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optimal policy, capital flows, instruments, target rules, trade-offs, insulation

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The Complementarity of Policy Instruments in an Open Economy Subject to Volatile Capital Flows

By

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Abstract: This paper highlights the complementarity of multiple policy instruments in an open economy subject to volatile capital flows. The central bank operates under a broad mandate and implements optimal policy with discretion. With three policy instruments - the policy rate, an interest equalization measure, and foreign exchange market intervention – the central bank restores the output-inflation trade-off in the canonical closed-economy New Keynesian model. It also achieves perfect stabilization of undesirable hot money flows and insulates the domestic economy, inflation, and the real exchange rate from foreign monetary policy and other demand-side shocks.

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Special thanks to Richard Froyen (†) and Karsten Staehr for stimulating discussions on the topic. All errors are the sole responsibility of the author. My sincere thanks to the Bank of Estonia and the Federal Reserve Bank of Boston for their hospitality. Contact details: alfred.guender@canterbury.ac.nz; Dept. of Economics and Finance, University of Canterbury, Christchurch, New Zealand; (64)-3-369-3958.

Arguably, financial stability considerations have loomed large since the Global Financial Crisis. The growing importance of financial stability as an ultimate objective is in large part due to the consequences of easy monetary conditions in center countries in the aftermath of the crisis. Record low interest rates in the more advanced countries unleashed a search for yield that resulted in huge flows of short-term capital across international borders into smaller open economies, notably emerging countries.

Policymakers in the latter countries became deeply concerned over the destabilizing effects of uncontrolled inflows of hot money on domestic financial markets.[1] Surging asset prices and lending booms were feared to be unsustainable and ultimately damaging to the real economy once market sentiments changed from optimism to pessimism and capital flows reversed. There was also widespread realization in policymaking circles that sole reliance on the policy rate was not sufficient to avoid getting entangled in the web of the global financial cycle that had emerged due to the closer integration of capital markets worldwide and the dominance of the United States as a financial center.

Over the past two decades, smaller and open economies have become increasingly exposed to swings in a global financial cycle that shift vast amounts of capital across international borders.[2] The catalyst for surges and flights of capital is often a monetary policy change by the US Federal Reserve or an abrupt change in risk appetite by global investors, aptly described as episodes of "risk-on" or "risk-off" behavior. The movement of enormous sums of particularly short-term financial capital across international borders has brought about a tighter nexus between capital flows and credit conditions in domestic financial markets of small open economies.[3] Growing concern about this vulnerability has led policymakers in a

[1] Several high-ranking policymakers in emerging countries, notably R. Rajan, the then Governor of the Bank of India and G. Mantega, the then Minister of Finance of Brazil, were quite outspoken in their criticism of the massive injection of liquidity by first-world countries into the global financial system (Blanchard (2017)).
[2]Empirical studies vary on the type of capital flows. Rey (2016) focuses on U.S. dollar debt flows; Kalemli-Özcan (2019) on aggregate debt flows; Caballero (2014) includes portfolio equity flows; Forbes and Warnock (2012), (2021) are most concerned about extreme capital flows. Lane and McQuade (2014) find a robust linkage between cross-border debt flows and domestic credit conditions in advanced (mostly European) countries. Carvalho, Lepers, and Mercado (2025) examine the nexus between capital flows and sectoral credit conditions in emerging countries and propose various measures to control it. On the effectiveness of capital controls, see Landi and Schiavoni (2021) and Rebucci and Ma (2019). For a general overview of the drivers of the global financial cycle, see Miranda-Agrippino and Rey (2022).
[3] Li and Su (2022) make the point that capital inflow surges are associated with more extensive short-term borrowing. Short-maturity demandable debt is a cheaper but riskier source of finance because of potential debt runs.

few countries to resort to additional policy levers in the implementation of stabilization policy. Two of these complementary policy tools are capital flow measures and foreign exchange market intervention.[4,5]

This paper assesses the performance of stabilization policy in a small open economy where the central bank is the sole policymaker and has a broad mandate. Stabilization policy is meant here to include the simultaneous optimal use of three policy instruments: the standard policy rate, the capital flow measure, and foreign exchange market intervention. A broad mandate is understood to be one where the central bank is concerned about core macroeconomic stability and financial stability. Core macroeconomic stability consists of price and output stability. Financial stability is grounded in avoiding excessive flows of short-term debt, termed hot money, in and out of the financial sector and keeping fluctuations in the real exchange rate in check.[6]

Our analysis of optimal discretionary policy in an analytically tractable model reveals a few novel findings. First, the deployment of three policy instruments by the central bank results in three target rules that guide stabilization policy. Second, optimal policy in our open economy framework restores the core macroeconomic trade-off in the canonical New Keynesian model for a closed economy. Third, under optimal policy the target variables are not displaced by aggregate demand disturbances. Fourth, each of the policy instruments is assigned to respond to specific shocks. The policy rate handles domestic credit market shocks; the capital flow measure offsets risk appetite shocks; and foreign exchange market

[4] Apart from the policy tools proper, the quality of the institutional framework that underpins a country's governance appears to mitigate the effect of the global financial cycle on financial stability in emerging countries (Ferrero et al. (2026)).

[5] Responding to record low interest rates in the US, Brazil imposed a tax on interest on domestic assets held by non-residents to counter the inflow of foreign capital. First applied in 2009, it was adjusted multiple times and was set between 2 and 6 percent. Brazilian authorities also intervened in the foreign exchange market. Other Latin American countries also relied on foreign exchange market intervention, notably Chile, Mexico, and Peru. See Cespedes et al. (2014) for an overview of the experience of the four countries during and after the Global Financial Crisis. Switzerland, too, intervened heavily in the foreign exchange market to stabilize the franc. The cap on the Swiss franc was lifted only in 2015.

[6] In the academic literature there are divergent views about the mandate of central banks. The essential disagreement is over the complementarity of macroeconomic and financial stability objectives and what it entails for policymaking. For instance, Woodford (2012) views financial stability as a secondary goal of the central bank whose primary task is to ensure price and output stability. Svensson (2012) is a clear advocate of separating monetary policy from policy geared towards ensuring financial stability. He calls for separate authorities, separate objectives, and separate policy tools. Brunnermeier and Sannikov (2014) take the opposite view and argue that macroeconomic and financial stability are entwined. Financial stability ensures price stability, while the mere attainment of price stability does not necessarily ensure financial stability.

intervention prevents a risk premium shock in the foreign exchange market from spreading to other sectors of the economy. Finally, a foreign monetary policy shock has no spillover effects on the domestic economy. All target variables are insulated from the foreign policy shock because the central bank can eliminate its effect on both domestic interest rates through joint use of the capital flow measure and foreign exchange market intervention.

The remainder of the paper consists of six sections. A short review of related literature appears in Section 2. Section 3 presents the model while Section 4 discusses the policy objectives of the central bank and the implementation of optimal policy. Section 5 briefly explains the target rules underlying optimal policy. In Section 6 we solve the model analytically. In the final section we highlight the complementarity of the three policy instruments and explain why the mere loss of one supplementary tool leads to markedly inferior stabilization outcomes.

2. Related Literature

A few recent contributions have examined the use of multiple policy instruments in an open economy framework. However, only Liu and Spiegel (2015) consider the joint use of the same three policy instruments, and they do so in a context where neither financial stability concerns nor the insulating property of joint effective instrument use are addressed. Their main conclusion is that combining foreign exchange market intervention with a tax on interest earnings by foreigners is effective in containing welfare losses. Alla et al. (2020) and Ghosh et al. (2016) examine the welfare gain of employing only foreign exchange market intervention alongside the policy rate. Both papers conclude that use of the additional policy tool improves welfare substantially. The former also find that foreign exchange market intervention is helpful in curtailing but not eliminating the effects of global risk appetite shocks. Davis and Presno (2017) argue that a capital control measure is welfare-enhancing, reduces the response of the policy rate to a monetary policy change abroad, and affords greater emphasis on containing domestic inflation. Farhi and Werner (2014) propose to combine a flexible exchange rate with capital controls that lean against the wind. This combination mitigates fluctuations in consumption, the terms of trade, and capital flows. Adrian et al. (2020) report that intervention in the foreign exchange market or a capital flow measure is similarly effective in stabilizing the domestic economy in conjunction with standard monetary policy. Using a very elaborate framework, Basu et al. (2025) conclude

that foreign exchange market intervention as a complementary tool is appropriate only in settings where capital mobility is limited and financial markets are shallow. Capital controls are a useful countercyclical tool to prevent systematic overborrowing in good times.

3. The Model

A log-linear open economy New Keynesian model serves as the basic framework for our analysis.[7] Apart from the core equations – a Phillips curve and IS equation - the model features a credit market and provides an explicit channel through which capital flows impact the credit market. The model of a small open economy consists of the following equations:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t + b q_t + u_t \quad (1)$$

$$y_t = E_t y_{t+1} - a_1(\rho_t - E_t \pi_{t+1}) + (a_2 - a_1\gamma)(q_t - E_t q_{t+1}) + a_3(y_t^f - E_t y_{t+1}^f) + v_t \quad (2)$$

All model parameters are positive. Equations (1) and (2) are an open-economy Phillips curve and IS relation where π_t = domestic inflation, y_t = the output gap, and $E_t(.)$ denotes the expectation of a variable formed at time *t*. Both relations feature a real exchange rate channel (q_t) and include a stochastic disturbance (u_t, v_t). In the IS relation, the foreign output gap (y_t^f), which drives the demand for exports, is treated as a stochastic random variable. The size of the expenditure switching effect in the IS relation is captured by $a_2 - a_1\gamma > 0$. The market interest rate ρ_t (rather than the policy instrument i_t) affects the demand for goods in the *IS* relation.[8] Control over aggregate demand is thus determined by the extent to which the central bank can steer the market interest rate.[9] A simple credit market is described by equations (3) and (4).

$$C_t^D = d(\rho_t - i_t) + d_1 E_t y_{t+1} + z_t^d \quad (3)$$

$$C_t^S = -s(\rho_t - E_t \pi_{t+1}) + s_1 E_t y_{t+1} + z_t^s \quad (4)$$

[7] This section focuses exclusively on the aggregate framework. The appendix provides further details about the microeconomic underpinnings of the aggregate model.

[8] Guender (2006) and Monacelli (2013) incorporate a real exchange rate channel into the Phillips curve. Both papers also provide microeconomic underpinnings for the aggregate relations. Ravenna and Walsh (2006) and Friedman (2013) motivate the inclusion of a market interest rate in the IS relation in a closed economy model.

[9] The depth of financial markets is of crucial importance here. Kalemli-Ozcan (2019) points out that central bank control over market interest rates may be imperfect, particularly in emerging countries, due to the thinness of financial markets.

According to equation (3), the demand by domestic investors for a privately issued asset, a short-term bond, increases as the spread between the risky market rate rises relative to the riskless interest rate, which is taken to be the policy instrument. In equation (4), the supply of bonds is inversely related to the cost of credit, measured by the expected real market rate of interest. Reflecting an optimistic outlook on the future, a positive expected output gap stimulates both sides of the credit market. Both credit market relations are subject to a stochastic disturbance (z_t^d, z_t^s).[10]

The next two relations describe financial flows across borders.

$$CAP_t = c_1(\rho_t - E_t\pi_{t+1} - (\rho_t^f - E_t\pi_{t+1}^f + E_t q_{t+1} - q_t + \varepsilon_t)) \quad (5)$$

$$L_t = L^* + l_1(\rho_t - \tau_t - \rho_t^f) - l_2 VIX_t \quad (6)$$

Equations (5) and (6) represent capital flows of which there are two types. CAP_t represents equity, foreign direct investment, and debt flows other than hot money on the standard capital account. These capital movements are imperfectly mobile; they respond to the difference in expected yields in the domestic economy relative to those abroad with $c_1 > 0$ measuring the sensitivity of these flows to the difference in expected yields.[11] In contrast, L_t is distinct from CAP_t and denotes short-term volatile debt flows, termed hot money, that enter or exit the domestic credit market. Hot money flows directly affect domestic credit conditions as they impact credit availability and the market interest rate. As shown by equation (6), these flows, relative to a target level L^*, depend in the absence of taxation or subsidies (τ_t=0) on the difference between the domestic and foreign market interest rate

[10] The modelling of the domestic credit market is kept intentionally simple. The primary aim is to motivate a distinction between the market interest rate and the policy rate in the model. Think of two different types of households: patient and impatient. Impatient households issue bonds at the going market rate to partly finance their consumption needs. Patient households' willingness to purchase bonds varies positively with the spread between the market and the policy rate. Alternatively, bank loans could substitute for the financial asset in which case eqn. (3) represents the supply of bank loans and eqn. (4) the demand for bank loans. Banks increase loans as the spread between the bank lending rate and the cost of raising deposits, which equals the riskless rate, widens. See Curdia and Woodford (2011) who motivate the existence of a bank lending – deposit rate spread by the existence of loan origination cost and loan losses. They also distinguish between patient and impatient households.

[11] Equation (5) reduces to the uncovered interest rate parity condition if $c_1 \to \infty$.

and on the level of risk appetite VIX_t in world financial markets. [12] A higher domestic market interest rate compared to the foreign (centre country such as the United States) interest rate, for instance, is sufficient to attract inflows of hot money as foreign speculators take advantage of the market interest rate difference. Greater risk appetite amongst international investors ($VIX_t \downarrow$) also leads to capital inflows beyond the target level L^*. l_1 measures the sensitivity of hot money flows to the interest rate differential while l_2 captures the effect of risk appetite on cross-border hot money flows.

$$CAP_t + L_t + FXI_t + TB_t = 0 \quad (7)$$

$$L_t + C_t^D + C_t^{CB} = C_t^S \quad (8)$$

$$TB_t = -t_1 y_t + t_2 q_t + t_3 y_t^f \quad (9)$$

Equation (7) represents the balance of payments equilibrium condition where the trade balance (TB_t), both types of capital flows (CAP_t, L_t) and official foreign exchange transactions (FXI_t) sum to zero. An increase in FXI_t denotes a sale of foreign currency reserves by the central bank. The balance of sources and uses of funds in the domestic credit market appears in equation (8), which also exemplifies the "hot money – credit" nexus.[13] The trade balance relation and its drivers are spelled out in equation (9).

The model above permits the use of three policy instruments by the central bank. First, there is the standard policy tool i_t that acts as a benchmark for the market determined interest rate (ρ_t). The second tool, the capital flow measure, is a time-varying interest equalization tool (τ_t) that the central bank can activate to regulate the flow of hot money. For instance, if the foreign (US) interest rate decreases, which stimulates flows of hot money into the domestic credit market, the central bank can impose a tax on the interest rate earned by foreign investors to stem these inflows. The third tool comes in the form of intervention in the foreign exchange market (FXI_t) through foreign reserves transactions.

[12] A lower value of VIX implies greater risk appetite amongst international investors. One can equally think of VIX as a barometer of optimism in a leading financial market, such as the US capital market. The choice of $L^*$is aligned with market fundamentals and set by the central bank.

[13] We abstract from unconventional monetary policy through purchases of credit obligations by the central bank ($C_t^{CB} = 0$) that may be precipitated by the zero lower bound constraint for the policy interest rate.

Equations (3), (4), (6), and (8) establish a relationship between the market rate and the two policy instruments i_t and τ_t:[14]

$$\rho_t = \frac{1}{d+l_1+s}(z_t^s\text{-}z_t^d + di_t + l_1(\rho_t^f + \tau_t) + l_2 VIX_t - L^*) \qquad (10)$$

Equations (5), (6), (7) and (9) establish a relationship between the real exchange rate, the two policy instruments FXI_t and τ_t the market interest rate, and the output gap:

$$q_t = \frac{1}{c_1+t_2}(-L^* + (l_1+c_1)(\rho_t^f - \rho_t) + l_1\tau_t + l_2 VIX_t - FXI_t) + t_1 y_t - t_3 y_t^f + \varepsilon_t \qquad (11)$$

Equations (10) and (11) figure as important constraints in the derivation of the target rules which underlie optimal monetary policy. Before we turn to a discussion of these rules, we describe in the next section the objective function of the policymaker and the type of optimal monetary policy the central bank is assumed to implement.

2. The Central Bank's Objectives and Optimal Policy

The primary concern of the central bank is to stabilize domestic inflation and the output gap.[15] Financial stability ranks as a secondary concern. The central bank's interpretation of financial stability extends to limiting undesirable capital flows of "hot money" in addition to avoiding excessive fluctuations in the real exchange rate.

Recent experience has shown that capital surges and stops triggered by monetary policy changes abroad or changes in global risk appetite can undermine the ability of the domestic financial sector to intermediate funds between borrowers and savers efficiently and can threaten the financial health of private sector companies. For instance, large scale inflows of foreign hot money during good times cause an undesirable appreciation of the domestic currency that puts domestic products at a competitive disadvantage in world markets and often cause systematic overborrowing (in both domestic and foreign currency) that may later lead to insolvency when the economic cycle turns and the domestic currency depreciates. Severe depreciations are undesirable because they have the potential of

[14] From hereon we set $E_t y_{t+1}$= 0 = $E_t q_{t+1}$= $E_t \pi_{t+1}$as all shocks are considered white noise and optimal policy is set by discretion. Introducing serially correlated disturbances does not affect the specification of the target rules in Section 4 but complicates the derivation of the analytical solutions of the model. We defer discussion of the effects of serially correlated disturbances until Section 6.2.

[15] The source of the nominal friction is the rigidity of domestic prices.

worsening the financial burden of firms borrowing in foreign currency. Adverse balance sheet effects at best lead to financial bottlenecks that interfere with the smooth production of output and in the worst case lead to widespread bankruptcy.[16] Concern for financial stability thus requires a central bank to avoid excessive fluctuations in hot money flows from target and the real exchange rate alike.

The central bank implements policy by discretion and minimizes the following intertemporal objective function:

$$\sum_{j=0}^{\infty} \beta^j [\frac{1}{2}(y_{t+j}^2 + \mu\pi_{t+j}^2 + \delta((L_{t+j} - L^*)^2 + q_{t+j}^2))] \qquad \beta \leq 1 \qquad (12)$$

where $\delta < \mu$ reflects the secondary concern with financial stability compared to macroeconomic stability. For convenience we set the inflation target and the real exchange rate target equal to zero.[17] There are no costs associated with the use of policy instruments.[18]

The constraints faced by the central bank consist of the Phillips curve and the IS relation where the real exchange rate has been replaced by equation (11) plus the equilibrium condition in the credit market represented by equation (10). Minimizing the period loss function subject to the model constraints and combining the optimizing conditions produces the target rule(s) that guides optimal policy.[19]

3. The Target Rules Under Optimal Discretionary Policy

Throughout the discussion in this section, we make one fundamental assumption. The central bank has fewer policy instruments than ultimate targets. The existence of a cost-push shock in the Phillips curve therefore causes tension between the achievement of the

[16] Blanchard et al. (2010) and Ghosh et al. (2015) are firm advocates of the view that stability of the real exchange rate ought to be a policy objective in small open economies. Cespedes et al. (2014, p. 204) argue that the crisis period of 2008/09 is a good example for why "in emerging economies central banks may be much more concerned about external variables – such as capital flows and exchange rates – and about preserving credibility than are monetary authorities in advanced economies."

[17] Thus, the aim of the central bank is to achieve parity between the price of the domestically produced good and the price of the foreign good expressed in domestic currency.

[18] Sceptics would point to the distortions caused by the imposition of a tax on yields (Dunn (1983), Fischer (2010), Jeanne (2022)). Foreign exchange intervention may also involve carry cost.

[19] A step-by-step derivation of the target rules is laid out in the appendix.

inflation and output goal, respectively.[20] The instrument shortage results in trade-offs between the target variables. These trade-offs appear in the three target rules that show how the target variables are related to each other under (discretionary) optimal monetary policy.

$$y_t + \mu\kappa\pi_t = 0 \qquad (13)$$

$$\delta q_t + \mu b\pi_t = 0 \qquad (14)$$

$$\delta l_1(L_t - L^*) = a_1(y_t + \mu\kappa\pi_t) \qquad (15)$$

The deployment of the three policy instruments results in three separate target rules. The first of these, equation (13), permits the central bank to trade output gap deviations directly for deviations of inflation from target by manipulating the policy rate, just like in the canonical closed-economy New Keynesian framework. The second target rule, equation (14), encapsulates the trade-off between the rate of inflation and the real exchange rate that the central bank manages through the exchange rate channel in the Phillips curve. This trade-off pits a core macroeconomic objective against a financial stability objective. The third target rule, equation (15), implies there is no trade-off between undesirable capital flows from target and core macroeconomic stability thanks to the central bank's ability to fully stabilize capital flows at their desired level through optimal choice of the interest equalization tax. The dependence of the requisite trade-offs in equations (13) and (14) on only Phillips curve parameters (b, κ) next to preference parameters (μ, δ) foreshadows that the central bank exercises complete control over aggregate demand by appropriate deployment of its three policy instruments. This crucial finding is established in the next section.

4. Solving the Model

6.1 Analytical Solutions for White Noise Disturbances

The starting point of the solution procedure is one of the three target rules that underpin optimal discretionary policy. Equation (14) establishes the optimal relation between the real exchange rate and the rate of inflation. It can be restated here as

[20] Aizenman (2019) and Obstfeld ((2015), (2020)) point to the existence of these trade-offs but do not examine them in the context of a specific model.

$$q_t = -\frac{\mu b}{\delta}\pi_t \qquad (16)$$

The above relation can be used to eliminate the real exchange rate from the Phillips curve:

$$\pi_t = \frac{1}{1+\frac{b^2\mu}{\delta}}(\kappa y_t + u_t) \qquad (17)$$

Substituting equation (17) into the first target rule (equation (13)) yields the solution for the output gap in the three-instrument case:

$$y_t = -\frac{\mu\kappa}{\mu(\kappa^2 + \frac{b^2}{\delta}) + 1}u_t \qquad (18)$$

The above result can be combined with the target rule (equation (13)) to yield the solution for the rate of inflation:

$$\pi_t = \frac{1}{\mu(\kappa^2 + \frac{b^2}{\delta}) + 1}u_t \qquad (19)$$

The solution for the real exchange rate follows directly from equation (16) after substituting for the rate of inflation on the right-hand side:

$$q_t = -\frac{\frac{\mu b}{\delta}}{\mu(\kappa^2 + \frac{b^2}{\delta}) + 1}u_t \qquad (20)$$

The reaction function of the market interest rate can be obtained by substituting the Phillips curve and IS relation (after eliminating the real exchange rate) into the target rule (eqn. (13)) and solving for ρ_t:

$$\rho_t = \frac{1}{a_1}\left(\frac{\mu\left(\kappa - \frac{(a_2 - a_1\gamma)b}{\delta}\right)}{\mu\left(\kappa^2 + \frac{b^2}{\delta}\right) + 1}u_t + v_t + a_3 y_t^f\right) \qquad (21)$$

The solutions for the market interest rate and the real exchange rate can then be used to determine the trade balance and the standard capital account balance:

$$TB_t = \frac{\mu(t_1\kappa - t_2\frac{b}{\delta})u_t}{\mu\left(\kappa^2 + \frac{b^2}{\delta}\right) + 1} + t_3 y_t^f \tag{22}$$

$$CAP_t = c_1[\mu\left(\frac{\frac{1}{a_1}\left(\kappa - \frac{(a_2 - a_1\gamma)b}{\delta}\right) - \frac{b}{\delta}}{\mu\left(\kappa^2 + \frac{b^2}{\delta}\right) + 1}\right)u_t + \frac{1}{a_1}\left(v_t + a_3 y_t^f\right) - \rho_t^f - \varepsilon_t] \tag{23}$$

Optimal policy shields the trade balance is from all demand-side shocks except a foreign demand shock. In sharp contrast, the standard capital account must absorb the effects of all demand-side shocks except a risk-appetite shock. The respective effect of a cost-push shock on the trade balance and the standard capital account balance cannot be signed unambiguously and depends on key demand-side, Phillips curve, and the central bank's own preference parameters. In contrast, the effects of demand-side shocks on TB_t and $CAP_t$are clear-cut and depend only on demand-side parameters.

To get the optimal instrument responses, we proceed as follows. For the foreign exchange market intervention response to the shocks, substitute the solutions for the trade balance and the standard capital account into the balance of payments equation (7):

$$FXI_t = \frac{\mu[c_1\left(\frac{b}{\delta}(a_1(1-\gamma)+a_2)-\kappa\right)+a_1\left(t_2\frac{b}{\delta}-t_1\kappa\right)]}{a_1(\mu(\kappa^2+\frac{b^2}{\delta})+1)}u_t - \frac{c_1}{a_1}v_t - \left(\frac{c_1 a_3}{a_1} + t_3\right)y_t^f + c_1(\varepsilon_t + \rho_t^f) \tag{24}$$

The optimal reaction of the interest equalization tax tool is:

$$\tau_t = \frac{1}{a_1}\left(\frac{\mu\left(\kappa - \frac{(a_2 - a_1\gamma)b}{\delta}\right)}{\mu\left(\kappa^2+\frac{b^2}{\delta}\right)+1}\right)u_t + \frac{1}{a_1}v_t + \frac{a_3}{a_1}y_t^f - \rho_t^f - \frac{l_2}{l_1}VIX_t \tag{25}$$

The optimal feedback setting for the policy rate is given by:

$$i_t = \frac{\mu\left(\kappa - \frac{(a_2 - a_1\gamma)b}{\delta}\right)(s+d)}{a_1 d(\mu(\kappa^2+\frac{b^2}{\delta})+1)}u_t + \frac{(d+s)}{a_1 d}\left(v_t + a_3 y_t^f\right) + \frac{1}{d}(z_t^d - z_t^s) \tag{26}$$

There are several noteworthy findings in the present case.

First, by following the reaction function for the interest equalization tax (equation (25)), the central bank stabilizes $L_t$at L^*(= 0). There are no fluctuations in hot money flows.

Second, the remaining target variables ($\pi_t y_t, q_t$) are displaced only by cost-push shocks. The insulation of the domestic economy from <u>all</u> demand-side disturbances is the result of synergy effects of optimal policy. The simultaneous use of all three policy levers prevents a change in the real exchange rate in the wake of demand-side shocks and thus prevents the Phillips curve from shifting. The irrelevance of demand-side characteristics is further underscored by the sensitivity of π_t, y_t, and q_t to cost-push shocks depending only on the central bank's relative emphasis on macroeconomic versus financial stability(μ, δ) and two Phillips curve(κ, b) parameters. It is important to note that both the output gap and the rate of inflation are less sensitive to a cost-push shock in an open compared to a closed economy due to the stabilizing effect of the real exchange rate on inflation in the Phillips curve: b appears in the denominator of the coefficient on u_t.

Third, neither the policy rate nor the market interest rate responds to the foreign interest rate. There are thus no spill-over effects from a monetary policy change abroad on the domestic monetary policy stance. The task of handling a change in monetary policy abroad falls squarely on τ_t and FXI_t. Both policy instruments respond to insulate the domestic economy from the effects of a monetary policy change abroad.[21] According to equation (24), the central bank purchases (sells) foreign currency reserves in the foreign exchange market to counter the appreciation (depreciation) of the domestic currency in the wake of a decrease (increase) of ρ_t^f. In equation (25) the tax instrument increases (decreases) one-for-one following a decrease (an increase) in ρ_t^f. Similarly, both domestic interest rates are immune to shifts in global risk appetite. A sudden change in investor sentiment evokes merely an adjustment in the time-varying interest equalization tool. On the whole then, the spread between the market rate and the riskless policy rate is immune to both a foreign

[21] This result articulates the gain that simultaneous application of the tax tool and FX intervention delivers by freeing the main policy instrument from responding to a foreign monetary policy shock. See Froyen and Guender (2022) for the optimal response of the policy rate to a foreign monetary policy shock in the sole instrument case.

monetary policy shock and a shift in global risk appetite, thus ensuring stability in the domestic financial market and the real economy.

Fourth, the response of the two domestic interest rates to a cost-push shock is ambiguous and depends primarily on the strength of the output gap channel in the Phillips curve relative to the real exchange rate channels in the IS relation and the Phillips curve, as well as the relative emphasis on financial stability as an ultimate objective. The response of τ_t and FXI_t to a cost-push shock is similarly ambiguous, and in the case of FXI_t depends on additional parameters that capture the degree of capital mobility and effects of fundamentals on the trade balance.

Fifth, certain parameters are exclusively tied to the response of a policy instrument. For instance, c_1, t_1, t_2, t_3 figure only in the response of foreign exchange market intervention to shocks. Similarly, l_1 and l_2 appear only in the response of the tax instrument to a risk appetite shock. Domestic credit market parameters *d* and *s* only show up in the reaction function of the standard policy instrument i_t (equation (26)).

Finally, the three policy instruments offset demand-side disturbances ($v_t, y_t^f, \varepsilon_t, \rho_t^f, VIX_t$) and domestic credit market disturbances (z_t^d, z_t^s) mechanically, i.e. the central bank's preference parameters (μ, δ) do not figure in the respective responses to a demand-side shock. Also note that FXI_t handles exclusively risk premium shocks; the tax tool is exclusively responsible for offsetting risk appetite shocks; and the policy rate eliminates domestic credit market shocks. Thus, the availability of three instruments enables the central bank not only to assign specific instruments to respond to specific demand-side shocks but also to nullify the latter's effects on the target variables. This is in marked contrast to results reported elsewhere (e.g. Alla (2020) in a two-instrument setting where FX intervention must handle risk appetite and risk premium shocks but cannot fully stabilize the target variables).

6.2 Impulse Response Functions for AR(1) Disturbances

A quick look at the impulse response functions of the variables to a serially correlated cost-push shock, depicted in Figure 1, shows that the joint effective use of the three policy

instruments leads to desirable stabilization outcomes.[22] Suppose the cost-push shock is an autoregressive ($\phi = 0.8$) mark-up factor. A one-percent increase in the mark-up leads to a three-percent increase (decrease) in the rate of inflation (real exchange rate) but only to a moderate decrease in real output. The relatively sharp increase in the inflation rate is primarily due to the small weight on the inflation rate ($\mu\kappa = .90 * 0.1$) in the target rule (eqn. 13).

The cost-push shock also prompts a sharp reaction by the two domestic interest rates and the tax tool. The brunt of the adjustment is borne by foreign exchange market intervention to restore balance of payment equilibrium. Sales of foreign exchange reserves increase to offset the negative trade balance and the negative standard capital account balance due in large part to the relatively sharp appreciation of the domestic currency.

Figure 2 underscores the singular insulation capacity of the three-instrument case in the wake of a foreign monetary policy easing that was established in Section 6.1. The figure illustrates the sharp reaction of the tax and intervention tools to a one percentage point decrease in the foreign interest rate. The matching increase in the interest equalization tax snuffs out the effect of the easing of monetary policy abroad and stabilizes hot money flows at the target level. The standard capital account turns positive because of the lower foreign interest rate and an unchanged real exchange rate ensured by foreign exchange market intervention. Purchases of foreign exchange reserves cancel the inflow of foreign capital on the standard capital account to keep the balance of payments in equilibrium.

5. Conclusion

By convention, small open economies resort to ex-post instruments to protect their economies from disruptive exogenous shocks. This paper underscores the complementarity of three policy tools in the implementation of optimal discretionary stabilization policy in an open economy where capital flows matter. By effectively combining all three policy tools, the central bank generates superior stabilization outcomes. Notably, the joint use of instruments enables a central bank with a broad mandate to replicate two crucial outcomes in a small open economy that obtain under a dual mandate in the standard New Keynesian

[22] The values of the parameters used and the size of the variances of the shocks are listed in the appendix.

closed economy model: first, the output-inflation trade-off depends only on the central bank's relative aversion to inflation variability and the sensitivity of the rate of inflation to the output gap and, second, demand-side disturbances have no effect on the target variables, which include the real exchange rate and hot money flows in addition to the inflation rate and the output gap. Importantly, a foreign monetary policy shock does not prompt a change in the domestic policy rate because the central bank adjusts the tax tool and uses foreign exchange market intervention to nullify the effect of the policy change abroad. The domestic economy is completely insulated from this source of perturbation. Thus, the effective deployment of all three instruments reproduces the isomorphism result, according to which optimal policy in an open economy is akin to policymaking in a closed economy (Clarida, Gali, and Gertler (2002)).

The mere loss of one of the supplementary policy instruments, the interest equalization tool or foreign exchange market intervention, leads to the breakdown of the isomorphism result. Stabilization policy loses its singular ability to shield the target variables from demand-side shocks, including foreign monetary policy shocks. With two instruments only, the central bank can no longer shut down the real exchange rate channel in the Phillips curve. Thus, a demand-side shock, including a foreign monetary policy shock, affects the real exchange rate through its effect on the policy and market interest rate. Insulation disappears as both the output gap and the inflation rate need to adjust. The central bank must now confront a trade-off between core macroeconomic stability and financial stability objectives. Further exploration of the exact nature of this trade-off is left for future research.

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Figure 1: Impulse Response Functions to a Positive Cost-Push Shock: TB=Trade Balance

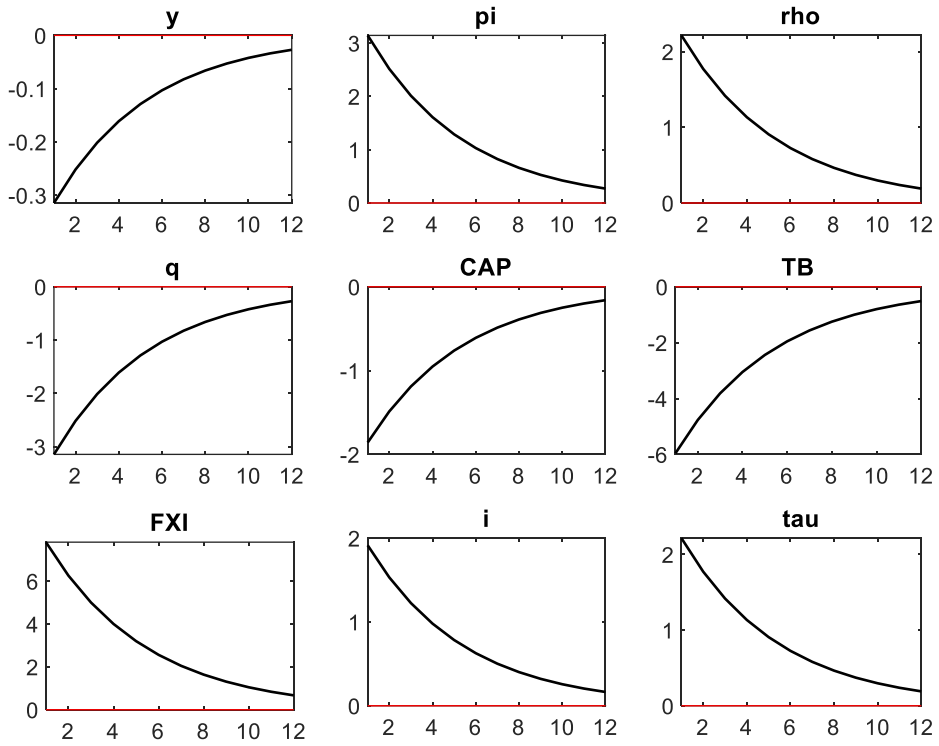
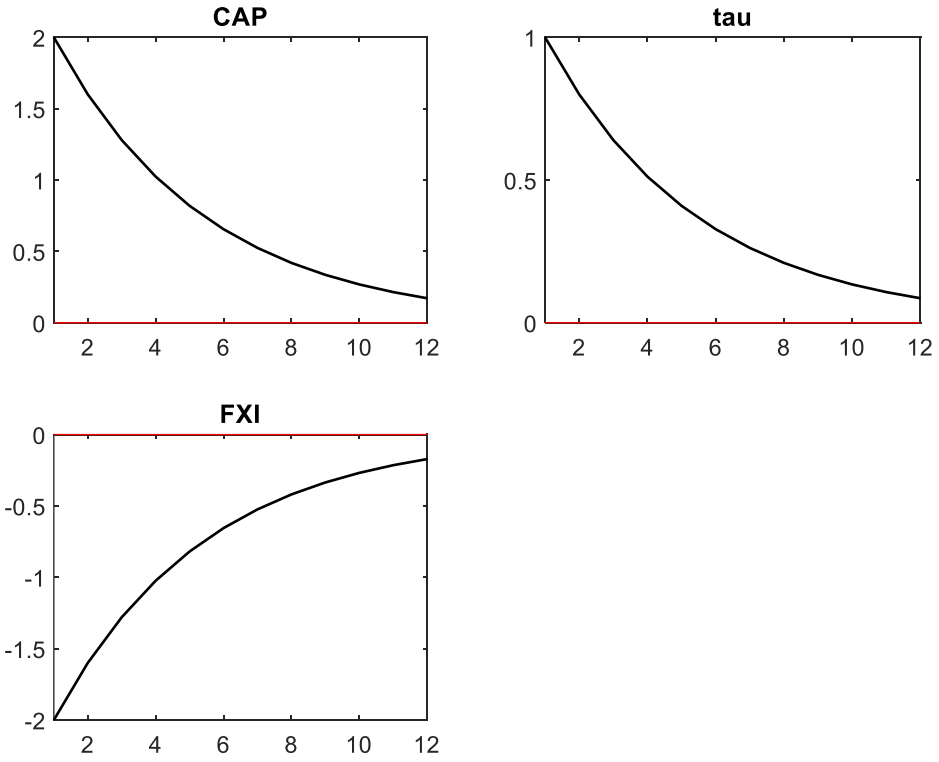


Figure 2: Impulse Response Functions to a Negative Foreign Interest Rate Shock



Appendix

Optimal Discretionary Policy and the Underlying Target Rules:

The Lagrangean underlying the choice of optimal policy is composed of the objective function of the central bank in period *t* and the model's equations that serve as constraints. The policy horizon of the central bank is confined to the current period only. All shocks are considered independent white noise. Hence, we can omit all current expectations of future variables. Equation (11) in the paper is used to substitute for the real exchange rate, and equation (10) represents the relationship between the market interest rate, the policy rate, and the tax instrument in credit market equilibrium. The Lagrangean is given by:

$$\mathcal{L}_t = \frac{1}{2}[y_t^2 + \mu\pi_t^2 + \delta((l_1(\rho_t - \tau_t - \rho_t^f) - l_2 VIX_t)^2 + \left(-\frac{L^*}{c_1+t_2} + \left(\frac{1_1+c_1}{c_1+t_2}\right)(\rho_t^f - \rho_t) + \frac{l_1}{c_1+t_2}\tau_t + \frac{l_2}{c_1+t_2}VIX_t - \frac{FXI_t}{c_1+t_2} + \frac{c_1}{c_1+t_2}\varepsilon_t + \frac{t_1}{c_1+t_2}y_t - \right.$$
$$\left. - \frac{t_3}{c_1+t_2}y_t^f\right)^2)] + \lambda_{1t}\left(\kappa y_t + b\left(-\frac{L^*}{c_1+t_2} + \left(\frac{1_1+c_1}{c_1+t_2}\right)(\rho_t^f - \rho_t) + \frac{l_1}{c_1+t_2}\tau_t + \frac{l_2}{c_1+t_2}VIX_t - \frac{FXI_t}{c_1+t_2} + \frac{c_1}{c_1+t_2}\varepsilon_t + \frac{t_1}{c_1+t_2}y_t - \frac{t_3}{c_1+t_2}y_t^f\right) + u_t - \pi_t\right) +$$
$$\lambda_{2t}\left(a_3 y_t^f - a_1\rho_t + (a_2 - a_1\gamma)\left(-\frac{L^*}{c_1+t_2} + \left(\frac{1_1+c_1}{c_1+t_2}\right)(\rho_t^f - \rho_t) + \frac{l_1}{c_1+t_2}\tau_t + \frac{l_2}{c_1+t_2}VIX_t - \frac{FXI_t}{c_1+t_2} + \frac{c_1}{c_1+t_2}\varepsilon_t + \frac{t_1}{c_1+t_2}y_t - \frac{t_3}{c_1+t_2}y_t^f\right) + v_t - y_t\right) +$$
$$\lambda_{3t}\left(\frac{1}{d+l_1+s}\left(z_t^s - z_t^d + di_t + l_1(\tau_t + \rho_t^f) + l_2 VIX_t\right) - \rho_t\right) \quad \text{(A.1)}$$

The first-order conditions (FOC) with respect to $(y_t, \pi_t, \rho_t, \tau_t, FXI_t, i_t)$ are:

$$y_t + \frac{\delta t_1}{c_1+t_2}q_t + \lambda_{1t}\left(\kappa + b\frac{t_1}{c_1+t_2}\right) - \lambda_{2t}((a_2 - a_1\gamma)\frac{t_1}{c_1+t_2} - 1) = 0 \qquad \text{(A.2)}$$

$$\mu\pi_t - \lambda_{1t} = 0 \qquad \text{(A.3)}$$

$$\delta(l_1(L_t - L^*) - \left(\frac{1_1+c_1}{c_1+t_2}\right)q_t) - \lambda_{1t}b\left(\frac{1_1+c_1}{c_1+t_2}\right) - \lambda_{2t}(a_1 + (a_2 - a_1\gamma)\left(\frac{1_1+c_1}{c_1+t_2}\right)) - \lambda_{3t} = 0 \qquad \text{(A.4)}$$

$$\delta((-l_1)(L_t - L^*) + \left(\frac{1_1}{c_1+t_2}\right)q_t) + \lambda_{1t}b\left(\frac{1_1}{c_1+t_2}\right) + \lambda_{2t}(a_2 - a_1\gamma)\left(\frac{1_1}{c_1+t_2}\right) + \lambda_{3t}(\frac{l_1}{d+l_1+s}) = 0 \qquad \text{(A.5)}$$

$$\delta q_t\left(-\frac{1}{c_1+t_2}\right) + \lambda_{1t}b\left(-\frac{1}{c_1+t_2}\right) + \lambda_{2t}(a_2 - a_1\gamma)\left(-\frac{1}{c_1+t_2}\right) = 0 \qquad \text{(A.6)}$$

$$\lambda_{3t}\left(\frac{1}{d+l_1+s}\right)d = 0 \qquad \text{(A.7)}$$

From the last equation it follows that $\lambda_{3t} = 0$. Also note that the FOC for $\tau_t$does not contain information that is not part of the FOC for ρ_t. Hence the fourth FOC can be safely ignored in the three-instrument case.

Solving the FOC for FXI_t (A.6) for the real exchange rate yields:

$$q_t = \left(-\frac{1}{\delta}\right)(\lambda_{1t} b + \lambda_{2t}(a_2 - a_1\gamma)) \qquad \text{(A.8)}$$

This result for the real exchange rate can be substituted into the FOC for ρ_t (eq. A.4). The resulting equation is:

$$\delta l_1(L_t - L^*) - \lambda_{2t} a_1 = 0 \qquad \text{(A.9)}$$

From the FOCs for y_t and π_t we obtain:

$$y_t + \mu\kappa\pi_t = \lambda_{2t} \qquad \text{(A.10)}$$

Hence, we can now substitute for λ_{2t} in (A.9):

$$\delta l_1(L_t - L^*) - (y_t + \mu\kappa\pi_t)a_1 = 0 \qquad \text{(A.11)}$$

The central bank uses τ_t to ensure $(L_t - L^*) = 0$. Doing so allows the central bank to follow a closed-economy target rule:

$$y_t + \mu\kappa\pi_t = 0 = \lambda_{2t} \qquad \text{or} \qquad \frac{1}{\mu\kappa} y_t = -\pi_t. \qquad \text{(A.12)}$$

The IS relation thus does not act as a constraint. A relationship between the real exchange rate and the rate of inflation emerges after substituting $\lambda_{1t} = \mu\pi_t$ and $\lambda_{2t} = 0$ into equation (A.8):

$$q_t = -\frac{1}{\delta}\mu b\pi_t \qquad \text{(A.13)}$$

Equations (A.11), (A.12), and (A.13) are the target rules in the text.

Appendix B: Microeconomic Underpinnings

1. Aggregate Demand Specification

Letting a lower-case letter express a log deviation of the variable from its long-run value, we can state the resource constraint for domestic output as

$$y_t = (1-\omega)c_t^h + \omega c_t^{hf}, \quad \text{(B1)}$$

where y_t= output, c_t^h= domestic consumption of domestically produced output, c_t^{hf} = foreign consumption of domestically produced output (exports), and ω represents the (long-run) share of exports in (long-run) output.

The standard Euler equation for total consumption c_t reads

$$c_t = E_t c_{t+1} - \sigma(\rho_t - E_t \pi_{t+1}^{CPI}), \quad \text{(B2)}$$

where ρ_t= market interest rate, $E_t\pi_{t+1}^{CPI}$= expected rate of CPI inflation, and σ = intertemporal elasticity of substitution.

Total consumption c_t decomposes into consumption of domestically produced output and imports

$$c_t = (1-\gamma)c_t^h + \gamma c_t^m, \quad \text{(B3)}$$

where c_t^m= imports and γ = share of imports in total consumption.

Combining equations (B.2) and (B.3), yields

$$(1-\gamma)c_t^h + \gamma c_t^m = E_t\left[(1-\gamma)c_{t+1}^h + \gamma c_{t+1}^m\right] - \sigma(\rho_t - E_t\pi_{t+1}^{CPI}). \quad \text{(B4)}$$

Next, use domestic resource constraint (eqn. (B.1)) to substitute for c_t^h in equation (B.4):

$$\frac{y_t - \omega c_t^{hf}}{1-\omega} = c_t^h.$$

This permits equation (B.4) to be rewritten as

$$(1-\gamma)\left(\frac{y_t-\omega c_t^{hf}}{1-\omega}\right) = E_t\left[(1-\gamma)\left(\frac{y_{t+1}-\omega c_{t+1}^{hf}}{1-\omega}\right)\right] + \gamma(E_t c_{t+1}^m - c_t^m) - \sigma(\rho_t - E_t\pi_{t+1}^{CPI}), \quad \text{(B5)}$$

The demand for home-produced exports is given by

$$c_t^{hf} = c_t^f + \eta^f(1-\gamma^f)q_t \quad \text{(B6)}$$

where c_t^f = total foreign consumption, η^f = the foreign elasticity of substitution of foreign for domestic consumption, γ^f = the share of imports in total foreign consumption, q_t= the real exchange rate defined as

$$q_t = p_t^f + e_t - p_t, \quad \text{(B7)}$$

where p_t^f = the price of the foreign consumption good in foreign currency

e_t= nominal exchange rate (domestic currency per unit of foreign currency)

p_t= price of domestic consumption good.

Foreign consumption c_t^f is a fraction of foreign output y_t^f: $c_t^f = \beta^f y_t^f$ (B8)

Import demand in the domestic economy depends inversely on the price of the foreign relative to the domestic good and total domestic consumption:

$$c_t^m = -\eta(1-\gamma)q_t + c_t \quad \text{(B9)}$$

Equation (B.9) can now be substituted into equation (B.3) to eliminate c_t^m.

$$c_t = c_t^h - \eta\gamma q_t \quad \text{(B10)}$$

After substituting equation (B.10) into the Euler equation (B.2), we obtain

$$c_t^h - \eta\gamma q_t = E_t c_{t+1}^h - \eta\gamma E_t q_{t+1} - \sigma(\rho_t - E_t \pi_{t+1}^{CPI}). \quad \text{(B11)}$$

Next, solve the domestic resource constraint for c_t^h and substitute the resulting equation into the above equation.

After some manipulation, the IS equation takes the following form:

$$y_t = E_t y_{t+1} - a_1(\rho_t - E_t\pi_{t+1}) + (a_2 - a_1\gamma)(q_t - E_t q_{t+1}) + a_3(y_t^f - E_t y_{t+1}^f) \quad \text{(B12)}$$

$$a_1 = (1-\omega)\sigma$$

$$a_2 = (1-\omega)\gamma\eta + \omega(1-\gamma^f)\eta^f$$

$$a_3 = \omega\beta^f$$

The derivation of the IS equation is based on a few additional assumptions. For $\eta = 1$, the consumer price index is a weighted average of the price of the domestic and foreign consumption good: $p_t^{CPI} = (1-\gamma)p_t + \gamma(p_t^f + e_t)$. Under perfect exchange rate pass-through the rate of CPI inflation can then be written as: $\pi_t^{CPI} = \pi_t + \gamma\Delta q_t$. Updating and taking conditional expectations of π_t^{CPI} permits the replacement of $E_t\pi_{t+1}^{CPI}$ in equation (B.11).

2. Trade Balance

Define the trade balance as $TB_t = c_t^{hf} - c_t^m$. (B13)

From equation (B.9) we know that imports are inversely related to the real exchange rate but positively related to total consumption:

$$c_t^m = -\eta(1-\gamma)q_t + c_t \quad \text{(B14)}$$

From equation (B.3) we know that

$$c_t = (1-\gamma)c_t^h + \gamma c_t^m, \quad \text{(B15)}$$

Combining the two equations yields

$$c_t^m = -\eta q_t + c_t^h. \quad \text{(B16)}$$

Using the domestic resource constraint, we can substitute for c_t^h:

$$c_t^m = -\eta q_t + \frac{y_t - \omega c_t^{hf}}{1-\omega} \tag{B17}$$

Substituting equation (B.17) into equation (B.13) results in

$$TB_t = c_t^{hf} + \eta q_t - \frac{(y_t - \omega c_t^{hf})}{1-\omega} \tag{B18}$$

After substitution of c_t^{hf} the trade balance responds to its drivers in the following way:

$$TB_t = \frac{\beta^f y_t^f + (\eta^f(1-\gamma^f) + \eta(1-\omega))q_t - y_t}{1-\omega} \; or \tag{B19}$$

$$TB_t = -t_1 y_t + t_2 q_t + t_3 y_t^f \tag{B20}$$

where $t_1 = \frac{1}{1-\omega}$ $t_2 = \frac{\eta^f(1-\gamma^f)}{1-\omega} + \eta$ $t_3 = \frac{\beta^f}{1-\omega}$

3. Phillips Curve

For a derivation of the open-economy Phillips Curve see Guender (2006).

Appendix C: The Parameters of the Model

$a_1 = (1-\omega)\sigma = 0.45$

$a_2 = (1-\omega)\gamma\eta + \omega(1-\gamma^f)\eta^f = 0.495$

$a_3 = \omega\beta^f = 0.3$

$b = 0.1$

$\kappa = 0.1$

$c_1 = 2$

$\omega = 0.4$

$\gamma = 0.4$

$\eta = 1$

$\eta^f = 0.75$

$\gamma^f = 0.15$

$\beta^f = 0.75$

$l_1 = 4$

$l_2 = 0.5$

$d = 0.5$

$s = 0.5$

$\sigma = 0.75$

$t_1 = \frac{1}{1-\omega} = 1.67$ $\quad t_2 = \frac{\eta^f(1-\gamma^f)}{1-\omega} + \eta = 2.0625$ $t_3 = \frac{\beta^f}{1-\omega} = 1.25$

$d_1 = s_1 = 0.5$

$\delta = 0.1\mu$

$\beta = 0.99$

$\mu = 0.9091$

All shocks are autocorrelated with an autoregressive parameter of $\phi = 0.8$. For example, the cost push is modelled as $u_t = \phi u_{t-1} + \hat{u}_t$ where the $\hat{u}_t$ follows a white noise process with variance 1.

Note:
$\mu = 0.9091$ results from the sum of the weights on the target variables in the loss function adding up to 2. The weights on the output gap and inflation are the same.