

Expected nominal exchange rate against USD
$$s_t^{E,US} = c_1^{s^{E,US}} \cdot s_{t+1}^{US} + (1 - c_1^{s^{E,US}}) \cdot (s_{t-1}^{US} + 2 \cdot (\Delta \bar{z}_t^{US} - \pi^{C,US,SS} + \bar{\pi}_t^C)) \tag{199}$$

Policy Interest Rate Rule
$$r_t^{unc} = c_1^r \cdot r_{t-1} + (1 - c_1^r) \cdot (\bar{r}_t^R + \pi_t^C + c_2^r \cdot (\pi_{t+1}^C - \bar{\pi}_t^C) + c_3^r \cdot \hat{y}_t^R) + \varepsilon_t^r \tag{200}$$

Inflation target
$$\bar{\pi}_t^C = c_1^{\bar{\pi}^C} \cdot \bar{\pi}_{t-1}^C + (1 - c_1^{\bar{\pi}^C}) \cdot \bar{\pi}^{C,SS} + \varepsilon_t^{\bar{\pi}^C} \tag{201}$$

Policy rate subject to the ELB
$$r_t = \max(r_t^{unc} - \underline{r}, 1e-9) + \underline{r} \tag{202}$$

Fisher equation
$$r_t^R = r_t - \pi_t^C \tag{203}$$

Trend UIP
$$\bar{r}_t^R = \bar{r}_t^{R,US} + \bar{\gamma}_t + (\bar{z}_{t+1}^{US} - \bar{z}_t^{US}) \tag{204}$$

Real interest rate breakdown
$$r_t^R = \bar{r}_t^R + \hat{r}_t^R \tag{205}$$

Sovereign LCY debt interest rate
$$r_t^{G,LCY} = r_t^{G,Comp,LCY} + \gamma_t^{G,LCY} + \gamma_t^{G,FCY} + \varepsilon_t^{r^{G,LCY}} \tag{206}$$

Compounded short term sovereign rate
$$r_t^{G,Comp,LCY} = IN^{LCY} \cdot r_t + (1 - IN^{LCY}) \cdot r_{t+1}^{G,Comp,LCY} \tag{207}$$

Sovereign LCY debt term premium
$$\begin{aligned}\gamma_t^{G,LCY} = {} & c_1^{\gamma^{G,LCY}} \cdot \gamma_{t-1}^{G,LCY} + (1 - c_1^{\gamma^{G,LCY}}) \cdot (\gamma^{G,LCY} + c_2^{\gamma^{G,LCY}} \cdot (B_t^Y - B^{Y,SS})) \\ & + \varepsilon_t^{\gamma^{G,LCY}}\end{aligned} \tag{208}$$

Sovereign LCY debt real equilibrium interest rate
$$\bar{r}_t^{R,G,LCY} = r_t^{R,G,Comp,LCY} + \gamma_t^{G,LCY} + \gamma_t^{G,FCY} \tag{209}$$

Compounded short term sovereign real LCY rate
$$r_t^{R,G,Comp,LCY} = IN^{LCY} \cdot \bar{r}_t^R + (1 - IN^{LCY}) \cdot r_{t+1}^{R,G,Comp,LCY} \tag{210}$$

Sovereign FCY debt interest rate
$$r_t^{G,FCY} = r_t^{G,Comp,FCY} + \gamma_t^{G,FCY} + \varepsilon_t^{r^{G,FCY}} \tag{211}$$

Compounded short term sovereign FCY rate
$$r_t^{G,Comp,FCY} = IN^{FCY} \cdot r_t^{US} + (1 - IN^{FCY}) \cdot r_{t+1}^{G,Comp,FCY} \tag{212}$$

Table continues on the next page.

Sovereign FCY debt term premium

$$\gamma_t^{G,FCY} = c_1^{\gamma^{G,FCY}} \cdot \gamma_{t-1}^{G,FCY} + (1 - c_1^{\gamma^{G,FCY}}) \cdot (\gamma^{G,FCY} + c_2^{\gamma^{G,FCY}} \cdot (B_t^Y - B^{Y,SS})) + \varepsilon_t^{\gamma^{G,FCY}} \tag{213}$$

Sovereign FCY real equilibrium interest rate

$$\overline{r}_t^{R,G,FCY} = r_t^{R,G,Comp,FCY} + \gamma_t^{G,FCY} \tag{214}$$

Compounded short term sovereign real FCY rate

$$r_t^{R,G,Comp,FCY} = IN^{FCY} \cdot \overline{r}_t^{R,US} + (1 - IN^{FCY}) \cdot r_{t+1}^{R,G,Comp,FCY} \tag{215}$$

Private NFA interest rate

$$r_t^{NFA^O} = r_t^{NFA^O,Comp} + \gamma_t^{NFA^O} + \varepsilon_t^{r^{NFA^O}} \tag{216}$$

Compounded short term private NFA rate

$$r_t^{NFA^O,Comp} = IN^{NFA^O} \cdot r_t^{US} + (1 - IN^{NFA^O}) \cdot r_{t+1}^{NFA^O,Comp} \tag{217}$$

Private NFA term premium

$$\gamma_t^{NFA^O} = c_1^{\gamma^{NFA^O}} \cdot \gamma_{t-1}^{NFA^O} + (1 - c_1^{\gamma^{NFA^O}}) \cdot \gamma^{NFA^O} + \varepsilon_t^{\gamma^{NFA^O}} \tag{218}$$

FX reserves target path

$$\overline{FXR}_t^Y = c_1^{\overline{FXR}^Y} \cdot \overline{FXR}_{t-1}^Y + (1 - c_1^{\overline{FXR}^Y}) \cdot \overline{FXR}^{Y,SS} + \varepsilon_t^{\overline{FXR}^Y} \tag{219}$$

FX reserves

$$FXR_t^Y = FXI_t^Y + FXA_t^Y + (1 + r_{t-1}^{US}/100) \cdot FXR_{t-1}^Y \cdot (1 + \Delta s_t^{US}/100)/(1 + \Delta y_t/100) + \varepsilon_t^{FXR^Y} \tag{220}$$

FX interventions rule

$$FXI_t^{Y,unc} = c_1^{FXI^Y} \cdot FXI_{t-1}^Y - c_2^{FXI^Y} \cdot (\Delta s_t^{US} - \Delta \overline{s}_t^{US}) + \varepsilon_t^{FXI^Y} \tag{221}$$

FX interventions subject to the FXR floor

$$FXI_t^Y = \max(FXR^{min} - (FXA_t^Y + (1 + r_{t-1}^{US}/100) \cdot FXR_{t-1}^Y \cdot (1 + \Delta s_t^{US}/100)/(1 + \Delta y_t/100)) - FXI_t^{Y,unc}, 1e-9) + FXI_t^{Y,unc} \tag{222}$$

FX accumulation target path

$$\overline{FXR}_t^Y = \overline{FXA}_t^Y + (1 + (\overline{r}_t^{R,US} + \pi^{C,US,SS})/100) \cdot \overline{FXR}_t^Y \cdot (1 + (\Delta \overline{z}_t^{US} - \pi^{C,US,SS} + \overline{\pi}_t^C)/100)/(1 + \Delta \overline{y}_t/100) \tag{223}$$

FX accumulation

$$FXA_t^Y = c_1^{FXA^Y} \cdot FXA_{t-1}^Y + (1 - c_1^{FXA^Y}) \cdot \overline{FXA}_t^Y - c_2^{FXA^Y} \cdot \widehat{FXR}_t^Y + \varepsilon_t^{FXA^Y} \tag{224}$$

FX reserves gap

$$\widehat{FXR}_t^Y = c_1^{\widehat{FXR}^Y} \cdot (FXR_t^Y - \overline{FXR}_t^Y) + (1 - c_1^{\widehat{FXR}^Y}) \cdot \widehat{FXR}_{t+1}^Y \tag{225}$$

FX reserves position contribution to the UIP premium

$$\gamma_t^{FXR} = c_4^{\gamma^{FXR}} \cdot (\gamma^{FXR,max} + \min(c_1^{\gamma^{FXR}} + c_3^{\gamma^{FXR}} \cdot \exp(-c_2^{\gamma^{FXR}} \cdot FXR_t^Y) - \gamma^{FXR,max}, 1e-8)) \tag{226}$$

Total revenues identity

$$GR_t^Y = GR_t^{Y,Y} + GR_t^{C,Y} + GR_t^{M^{NOIL},Y} + GR_t^{M^{OIL},Y} + GR_t^{NR,Y} + GR_t^{O,Y} \tag{227}$$

Consumption tax revenues

$$GR_t^{C,Y} = \tau_t^C/100/(1 + \tau_t^C/100) \cdot C_t^Y \tag{228}$$

Table continues on the next page.

Non-oil imports tax revenues
$$GR_t^{M^{NOIL},Y} = \tau_t^{M^{NOIL}}/100/(1+\tau_t^{M^{NOIL}}/100)\cdot M_t^{NOIL,Y} \tag{229}$$

Oil imports tax revenues
$$GR_t^{M^{OIL},Y} = \tau_t^{M^{OIL}}/100/(1+\tau_t^{M^{OIL}}/100)\cdot M_t^{OIL,Y} \tag{230}$$

Natural resource royalty revenues
$$GR_t^{NR,Y} = \tau_t^{NR}/100\cdot G_t^{NR,Y} \tag{231}$$

Equilibrium natural resource royalty revenues
$$\overline{GR}_t^{NR,Y} = \tau_t^{NR}/100\cdot \overline{G}_t^{NR,Y} \tag{232}$$

Income tax revenues
$$GR_t^{Y,Y} = \tau_t^{Y} \tag{233}$$

Equilibrium revenues
$$\begin{aligned}\overline{GR}_t^{Y} &= \tau_t^{Y} + \tau_t^{C}/100/(1+\tau_t^{C}/100)\cdot \overline{C}_t^{Y} + \tau_t^{M^{NOIL}}/100/(1+\tau_t^{M^{NOIL}}/100)\cdot \overline{M}_t^{NOIL,Y}\\ &+ \tau_t^{M^{OIL}}/100/(1+\tau_t^{M^{OIL}}/100)\cdot \overline{M}_t^{OIL,Y} + \overline{GR}_t^{NR,Y} + \overline{GR}_t^{O,Y}\end{aligned} \tag{234}$$

Total revenues breakdown
$$GR_t^{Y}\cdot(1+c_1^{GR^Y}\cdot \hat{y}_t^R/100) = \overline{GR}_t^{Y} + \widehat{GR}_t^{Y} \tag{235}$$

Income tax rate
$$\tau_t^{Y} = c_1^{\tau^Y}\cdot \tau_{t-1}^{Y} + (1-c_1^{\tau^Y})\cdot \tau^{Y,SS} + \varepsilon_t^{\tau^Y} \tag{236}$$

Consumption tax rate
$$\tau_t^{C} = c_1^{\tau^C}\cdot \tau_{t-1}^{C} + (1-c_1^{\tau^C})\cdot \tau^{C,SS} + \varepsilon_t^{\tau^C} \tag{237}$$

Expected consumption tax rate
$$\tau_t^{C,E} = \tau_{t+1}^{C} \tag{238}$$

Non-oil imports tax rate
$$\tau_t^{M^{NOIL}} = c_1^{\tau^{M^{NOIL}}}\cdot \tau_{t-1}^{M^{NOIL}} + (1-c_1^{\tau^{M^{NOIL}}})\cdot \tau^{M^{NOIL},SS} + \varepsilon_t^{\tau^{M^{NOIL}}} \tag{239}$$

Expected non-oil imports tax rate
$$\tau_t^{M^{NOIL},E} = \tau_{t+1}^{M^{NOIL}} \tag{240}$$

Oil imports tax rate
$$\tau_t^{M^{OIL}} = c_1^{\tau^{M^{OIL}}}\cdot \tau_{t-1}^{M^{OIL}} + (1-c_1^{\tau^{M^{OIL}}})\cdot \tau^{M^{OIL},SS} + \varepsilon_t^{\tau^{M^{OIL}}} \tag{241}$$

Expected oil imports tax rate
$$\tau_t^{M^{OIL},E} = \tau_{t+1}^{M^{OIL}} \tag{242}$$

Natural resource royalty rate
$$\tau_t^{NR} = c_1^{\tau^{NR}}\cdot \tau_{t-1}^{NR} + (1-c_1^{\tau^{NR}})\cdot \tau^{NR,SS} + \varepsilon_t^{\tau^{NR}} \tag{243}$$

Equilibrium other revenues
$$\overline{GR}_t^{O,Y} = c_1^{\overline{GR}^{O,Y}}\cdot \overline{GR}_{t-1}^{O,Y} + (1-c_1^{\overline{GR}^{O,Y}})\cdot GR^{O,Y,SS} + \varepsilon_t^{\overline{GR}^{O,Y}} \tag{244}$$

Other revenues
$$GR_t^{O,Y} = c_1^{GR^{O,Y}}\cdot GR_{t-1}^{O,Y} + (1-c_1^{GR^{O,Y}})\cdot \overline{GR}_t^{O,Y} + \varepsilon_t^{GR^{O,Y}} \tag{245}$$

Table continues on the next page.

Total expenditures
$$GE_t^{Y} = G_t^{Y} + GE_t^{B,Y} + GE_t^{O,Y} + GE_t^{Tr,Y} \tag{246}$$

Government absorption breakdown
$$G_t^{Y} = \overline{G}_t^{Y} + \hat{G}_t^{Y} \tag{247}$$

Government absorption components
$$G_t^{Y} = GE_t^{C,Y} + GE_t^{I^G,Y} \tag{248}$$

Government consumption expenditures
$$GE_t^{C,Y} = c_1^{GE^{C,Y}} \cdot GE_{t-1}^{C,Y} + (1 - c_1^{GE^{C,Y}}) \cdot GE^{C,Y,SS} + \varepsilon_t^{GE^{C,Y}} \tag{249}$$

Government investment expenditure
$$GE_t^{I^G,Y} = 100 \cdot P_t^{G} \cdot GE_t^{R,I^G} / (P_t^{Y} \cdot Y_t^{R}) \tag{250}$$

Public capital accumulation
$$K_t^{R,G} = (1 - \delta^{K^{R,G}}) \cdot K_{t-1}^{R,G} + (1 - c_2^{K^{R,G}} - c_3^{K^{R,G}} - c_4^{K^{R,G}}) \cdot GE_t^{R,I^G} + c_2^{K^{R,G}} \cdot GE_{t-1}^{R,I^G} + c_3^{K^{R,G}} \cdot GE_{t-2}^{R,I^G} + c_4^{K^{R,G}} \cdot GE_{t-3}^{R,I^G} \tag{251}$$

Level of public capital
$$k_t^{R,G} = 100 \cdot \log(K_t^{R,G}) \tag{252}$$

Public capital growth
$$\Delta k_t^{R,G} = k_t^{R,G} - k_{t-1}^{R,G} \tag{253}$$

Government interest expenditures
$$GE_t^{B,Y} = GE_t^{B^{LCY},Y} + GE_t^{B^{FCY},Y} \tag{254}$$

Government LCY interest expenditures
$$GE_t^{B^{LCY},Y} = (r_{t-1}^{G,LCY}/100) \cdot B_{t-1}^{LCY,Y} / (1 + \Delta y_t/100) \tag{255}$$

Government FCY interest expenditures
$$GE_t^{B^{FCY},Y} = r_{t-1}^{G,FCY}/100 \cdot B_{t-1}^{FCY,Y} \cdot (1 + \Delta s_t^{US}/100)/(1 + \Delta y_t/100) \tag{256}$$

Government equilibrium interest expenditures
$$\overline{GE}_t^{B,Y} = \overline{GE}_t^{B^{LCY},Y} + \overline{GE}_t^{B^{FCY},Y} \tag{257}$$

Government equilibrium LCY interest expenditures
$$\overline{GE}_t^{B^{LCY},Y} = (\overline{r}_t^{R,G,LCY} + \overline{\pi}_t^{C})/100 \cdot \overline{B}_t^{LCY,Y} / (1 + \Delta \overline{y}_t/100) \tag{258}$$

Government equilibrium FCY interest expenditures
$$\overline{GE}_t^{B^{FCY},Y} = (\overline{r}_t^{R,G,FCY} + \pi^{C,US,SS})/100 \cdot \overline{B}_t^{FCY,Y} \cdot (1 + (\Delta \overline{z}^{SS,US} - \pi^{C,US,SS} + \overline{\pi}_t^{C})/100)/(1 + \Delta \overline{y}_t/100) \tag{259}$$

Government other expenditures
$$GE_t^{O,Y} = c_1^{GE^{O,Y}} \cdot GE_{t-1}^{O,Y} + (1 - c_1^{GE^{O,Y}}) \cdot GE^{O,Y,SS} + \varepsilon_t^{GE^{O,Y}} \tag{260}$$

Government transfers
$$GE_t^{Tr,Y} = c_1^{GE^{Tr,Y}} \cdot GE_{t-1}^{Tr,Y} + (1 - c_1^{GE^{Tr,Y}}) \cdot \overline{GE}_t^{Tr,Y} + \varepsilon_t^{GE^{Tr,Y}} \tag{261}$$

Government equilibrium transfers
$$\overline{GE}_t^{Tr,Y} = c_1^{\overline{GE}^{Tr,Y}} \cdot \overline{GE}_{t-1}^{Tr,Y} + (1 - c_1^{\overline{GE}^{Tr,Y}}) \cdot \overline{GE^{Tr,Y,SS}} + \varepsilon_t^{\overline{GE^{Tr,Y}}} \tag{262}$$

Table continues on the next page.

Government transfers gap
$$GE_t^{Tr,Y} = \overline{GE}_t^{Tr,Y} + \widehat{GE}_t^{Tr,Y} \tag{263}$$

Government transfers relative to nominal GDP 5 periods ago (adjusted by BGP growth)
$$GE_t^{Tr,Y_{-5}} = GE_t^{Tr,Y} \cdot Y_t/Y_{t-5}/(\exp(\mathcal{S}(\Delta y)/100)^5) \tag{264}$$

Overall deficit
$$GD_t^Y = GE_t^Y - GR_t^Y \tag{265}$$

Overall deficit breakdown
$$GD_t^Y = GD_t^{S,Y} + GD_t^{C,Y} \tag{266}$$

Primary deficit
$$GD_t^{P,Y} = GD_t^Y - GE_t^{B,Y} \tag{267}$$

Overal deficit financing
$$GD_t^Y = GF_t^{LCY,Y} + GF_t^{FCY,Y} \tag{268}$$

Foreign financing rule
$$\begin{aligned} GF_t^{FCY,Y} &= c_1^{GF^{FCY,Y}} \cdot GF_{t-1}^{FCY,Y} + (1 - c_1^{GF^{FCY,Y}}) \cdot (\overline{GF}_t^{FCY,Y} \\ &- c_2^{GF^{FCY,Y}} \cdot (100 \cdot B_{t+1}^{FCY,Y}/B_{t+1}^Y - \overline{B}_t^{FCY,B})) \\ &+ c_3^{GF^{FCY,Y}} \cdot (GD_t^Y - \overline{GD}_t^{S,Y}) + \varepsilon_t^{GF^{FCY,Y}} \end{aligned} \tag{269}$$

Foreign financing target
$$\overline{GF}_t^{FCY,Y} = (1 - (1 + (\Delta\overline{z}^{SS,US} - \pi^{C,US,SS} + \overline{\pi}_t^C)/100)/(1 + \Delta\overline{y}_t/100)) \cdot \overline{B}_t^{FCY,Y} \tag{270}$$

Structural deficit target breakdown
$$\overline{G}_t^Y = c_1^{\overline{G}^Y} \cdot \overline{G}_{t-1}^Y + (1 - c_1^{\overline{G}^Y}) \cdot (\overline{GD}_t^{S,Y} - \overline{GE}_t^{B,Y} + \overline{GR}_t^Y - GE^{O,Y,SS} - \overline{GE}_t^{Tr,Y}) \tag{271}$$

Fiscal policy rule on structural deficit
$$GD_t^{S,Y} = c_1^{GD^{S,Y}} \cdot GD_{t-1}^{S,Y} + (1 - c_1^{GD^{S,Y}}) \cdot \overline{GD}_t^{S,Y} - c_2^{GD^{S,Y}} \cdot \hat{B}_t^Y + c_3^{GD^{S,Y}} \cdot \hat{y}_t^R + \varepsilon_t^{GD^{S,Y}} \tag{272}$$

Cyclical deficit
$$GD_t^{C,Y} = -\widehat{GR}_t^Y - c_1^{GD^{C,Y}} \cdot \hat{y}_t^R \tag{273}$$

Debt target
$$\overline{B}_t^Y = c_1^{\overline{B}^Y} \cdot \overline{B}_{t-1}^Y + (1 - c_1^{\overline{B}^Y}) \cdot B^{Y,SS} + \varepsilon_t^{\overline{B}^Y} \tag{274}$$

Structural deficit target
$$\overline{B}_t^Y = \overline{GD}_t^{S,Y} + (\overline{B}_t^{FCY,Y} \cdot (1 + (\Delta\overline{z}^{SS,US} - \pi^{C,US,SS} + \overline{\pi}_t^C)/100) + \overline{B}_t^{LCY,Y})/(1 + \Delta\overline{y}_t/100) \tag{275}$$

Overal debt components
$$B_t^Y = B_t^{LCY,Y} + B_t^{FCY,Y} \tag{276}$$

Forward-looking debt deviation
$$\hat{B}_t^Y = (1 - c_1^{\hat{B}^Y}) \cdot (B_t^Y - \overline{B}_t^Y) + c_1^{\hat{B}^Y} \cdot \hat{B}_{t+1}^Y \tag{277}$$

Debt breakdown
$$\overline{B}_t^Y = \overline{B}_t^{FCY,Y} + \overline{B}_t^{LCY,Y} \tag{278}$$

FCY Debt target
$$\overline{B}_t^{FCY,Y} = \overline{B}_t^{FCY,B}/100 \cdot \overline{B}_t^Y \tag{279}$$

Table continues on the next page.

Share of FCY debt in total debt
$$\overline{B}_t^{FCY,B} = c_1^{\overline{B}^{FCY,B}} \cdot \overline{B}_{t-1}^{FCY,B} + (1 - c_1^{\overline{B}^{FCY,B}}) \cdot B^{FCY,B,SS} + \varepsilon_t^{\overline{B}^{FCY,B}} \tag{280}$$

FCY Debt accumulation
$$B_t^{FCY,Y} = GF_t^{FCY,Y} + B_{t-1}^{FCY,Y} \cdot (1 + \Delta s_t^{US}/100)/(1 + \Delta y_t/100) + \varepsilon_t^{B^{FCY,Y}} \tag{281}$$

LCY Debt accumulation
$$B_t^{LCY,Y} = GF_t^{LCY,Y} + B_{t-1}^{LCY,Y}/(1 + \Delta y_t/100) + \varepsilon_t^{B^{LCY,Y}} \tag{282}$$

US real interest rate
$$r_t^{R,US} = r_t^{US} - \pi_{t+1}^{C,US} \tag{283}$$

US nominal interest rate
$$r_t^{US} = c_1^{r^{US}} \cdot r_{t-1}^{US} + (1 - c_1^{r^{US}}) \cdot (\overline{r}_t^{R,US} + \pi^{C,US,SS}) + \varepsilon_t^{r^{US}} \tag{284}$$

US equilibrium real interest rate
$$\overline{r}_t^{R,US} = c_1^{\overline{r}^{R,US}} \cdot \overline{r}_{t-1}^{R,US} + (1 - c_1^{\overline{r}^{R,US}}) \cdot \overline{r}^{R,US,SS} + \varepsilon_t^{\overline{r}^{R,US}} \tag{285}$$

GDP gap - US
$$\hat{y}_t^{R,US} = c_1^{\hat{y}^{R,US}} \cdot \hat{y}_{t-1}^{R,US} + \varepsilon_t^{\hat{y}^{R,US}} \tag{286}$$

Real GDP breakdown - US
$$y_t^{R,US} = \overline{y}_t^{R,US} + \hat{y}_t^{R,US} \tag{287}$$

Real GDP growth - US
$$\Delta y_t^{R,US} = ((y_t^{R,US}) - (y_{t-1}^{R,US})) \tag{288}$$

Potential real GDP growth identity - US
$$\Delta \overline{y}_t^{R,US} = ((\overline{y}_t^{R,US}) - (\overline{y}_{t-1}^{R,US})) \tag{289}$$

Potential real GDP growth - US
$$\Delta \overline{y}_t^{R,US} = c_1^{\Delta \overline{y}^{R,US}} \cdot \Delta \overline{y}_{t-1}^{R,US} + (1 - c_1^{\Delta \overline{y}^{R,US}}) \cdot \Delta \overline{y}^{US,SS} + \varepsilon_t^{\Delta \overline{y}^{R,US}} \tag{290}$$

Consumption inflation identity - US
$$\pi_t^{C,US} = ((p_t^{C,US}) - (p_{t-1}^{C,US})) \tag{291}$$

Consumption inflation - US
$$\pi_t^{C,US} = c_1^{\pi^{C,US}} \cdot \pi_{t-1}^{C,US} + (1 - c_1^{\pi^{C,US}}) \cdot \pi^{C,US,SS} + \varepsilon_t^{\pi^{C,US}} \tag{292}$$

Real exchange rate depreciation identity - US
$$\Delta z_t^{US} = ((z_t^{US}) - (z_{t-1}^{US})) \tag{293}$$

Logarithm of eq. real exchange rate - US
$$\overline{z}_t^{US} = 100 \cdot \log(\overline{Z}_t^{US}) \tag{294}$$

Equilibrium real exchange rate depreciation identity - US
$$\Delta \overline{z}_t^{US} = ((\overline{z}_t^{US}) - (\overline{z}_{t-1}^{US})) \tag{295}$$

GDP gap - EZ
$$\hat{y}_t^{R,EZ} = c_1^{\hat{y}^{R,EZ}} \cdot \hat{y}_{t-1}^{R,EZ} + \varepsilon_t^{\hat{y}^{R,EZ}} \tag{296}$$

Real GDP breakdown - EZ

Table continues on the next page.

$$y_t^{R,EZ} = \overline{y}_t^{R,EZ} + \hat{y}_t^{R,EZ} \quad (297)$$

Real GDP growth - EZ
$$\Delta y_t^{R,EZ} = ((y_t^{R,EZ}) - (y_{t-1}^{R,EZ})) \quad (298)$$

Potential real GDP growth identity - EZ
$$\Delta\overline{y}_t^{R,EZ} = ((\overline{y}_t^{R,EZ}) - (\overline{y}_{t-1}^{R,EZ})) \quad (299)$$

Potential real GDP growth - EZ
$$\Delta\overline{y}_t^{R,EZ} = c_1^{\Delta\overline{y}^{R,EZ}} \cdot \Delta\overline{y}_{t-1}^{R,EZ} + (1 - c_1^{\Delta\overline{y}^{R,EZ}}) \cdot \Delta\overline{y}^{EZ,SS} + \varepsilon_t^{\Delta\overline{y}^{R,EZ}} \quad (300)$$

Consumption inflation identity - EZ
$$\pi_t^{C,EZ} = ((p_t^{C,EZ}) - (p_{t-1}^{C,EZ})) \quad (301)$$

Consumption inflation - EZ
$$\pi_t^{C,EZ} = c_1^{\pi^{C,EZ}} \cdot \pi_{t-1}^{C,EZ} + (1 - c_1^{\pi^{C,EZ}}) \cdot \pi^{C,EZ,SS} + \varepsilon_t^{\pi^{C,EZ}} \quad (302)$$

Real exchange rate identity - EZ
$$z_t^{EZ} = s_t^{EZ} + p_t^{C,US} - p_t^{C,EZ} \quad (303)$$

Real exchange rate breakdown - EZ
$$z_t^{EZ} = \hat{z}_t^{EZ} + \overline{z}_t^{EZ} \quad (304)$$

Real exchange rate gap - EZ
$$\hat{z}_t^{EZ} = c_1^{\hat{z}^{EZ}} \cdot \hat{z}_{t-1}^{EZ} + \varepsilon_t^{\hat{z}^{EZ}} \quad (305)$$

Equilibrium real exchange rate depreciation - EZ
$$\overline{z}_t^{EZ} = \overline{z}_{t-1}^{EZ} + \Delta\overline{z}_t^{G,EZ} + \varepsilon_t^{\overline{z}^{EZ}} \quad (306)$$

Persistent component of equilibrium real exchange rate depreciation - EZ
$$\Delta\overline{z}_t^{G,EZ} = c_1^{\Delta\overline{z}^{EZ}} \cdot \Delta\overline{z}_{t-1}^{G,EZ} + (1 - c_1^{\Delta\overline{z}^{EZ}}) \cdot \Delta\overline{z}^{EZ,SS} + \varepsilon_t^{\Delta\overline{z}^{EZ}} \quad (307)$$

Nominal exchange rate depreciation - EZ
$$\Delta s_t^{EZ} = ((s_t^{EZ}) - (s_{t-1}^{EZ})) \quad (308)$$

Real exchange rate depreciation identity - EZ
$$\Delta z_t^{EZ} = ((z_t^{EZ}) - (z_{t-1}^{EZ})) \quad (309)$$

Logarithm of eq. real exchange rate - EZ
$$\overline{z}_t^{EZ} = 100 \cdot \log(\overline{Z}_t^{EZ}) \quad (310)$$

Equilibrium real exchange rate depreciation identity - EZ
$$\Delta\overline{z}_t^{EZ} = ((\overline{z}_t^{EZ}) - (\overline{z}_{t-1}^{EZ})) \quad (311)$$

Effective foreign output gap
$$\hat{y}_t^{R,*} = +\omega^{X,US} \cdot \hat{y}_t^{R,US} + \omega^{X,EZ} \cdot \hat{y}_t^{R,EZ} \quad (312)$$

Effective foreign real GDP
$$y_t^{R,*} = +\omega^{X,US} \cdot y_t^{R,US} + \omega^{X,EZ} \cdot y_t^{R,EZ} \quad (313)$$

Effective foreign potential output
$$\overline{y}_t^{R,*} = +\omega^{X,US} \cdot \overline{y}_t^{R,US} + \omega^{X,EZ} \cdot \overline{y}_t^{R,EZ} \quad (314)$$

Effective foreign potential GDP growth

Table continues on the next page.

$\Delta\overline{y}_t^{R,*} = ((\overline{y}_t^{R,*}) - (\overline{y}_{t-1}^{R,*}))$	(315)
Effective trade weighted RER $z_t = \omega^{TR,US} \cdot z_t^{US} + \omega^{TR,EZ} \cdot (z_t^{US} - z_t^{EZ})$	(316)
Effective trade weighted RER gap $\hat{z}_t = \omega^{TR,US} \cdot \hat{z}_t^{US} + \omega^{TR,EZ} \cdot (\hat{z}_t^{US} - \hat{z}_t^{EZ})$	(317)
Effective trade weighted RER trend $\overline{z}_t = \omega^{TR,US} \cdot \overline{z}_t^{US} + \omega^{TR,EZ} \cdot (\overline{z}_t^{US} - \overline{z}_t^{EZ})$	(318)
REER level $z_t = 100 \cdot \log(Z_t)$	(319)
REER depreciation $\Delta z_t = ((z_t) - (z_{t-1}))$	(320)
REER definition $\Delta z_t = \Delta s_t^{US} + \pi_t^{C,*} - \pi_t^{C}$	(321)
Equilibrium REER depreciation $\Delta\overline{z}_t = \overline{z}_t - \overline{z}_{t-1}$	(322)
REER breakdown $z_t = \overline{z}_t + \hat{z}_t$	(323)
Effective export weighted RER $z_t^{Xw} = \omega^{X,US} \cdot z_t^{US} + \omega^{X,EZ} \cdot (z_t^{US} - z_t^{EZ})$	(324)
Effective export weighted RER gap $\hat{z}_t^{Xw} = \omega^{X,US} \cdot \hat{z}_t^{US} + \omega^{X,EZ} \cdot (\hat{z}_t^{US} - \hat{z}_t^{EZ})$	(325)
Effective export weighted RER trend $\overline{z}_t^{Xw} = \omega^{X,US} \cdot \overline{z}_t^{US} + \omega^{X,EZ} \cdot (\overline{z}_t^{US} - \overline{z}_t^{EZ})$	(326)
$\Delta\overline{z}_t^{Xw} = ((\overline{z}_t^{Xw}) - (\overline{z}_{t-1}^{Xw}))$	(327)
Effective import weighted RER $z_t^{Mw} = \omega^{M,US} \cdot z_t^{US} + \omega^{M,EZ} \cdot (z_t^{US} - z_t^{EZ})$	(328)
Effective import weighted RER gap $\hat{z}_t^{Mw} = \omega^{M,US} \cdot \hat{z}_t^{US} + \omega^{M,EZ} \cdot (\hat{z}_t^{US} - \hat{z}_t^{EZ})$	(329)
Effective import weighted RER trend $\overline{z}_t^{Mw} = \omega^{M,US} \cdot \overline{z}_t^{US} + \omega^{M,EZ} \cdot (\overline{z}_t^{US} - \overline{z}_t^{EZ})$	(330)
Depreciation of the effective import weighted RER trend $\Delta\overline{z}_t^{Mw} = ((\overline{z}_t^{Mw}) - (\overline{z}_{t-1}^{Mw}))$	(331)
Effective foreign CPI in USD $p_t^{C,*} = \omega^{TR,US} \cdot p_t^{C,US} + \omega^{TR,EZ} \cdot (p_t^{C,EZ} - s_t^{EZ})$	(332)
Effective foreign CPI inflation in USD $\pi_t^{C,*} = ((p_t^{C,*}) - (p_{t-1}^{C,*}))$	(333)
Effective foreign export-weighted CPI in USD $p_t^{C,Xw,*} = \omega^{X,US} \cdot p_t^{C,US} + \omega^{X,EZ} \cdot (p_t^{C,EZ} - s_t^{EZ})$	(334)

Table continues on the next page.

Effective foreign export-weighted CPI inflation in USD
$$\pi_t^{C,Xw,*} = ((p_t^{C,Xw,*}) - (p_{t-1}^{C,Xw,*})) \tag{335}$$

Effective foreign import-weighted CPI in USD
$$p_t^{C,Mw,*} = \omega^{M,US} \cdot p_t^{C,US} + \omega^{M,EZ} \cdot (p_t^{C,EZ} - s_t^{EZ}) \tag{336}$$

Effective foreign import-weighted CPI inflation in USD
$$\pi_t^{C,Mw,*} = ((p_t^{C,Mw,*}) - (p_{t-1}^{C,Mw,*})) \tag{337}$$

Real price of oil
$$p_t^{R,oil,*} = p_t^{oil,*} - p_t^{C,US} \tag{338}$$

Real oil price inflation
$$\Delta p_t^{R,oil,*} = p_t^{R,oil,*} - p_{t-1}^{R,oil,*} \tag{339}$$

Real oil price breakdown
$$p_t^{R,oil,*} = \overline{p}_t^{R,oil,*} + \hat{p}_t^{R,oil,*} \tag{340}$$

Real oil price gap
$$\hat{p}_t^{R,oil,*} = c_1^{\hat{p}^{R,oil,*}} \cdot \hat{p}_{t-1}^{R,oil,*} + \varepsilon_t^{\hat{p}^{R,oil,*}} \tag{341}$$

Real oil price trend growth
$$\Delta\overline{p}_t^{R,oil,*} = c_1^{\Delta\overline{p}^{R,oil,*}} \cdot \Delta\overline{p}_{t-1}^{R,oil,*} + (1 - c_1^{\Delta\overline{p}^{R,oil,*}}) \cdot \Delta p^{R,oil,*,SS} + \varepsilon_t^{\Delta\overline{p}^{R,oil,*}} \tag{342}$$

Real oil price trend growth identity
$$\Delta\overline{p}_t^{R,oil,*} = \overline{p}_t^{R,oil,*} - \overline{p}_{t-1}^{R,oil,*} \tag{343}$$

Oil price inflation identity
$$\pi_t^{oil,*} = p_t^{oil,*} - p_{t-1}^{oil,*} \tag{344}$$

Logarithm of natural resource price
$$p_t^{NR,*} = 100 \cdot \log(P_t^{NR,*}) \tag{345}$$

Real price of natural resource
$$p_t^{R,NR,*} = p_t^{NR,*} - p_t^{C,US} \tag{346}$$

Real natural resource price inflation
$$\Delta p_t^{R,NR,*} = p_t^{R,NR,*} - p_{t-1}^{R,NR,*} \tag{347}$$

Real natural resource price breakdown
$$p_t^{R,NR,*} = \overline{p}_t^{R,NR,*} + \hat{p}_t^{R,NR,*} \tag{348}$$

Real natural resource price gap
$$\hat{p}_t^{R,NR,*} = c_1^{\hat{p}^{R,NR,*}} \cdot \hat{p}_{t-1}^{R,NR,*} + \varepsilon_t^{\hat{p}^{R,NR,*}} \tag{349}$$

Logarithm of natural resource real price
$$\overline{p}_t^{R,NR,*} = 100 \cdot \log(\overline{P}_t^{R,NR,*}) \tag{350}$$

Real natural resource price trend growth
$$\Delta\overline{p}_t^{R,NR,*} = c_1^{\Delta\overline{p}^{R,NR,*}} \cdot \Delta\overline{p}_{t-1}^{R,NR,*} + (1 - c_1^{\Delta\overline{p}^{R,NR,*}}) \cdot \Delta p^{R,NR,*,SS} + \varepsilon_t^{\Delta\overline{p}^{R,NR,*}} \tag{351}$$

Real natural resource price trend growth identity
$$\Delta\overline{p}_t^{R,NR,*} = \overline{p}_t^{R,NR,*} - \overline{p}_{t-1}^{R,NR,*} \tag{352}$$

Table continues on the next page.

Natural resource price inflation identity

$$\pi_t^{NR,*} = p_t^{NR,*} - p_{t-1}^{NR,*} \tag{353}$$

PUBLICATIONS

FINEX - A New Workhorse Model for Macroeconomic Forecasting and Policy Analysis

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