

The Role of the Exchange Rate in Inflation-Targeting Emerging Economies

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Excerpt from forthcoming IMF Occasional Paper

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A Note to Readers

This is an excerpt from a forthcoming IMF Occasional Paper titled *The Role of the Exchange Rate in Inflation-Targeting Emerging Economies*. This paper explores the role of exchange rates in emerging economies with inflation-targeting regimes, an issue that has become especially germane during the current episode of financial turmoil and volatile capital flows. Under inflation targeting, the interest rate is the main monetary policy tool for influencing activity and inflation, and there is little agreement about the appropriate role of the exchange rate. The exchange rate is a more important monetary policy tool for emerging economies that have adopted inflation targeting than it is for inflation-targeting advanced economies. However, their sharper focus on the exchange rate may cause some confusion about the commitment of their central banks to achieve the inflation target and may also complicate policy implementation.

The full paper will be published in early 2009, and the contents of the forthcoming paper are included at the end of this excerpt.

The Role of the Exchange Rate in Inflation-Targeting Emerging Economies

ISBN: 978-1-58906-775-2

Pub. Date: March 2009

Format: Paperback, 8.5x11in, 40+ Pages

Price: US\$33.00

Series: Occasional Paper

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Executive Summary

The exchange rate plays a more important role in monetary policy for emerging economies that have adopted inflation targeting than for their advanced economy counterparts. Inflation-targeting emerging economies generally have less flexible exchange rate arrangements and intervene more frequently in the foreign exchange market. The enhanced role of the exchange rate reflects these economies' greater vulnerability to exchange rate shocks and their less developed financial markets. However, their sharper focus on the exchange rate may cause some confusion about the commitment of their central banks to the inflation target and may also complicate policy implementation. These tensions are being heightened by the inflation pressures, greater exchange rate volatility, and financial stress arising from the global financial turmoil that began in mid-2007.

This paper explores the policy and operational role of the exchange rate within the broader monetary framework of inflation-targeting emerging economies. It also examines how non-inflation-targeting emerging economies make the transition to inflation targeting. The analysis is based on case studies and detailed documentation of exchange rate practices in a variety of countries and on simulations using a small model tailored to open, inflation-targeting economies. The key findings are these:

- Model-based analysis provides support for an explicit, but limited, role for the exchange rate in the inflation-targeting frameworks of emerging economies under certain circumstances.
- The benefits of a more explicit policy role for the exchange rate depend on the structure of the economy, the shocks to which it is exposed, and how the exchange rate is taken into account in the policy rule.
- Intervening in the foreign exchange market plays a larger role in policy implementation for inflation-targeting emerging economies than for advanced economies, but it is a special challenge for emerging economies and modalities diverge considerably among them.

- The country experience suggests that a systematic, transparent, and market-based policy implementation approach can help reduce policy conflicts.

Summary of Key Findings

An Enhanced Role for the Exchange Rate in Inflation-Targeting Emerging Economies

The enhanced role of the exchange rate in inflation-targeting emerging economies reflects strong, uncertain, and heterogeneous exchange rate channels. First, pass-through from the exchange rate to inflation is especially important for emerging economies, in part reflecting lower policy credibility. Second, many emerging economies manage the exchange rate to mitigate the impact on output of relatively short-term currency movements. A third, longstanding motivation for active management of the exchange rate is to promote financial stability, particularly against the impact of a potential depreciation on balance sheets with currency mismatches. Fourth, exchange rate management can also help avoid or mitigate the adverse consequences for external stability of a “sudden stop” in capital inflows. Fifth, underdeveloped domestic financial markets reduce the scope for exchange rate flexibility by amplifying exchange rate shocks and constraining policy implementation. Finally, a high degree of overall policy credibility frees up the exchange rate to float and enhances policy implementation and thus is necessary for the adoption of a full-fledged inflation-targeting nominal anchor.

The Appropriate Role for the Exchange Rate in the Monetary Policy Rule

A quantitative assessment of the tradeoffs among monetary policy objectives demonstrates the circumstances under which different roles for the exchange rate in the policy rule can improve macroeconomic performance. The policy tradeoffs are gauged in this paper by using a small economic model to simulate the impact of shocks on advanced and emerging economies under different policy rules. The model demonstrates that inflation/output volatility is inherently higher for emerging economies. In general, the analysis tends to confirm the finding of earlier analyses that advanced, financially robust economies have little to gain from including the exchange rate explicitly in their policy reaction function, particularly in response to demand shocks.

At the same time, the analysis suggests that financially vulnerable emerging economies might benefit by including the exchange rate in the reaction function in a limited way, but that too much emphasis on the exchange rate is likely to be harmful. Including the exchange rate in the policy reaction function appears to help mitigate the impact of risk premium shocks and cost-push shocks, especially by dampening interest rate and exchange rate volatility. These results do not amount to a ringing endorsement of active exchange rate management in inflation-targeting emerging economies, but they do shed some light on why the exchange rate plays an important role for most of these economies. Of course, it is not possible to draw strong policy conclusions for diverse countries on the basis of simulation results using small and necessarily simplified models, and there is great scope for further work.

The Role of Foreign Exchange Market Intervention in Inflation Targeting

An effective role for the exchange rate in policy implementation under an inflation-targeting framework can reduce conflicts between the inflation objective and other considerations. However, establishing strong policy implementation can be especially challenging for inflation-targeting emerging economies owing to their policy legacy and their less developed financial markets. Under inflation targeting, the interest rate is the main monetary policy tool for influencing activity and inflation. Country experience suggests that foreign exchange market intervention should be implemented in the most systematic way possible. Transparency of the role of the exchange rate with respect to policy objectives, operational procedures, and ex post evaluation reduces the possibility of confusion about the inflation target. Of course, there will be limits to the transparency of foreign exchange policy implementation, and country experience offers some sound policy transparency practices. The existence of deeper foreign exchange and domestic money markets enhances the effectiveness of changes in the policy stance, including through better signaling of policy intentions. Money market development makes it possible to use domestic monetary instruments rather than relying excessively on foreign exchange intervention and also facilitates sterilization.

The Role of the Exchange Rate during the Transition to Inflation Targeting

The exchange rate plays an important, yet not well defined, role in the policy framework of emerging economies that have a flexible exchange rate but not a full-fledged inflation-targeting framework (referred to here as “non-inflation-targeting emerging economies”). These economies manage the exchange rate more, and policy implementation tends to be based on foreign exchange intervention that is more ad hoc and less market-based. Exchange rate channels are probably stronger and more uncertain for the typical non-inflation-targeting emerging economies because they are less financially developed, are more dollarized, and have less overall credibility compared to inflation-targeting emerging economies.

Establishing a more systematic, consistent, and market-based role for the exchange rate is a key to making the transition to inflation targeting. Model simulations suggest that giving the exchange rate a larger weight in the interest rate reaction function, or using the exchange rate as the operating policy target, can generate better macroeconomic performance than using a policy reaction function dominated by the interest rate. The degree of domestic money market development helps shape the choice of the operating target during the transition. Reducing the weights of the exchange rate in the reaction function over time is a sensible way to transition to an inflation-targeting regime. Central banks moving toward inflation targeting generally need to strengthen their macroeconomic analysis and develop a systematic approach to policy decision-making. Financial market development improves policy implementation by reducing the need to depend on foreign exchange intervention and by facilitating sterilization.

A Taxonomy of Inflation-Targeting Approaches

This section outlines a taxonomy of approaches for bringing the exchange rate into the inflation-targeting framework:

- the conventional open-economy inflation-targeting framework—“plain vanilla” inflation targeting—in which exchange rate movements are taken into account only indirectly;
- an open-economy approach that adds an explicit exchange rate objective to the plain vanilla approach;
- inflation targeting with an explicit exchange rate band; and
- inflation targeting with the exchange rate rather than a short-term interest rate as the policy instrument.

These four approaches have three important features in common. First, stabilizing inflation around the target rate is the overriding policy objective over the medium term.¹ Second, the central bank may also seek to reduce the volatility of output, interest rates, and the exchange rate, but it must do so in a way that is consistent with the medium-term inflation target.² Third, the different rules involve a systematic approach to policy in the sense that the elements in the central bank’s policy reaction function, and the weights placed on the different elements, are stable over time.

Plain Vanilla Inflation Targeting in an Open Economy

The plain vanilla approach describes the orthodox open-economy inflation-targeting framework practiced in advanced economies.³ Monetary policy formulation involves periodic adjustments in a target policy interest rate, guided primarily by deviations of projected inflation from the target and, to a lesser extent, by the deviation of actual GDP from the sustainable rate (the “output gap”). Typically, the central bank also seeks to smooth the path of interest rates. This approach to policy formulation is represented here by the policy reaction function:

$$\hat{i}_t = \lambda \hat{i}_{t-1} + (1 - \lambda) [\alpha \hat{\pi}_t + \beta \hat{y}_t] + v_t \quad (1)$$

where:

$\hat{i}_t \equiv i_t - (\bar{r} + \pi^T)$ is the deviation of policy target interest rate i_t in period t , from its long-run steady-state value, defined as the long-run equilibrium real interest rate $\bar{r}$, plus the target inflation rate π^T ;

¹Essentially, this requires that the policy instrument reacts strongly enough to a gap between the inflation forecast and the target to ensure that inflation will return to the target rate over the long term.

²In this context, it is important to distinguish clearly between targets and objectives. The central bank has a target for the steady-state level of inflation, but it has no target for either output or the exchange rate (either for the level or the rate of change). The inflation target is distinct from the objectives of minimizing variations in inflation around the target and of minimizing variations of output, interest rates, and the exchange rate around their steady-state values.

³See, for example, Mishkin (2000) and Truman (2003) for overviews of the framework, and Svensson (2000) for a model-based analysis of policy formulation.

$\hat{\pi}_t \equiv (\pi_t^f - \pi^T)$ is the deviation of the period t inflation forecast, π_t^f , from the inflation target π^T ;

$\hat{y}_t \equiv (y_t - \bar{y}_t)$ is the deviation of real output y_t from $\bar{y}_t$, the estimated level of potential output, in period t ;

v_t represents additional policy judgment as well as imprecision in policy implementation.

Key features of the plain vanilla reaction function include these:

- The exchange rate does not appear explicitly in the policy reaction function. However, exchange rate developments and prospects are taken into account implicitly because they affect the inflation forecasts and output.⁴
- To ensure that the central bank's actions are consistent with achieving the inflation target, the value of α should be > 1 , so that the real interest rate changes by at least as much as any change in deviation of projected inflation from target.⁵
- Although the central bank does not have a long-run target for the level of output or growth, it places some weight on dampening output volatility around the sustainable, noninflationary level of output ("potential" output), to ensure long-run consistency with the primary inflation objective.⁶
- The parameter λ characterizes the degree of policy inertia. If λ is high, the central bank will normally adjust the policy stance only gradually in response to economic developments or prospects.

Open-Economy Inflation Targeting

Open-economy inflation targeting involves the central bank taking exchange rate developments into account explicitly in the policy reaction function, rather than just indirectly through the effects on output and the inflation forecast. The way in which the exchange rate enters the reaction function is essentially similar to the way that output is included: there is no target for the exchange rate, but some weight is placed on dampening exchange rate volatility:⁷

$$\hat{i}_t = \lambda \hat{i}_{t-1} + (1 - \lambda) [\alpha \hat{\pi}_t + \beta \hat{y}_t + \gamma (\hat{q}_t - \phi \hat{q}_{t-1})] + v_t \quad (2)$$

⁴See, for example, Brook (2002), Ragan (2005), and Taylor (2001).

⁵The distinction between "strict" and "flexible" inflation targeting discussed in Svensson (2000) partly hinges on whether α is much greater than β or not.

⁶Caution is needed in interpreting the weights in the reaction function. These do not necessarily reflect the central bank's preferences regarding stable inflation versus other objectives. For example, even if the central bank had no interest in stabilizing output as such, it might nonetheless put some weight on dampening output volatility if this contributed to stabilizing inflation.

⁷See, for example, Ball (2000), Batini and others (2001), and Taylor (2001).

where:

$\hat{q}_t$ is the deviation of the real exchange rate in period t from its steady state equilibrium value.

This specification allows for dampening volatility in the level of the exchange rate relative to the long-run equilibrium rate, changes in the exchange rate, or both:

- If $\phi = 0$, the central bank systematically dampens deviations of the level of the real exchange rate from the steady-state equilibrium rate.⁸
- Alternatively, if $\phi = 1$, the central bank dampens changes in the real exchange rate, consistent with limiting exchange rate volatility.
- More generally, if $0 < \phi < 1$, the central bank places some weight on dampening rapid changes in the exchange rate as well as on limiting exchange rate misalignment.

Including the exchange rate in the reaction function does not imply setting an exchange rate target. Indeed, it is essential that dampening exchange rate volatility be conducted in a manner that is consistent with the noninflationary long-term equilibrium of the economy. This is particularly important if the policy responds to deviations in the level of the exchange rate around the estimated steady-state value, because errors in estimating the long-term equilibrium level may lead to a systematic bias in the stance of policy and a conflict between the inflation and exchange rate objectives.⁹

In practice, many inflation-targeting emerging economies appear to adjust interest rates systematically in response to exchange rate movements, consistent with an open-economy inflation-targeting approach.¹⁰ Several country experiences (for example, Peru) suggest that monetary policy in these countries might be better characterized as open-economy inflation targeting than as plain vanilla inflation targeting, insofar as the central banks have shown a fairly systematic tendency to lean against significant movements in the exchange rate.

Inflation Targeting with an Exchange Rate Band

Inflation targeting with an exchange rate band involves setting limits on the acceptable range of movement in the exchange rate. In the case of a symmetric exchange rate band, the policy reaction function can be represented as:¹¹

⁸Note that the steady-state value of the real exchange rate may have an upward or downward trend over time, particularly in emerging economies that are experiencing significant structural change.

⁹Of course, this applies equally to dampening fluctuations in the level of output relative to the estimated level of potential output.

¹⁰See, for example, Mohanty and Klau (2004), Frommel and Schobert (2006), and Leiderman and others (2006).

¹¹See Morón and Winkelried (2005).

$$\hat{i}_t = \lambda \hat{i}_{t-1} + (1 - \lambda) [\alpha \hat{\pi}_t + \beta \hat{y}_t + (\gamma + \theta)(\hat{q}_t - \phi \hat{q}_{t-1})] + v_t \quad (3)$$

where:

$$\theta = 0 \text{ if } |\hat{q}_t| < q'$$

$$\phi \neq 0 \text{ if } |\hat{q}_t| \geq q'$$

q' is half the width of the exchange rate band.

Within the band, the approach works essentially like the open-economy inflation-targeting approach, but once the edge of the band is reached, the inflation objective is overridden by the exchange rate objective.¹² Clearly, if the exchange rate band is wide relative to the typical magnitude of exchange rate changes, then the band will rarely be binding, and the approach will be similar to open-economy inflation targeting. If the band is relatively narrow, however, the regime may appear similar to an exchange rate peg (a crawling peg if the equilibrium exchange rate is moving over time or some kind of peg to a composite if the real effective exchange rate is used). The nonlinearity of the response of policy to exchange rate movements that is implied by this framework is difficult to incorporate in a simple model, and for this reason is not included in the model simulations.

Several countries have used this approach, especially to transition to inflation targeting. Chile (1990–99) and Israel (1992–96) used this framework during their transitions from relatively high-inflation, exchange-rate-based regimes, to low-inflation, full-fledged inflation-targeting frameworks.¹³ Recent examples include Hungary (until early 2008) and Slovakia.

Exchange-Rate-Based Inflation Targeting

The exchange rate rather than an interest rate can be used as the operating instrument or proximate target for monetary policy. In this case, the central bank's policy reaction function can be described as:

$$\hat{q}_t = \lambda \hat{q}_{t-1} + (1 - \lambda) [\alpha \hat{\pi}_t + \beta \hat{y}_t] + v_t \quad (4)$$

Key features of this approach are:

- As in the plain vanilla and open-economy approaches, the coefficient on the inflation objective, α , must be high enough to ensure that inflation will be brought back to target over the medium term.

¹²As long as the deviation of the real exchange rate from the steady-state equilibrium, $\hat{q}_t$, is less than some amount q' , then policy will be based on an open-economy inflation-targeting approach (or a plain vanilla approach if the exchange rate coefficient γ is set to 0). However, if the exchange rate reaches the q' threshold, then the interest rate response to further exchange rate deviation, $(\gamma + \theta)$, will be much stronger, over-riding the inflation objective.

¹³See Leiderman and Bufman (2000) and Morandé and Schmidt-Hebbel (2000).

- In principle, this approach could be implemented directly through unsterilized intervention in the foreign exchange market. Alternatively, the central bank could use a very short-term domestic interest rate to move the exchange rate to the desired level.¹⁴

To date, only two countries can be deemed to have used the exchange-rate-based approach: New Zealand during the early 1990s and Singapore currently.¹⁵ In both cases, the use of the exchange rate as the operational target substantially reflected the openness of the economies and, consequently, the importance of the exchange rate relative to interest rates in the monetary policy transmission mechanism.¹⁶

Evaluation of Alternative Inflation-Targeting Approaches

In this section, a small open-economy model is used to evaluate the performance of alternative inflation-targeting approaches in financially robust advanced economies and financially vulnerable emerging economies. The section begins with a brief description of the model, focusing on structural differences between the stylized advanced and emerging economies. This is followed by a discussion of the results of the model simulations, which compare how different policy rules perform in the different types of economies and in response to different kinds of economic disturbances.

The main purpose of the analysis is to provide a more systematic comparison of the performance of alternative approaches. In most studies, a range of alternative rules are compared in the context of a particular type of economy or particular kinds of shocks (see, for example, Batini, Harrison, and Millard, 2001; Cavoli and Rajan, 2006; McCallum, 2006; and Ravenna and Natalucci, 2008). In other studies, the performance of particular rules are compared across different economies but the issue of the benefit of including the exchange rate in the reaction function is not specifically addressed (see, for example, Morón and Winkelried, 2005). Finally, the range of shocks used in the evaluation of different rules and in different economies varies considerably from one paper to another. In this paper, the evaluation compares the performance of a range of simple policy rules both in financially robust and vulnerable economies and in response to a standard set of shocks.

Characteristics of the Model

The analysis is based on a conventional, small open-economy model. Standard features of such models include forward-looking optimizing behavior by households and firms, together with nominal and real rigidities that generate sluggish adjustments to economic disturbances.

¹⁴In the latter case, the exchange rate can be described as a proximate or operational target, intermediate between the operating instrument and the inflation objective.

¹⁵The classification of the monetary and exchange rate framework in Singapore is somewhat uncertain. One study (Parrado, 2004), estimates that there is a very high degree of exchange rate smoothing, which may not be fully consistent with inflation targeting. Moreover, the Singaporean authorities themselves do not describe their framework as an inflation-targeting regime.

¹⁶See Monetary Authority of Singapore (2001), Grimes and Wong (1994), and Mayes and Riches (1996).

These rigidities provide scope for monetary policy to have real effects in the short term, but not over the long term. The open-economy nature of the model is reflected both through the importance of international trade in aggregate demand and by the effects of international trade and financial flows on interest rates and the exchange rate. The model is discussed in greater detail in the Appendix, included here, but some important features that are particularly relevant to this paper may be noted here:

- Aggregate demand includes domestic and foreign demand components. Higher real interest rates dampen demand, while a weaker currency boosts demand.
- Firms use labor and imported inputs in production. Real wages are procyclical so that stronger aggregate demand increases production costs. A weaker currency also boosts production costs, and it induces substitution toward the use of more labor and less imports in production.¹⁷
- Inflation is largely determined by the price-setting behavior of firms. Prices are adjusted periodically and reflect both past changes in costs and forward-looking expectations of cost developments.
- The relationship between the exchange rate and interest rate comprises a conventional uncovered interest parity (UIP) condition linking domestic risk-free interest rates to foreign rates and to the expected change in the exchange rate, together with a risk premium reflecting the current account balance, the level of external debt relative to GDP, and the vulnerability of corporate balance sheets to exchange rate movements.

Two versions of the model are calibrated to create stylized representations of a financially robust advanced economy and a financially vulnerable emerging economy. The main differences between the stylized economies reflect the following:

- Domestic financial system development: In the emerging economy, interest rates are assumed to be less effective in influencing demand than in the advanced economy, reflecting a less developed financial system.
- External financial vulnerability: In the emerging economy, the interest rate differential versus foreign rates is assumed to be more sensitive to the evolution of the external debt and current account balance than in advanced economies, consistent with less stable capital mobility and asset substitutability.¹⁸ In addition, the emerging economy is assumed to have a high proportion of financial liabilities denominated in foreign currency, making it vulnerable to strong balance-sheet effects of exchange rate

¹⁷The model does not include direct exchange rate pass-through from foreign to domestic prices. Pass-through is indirect via the cost of imported goods used in production. The magnitude of pass-through therefore depends on the openness of the economy (the share of imported inputs in production) as well as the extent to which changes in costs can be passed on to consumers.

¹⁸In other words, the risk premium depends partly on the external-debt-to-GDP ratio and on the current external balance, and in the vulnerable economy the coefficients on these terms are assumed to be larger than in the financially robust economy.

changes. These balance-sheet effects of exchange rate changes are assumed to outweigh the more conventional macroeconomic effects of exchange rate changes.¹⁹

- Policy credibility: In the emerging economy, price-setting by firms is assumed to be more backward-looking than in the advanced economy. This reflects weaker policy credibility as a legacy of higher inflation and more limited central bank independence.²⁰

¹⁹This approach to modeling external financial vulnerability follows Céspedes, Chang, and Velasco (2000) and Morón and Winkelried (2005).

²⁰Rudebusch and Svensson (1999) argue that backward-looking expectations may be an appropriate specification in the early stages of an inflation-targeting regime, when agents are still learning about the regime.

Appendix: The Small Open-Economy Model

The first part of this appendix describes the structure and calibration of the Small Open-Economy Model used in the analysis of alternative monetary policy frameworks. The second part of the appendix reviews existing model-based analyses of hybrid inflation-targeting rules. The third part of the appendix describes the simulation methodology.

Model Structure

The model used in this paper to analyze alternative monetary policy rules is a fairly conventional New Keynesian open-economy model. These models embody a synthesis of the modeling approach of the real business cycle literature and micro foundations for Keynesian concepts.²¹ Such models have essentially neoclassical long-run characteristics—notably including monetary neutrality—but have Keynesian short-term characteristics which provide scope for monetary policy to affect the real economy over the short to medium term. However, such models are mostly founded on explicit micro foundations, making the underlying assumptions of the model more transparent and making them less vulnerable to the Lucas critique than more ad hoc reduced-form specifications.

The model used in this paper is deliberately conventional in the sense of drawing on standard micro foundations to derive the main behavioral equations. An important feature of the model is that it abstracts from the determination of the steady state of the economy as well as from permanent shocks that change the steady state. Inflation targeting focuses on the dynamics of the return to the steady state following macroeconomic disturbances.

The model includes several features that attempt to capture some characteristics of financially vulnerable emerging economies. These include:

²¹ See the overview of the synthesis of approaches in Goodfriend and King (1995), Clarida, Galí, and Gertler (1999), and Galí and Gertler (2007).

- Credit constraints limiting the degree of intertemporal arbitrage in consumption (following Amato and Laubach, 2003; and Galí, López-Salido, and Vallés, 2007), to reflect the relatively undeveloped domestic financial systems in many emerging economies; this is a procyclical component of aggregate demand, which is insensitive to the interest rate and has the potential to increase the reaction required of the central bank, introducing more volatility to exchange rates.
- An endogenous risk premium (following Céspedes, Chang, and Velasco, 2004), increasing in external indebtedness and the exchange rate.
- Allowance for perverse exchange rate effects on income (following Morón and Winkelried, 2005) to reflect adverse balance-sheet effects.
- Allowance for different timing of exchange rate pass-through to costs and prices (Monacelli, 2004).
- Inclusion of an exported natural resource, providing scope for terms of trade shocks.
- Allowance to explicitly include movements in the exchange rate in the central bank policy reaction function (Cavoli and Rajan, 2006; and Kirsanova, Campbell, and Wren-Lewis, 2006).
- Allowance to reflect weak policy credibility in more backward-looking inflation expectations and price formation (Erceg and others, 2003; and Argov and others, 2007).

The log-linearized equations included in the model are as follows:²²

Aggregate Spending

Aggregate spending on the domestically produced good, $\hat{y}_t^d$, is composed of domestic spending, $\hat{c}_t$, plus exports, $\hat{x}_t^d$:

$$\hat{y}_t^d = \hat{c}_t + \hat{x}_t^d \quad (1)$$

A fraction, λ , of domestic spending is by optimizing (Ricardian) consumers, $\hat{c}_t^o$, and the rest is by “rule-of-thumb” (non-Ricardian) consumers, $\hat{c}_t^r$:

$$\hat{c}_t = \lambda \hat{c}_t^r + (1 - \lambda) \hat{c}_t^o \quad (2)$$

Spending by optimizing Ricardian consumers is derived from a standard separable utility function on consumption, C_t , and labor, N_t :

$$U(C_t, N_t) = \frac{(C_t - \gamma C_{t-1})^{1-\sigma} - 1}{1-\sigma} - N_t^v \quad (3)$$

²²Variables with a hat, e.g., $\hat{C}_t$, represent the (log) deviation of the level of the variable C_t from its steady-state or long-run value $\bar{C}_t$.

where:

σ is the coefficient of relative risk aversion

γ is the degree of habit formation in consumption.

This introduces an element of inertia into consumption, and is a fairly standard feature of New Keynesian models.

The first-order conditions of utility maximization provide the Euler equation that guides consumption:

$$\hat{c}_t^o = \left(\frac{\gamma}{1+\gamma} \right) \hat{c}_{t-1}^o + \left(\frac{1}{1+\gamma} \right) \hat{c}_{t+1}^o - \left(\frac{1-\gamma}{1+\gamma} \right) \frac{1}{\sigma} [\hat{i}_t - \hat{\pi}_{t+1}] \quad (4)$$

where:

$\hat{i}_t$ is the current nominal interest rate

$\hat{\pi}_{t+1}$ is the inflation rate expected in period $t+1$.

Rule-of-thumb or non-Ricardian consumers do not smooth consumption through borrowing and lending. The lack of consumption smoothing may reflect limited access of some households to financial markets.²³ As a consequence, for these consumers, spending is based on current income:

$$\hat{c}_t^r = \hat{w}_t - \hat{p}_t + \hat{n}_t \quad (5)$$

where:

$\hat{w}_t$ is the nominal wage rate per unit of work supplied

$\hat{p}_t$ is the price level

$\hat{n}_t$ is the number of units of work supplied.

In addition to domestic demand, there is also foreign demand for the domestically produced good, $\hat{x}_t^d$. Export demand depends on foreign real income and the real exchange rate:

$$\hat{x}_t^d = \tau \omega \hat{q}_t + \omega \hat{y}_t^* + (1-\omega) \hat{x}_{t-1} \quad (6)$$

where:

$\hat{y}_t^*$ is foreign real income

$\hat{q}_t$ is the real exchange rate (the real cost of foreign currency)

ω is a measure of persistence in exports

τ is the exchange rate elasticity of foreign demand for the exported good.

²³ See, for example, Galí, Lopez-Salido, and Vallés (2004, 2006).

Aggregate Production

Output in the economy consists of two types of goods. One is a composite good produced by monopolistically competitive firms using labor and imported goods as inputs. This good is both consumed domestically and exported. The second is a natural endowment commodity which is exported.

The composite good is produced using a CES production technology with inputs of labor and an imported input. This production function is particularly convenient because of its generality, given that it embeds a Cobb-Douglas or even a Leontief technology, depending on the size of the elasticity of input substitution chosen:

$$y = A_t \left[\alpha I_t^{\frac{\sigma_s - 1}{\sigma_s}} + (1 - \alpha) N_t^{\frac{\sigma_s - 1}{\sigma_s}} \right]^{\frac{\sigma_s}{\sigma_s - 1}} \quad (7)$$

where:

σ_s is the elasticity of substitution in production

I_t is the imported intermediate input

N_t is the labor input

α is the share of the imported good in production—the openness of the economy

A_t is total factor productivity.

Production costs reflect the costs of the labor and the imported inputs, as well as labor. The real cost of imported inputs is determined by the real exchange rate, $\hat{q}_t$, while the real wage, $(\hat{w}_t - \hat{p}_t)$, is determined by the equilibration of producers' demand for labor, $\hat{n}_t$, with the supply of labor by households. The supply of labor is derived from maximization of utility in equation (3)²⁴ by both types of consumers. Aggregate supply depends positively on real wage and negatively on consumption. This is a typical result obtained from the first order condition with respect to labor of separable utility functions:

$$\hat{n}_t = \frac{1}{(\nu - 1)} \left\{ (\hat{w}_t - \hat{p}_t) - \sigma \left[\left(\frac{1}{1 + \gamma} \right) \hat{c}_t - \left(\frac{\gamma}{1 + \gamma} \right) \hat{c}_{t-1} \right] \right\} \quad (8)$$

where:

ν is the coefficient of disutility of labor.

With the production technology specified in equation (7), the real marginal cost of production, $\hat{m}c_r^R$, is given by:

$$\hat{m}c_r^R = (1 - \alpha)^{\sigma_s} (\hat{w}_t - \hat{p}_t) + \alpha^{\sigma_s} \hat{q}_t - \left[(1 - \alpha)^{\sigma_s} + \alpha^{\sigma_s} \right] \hat{a}_t \quad (9)$$

²⁴ Note that although some households may be constrained to follow a rule of thumb in consumption, it is assumed that all households are free to optimize their supply of labor services.

where:

$\hat{w}_t$ is the nominal wage rate per unit of work supplied

$\hat{p}_t$ is the price level $\hat{q}_t$ is the real exchange rate (the real cost of foreign currency)

$\hat{a}_t$ is the (log) deviation of A_t from its steady state value.

Equation (9) shows that the more open the economy, the larger the impact of exchange rate movements on production costs and inflation. The elasticity of substitution in production also plays an important role: the lower the possibility of substituting domestic labor for imported inputs, the larger the impact of an exchange rate movement on costs.

Production of the second endowment type good, $\hat{x}_t^{CM}$, is essentially exogenous and is completely exported. The amount produced of this commodity does not react to its price, and the requirement of local inputs to its production is negligible. Its value depends on the real exchange rate and its price, $\bar{p}_t^{CM}$, abroad, which is given by international markets. Consequently, the value of production is determined as:

$$\hat{x}_t^{CM} = \hat{q}_t + \hat{p}_t^{CM} \quad (10)$$

Firms set the price of output for the domestic market in one of two ways. One group of firms, accounting for a fraction, μ , of sales of the domestic good, follows a simple, backward-looking approach to adjusting their prices.²⁵ In effect, this leads to an element of indexation of prices, generating persistence in inflation. Another group of price-setters takes a forward-looking optimization approach to price setting but only adjust their prices periodically, à la Calvo. In any given period, it is assumed that only a fraction, $(1 - \theta)$, of the optimizing firms adjust their prices. The backward-looking component of price setting can be motivated by uncertainty regarding the central bank's inflation objective (Erceg and others, 2003) or limited credibility of the policy framework (Argov and others, 2007). In both cases, agents will tend to place a greater weight on recent inflation outcomes in forming inflation expectations than otherwise.

Taking these considerations into account, the aggregate inflation rate in the economy will be summarized by a New Keynesian Phillips curve of the form:

$$\hat{\pi}_t = \left(\frac{\beta}{1 + \beta\mu} \right) \hat{\pi}_{t+1} + \left(\frac{\mu}{1 + \beta\mu} \right) \hat{\pi}_{t-1} + \left(\frac{\varphi}{1 + \beta\mu} \right) \hat{m}c_r^R \quad (11)$$

where:

β is the subjective rate of time preference

μ is the proportion of price adjustment based on a simple indexation formula,

²⁵ See Smets and Wouters (2002).

$\varphi = \frac{1-\theta}{\theta}(1-\beta\theta)$, where $(1-\theta)$ is the average frequency of price adjustment by optimizing firms

$\hat{m}c_r^R$ is the real marginal cost of production.

This Phillips curve has three elements. The first is an expected inflation component. This reflects the assumption that firms adjust their prices periodically rather than continuously, so that when prices are adjusted, firms take into account the expected evolution of inflation. The second term is a lagged inflation component reflecting the indexation applied to a fraction, μ , of prices. The third term reflects the incorporation of marginal costs into optimizing firms' prices. Exchange rate movements feed into inflation through their impact on marginal costs. The speed of pass-through into inflation depends both on the proportion of optimizing firms and on the average frequency of price adjustments.

Exchange Rate Determination

The real exchange rate is assumed to be determined by the real uncovered interest parity condition, together with a risk premium:

$$\hat{q}_t = \hat{q}_{t+1} + [\hat{i}_t^* - \hat{\pi}_{t+1}^*] - [\hat{i}_t - \hat{\pi}_{t+1}] + \hat{\phi}_t \quad (12)$$

where:

$\hat{q}_t = \hat{s}_t + \hat{p}_t^* - \hat{p}_t$ is the real exchange rate ($\hat{s}_t$ is the spot price of foreign exchange and $\hat{p}_t^*$ is the foreign price level)

$\hat{i}_t^*$ is the foreign nominal interest rate

$\hat{\pi}_{t+1}^*$ is the expected foreign inflation rate

$\hat{\phi}_t$ is the risk premium.

Following Céspedes, Chang, and Velasco (2004), the risk premium, $\hat{\phi}_t$, depends on debt, the exchange rate, and GDP:²⁶

$$\hat{\phi}_t = \phi_0 (\hat{b}_{t+1}^* - \hat{y}_t) - \phi_1 ((\tau-1)\hat{q}_t + \hat{y}_t^*) + \phi_2 (\hat{I}_t) + \phi_3 (\hat{q}_t) \quad (13)$$

where:

$(\hat{b}_{t+1}^* - \hat{y}_t)$ is the projected external debt-to-GDP ratio.

²⁶See also Morón and Winkelried (2005). Gertler, Gilchrist, and Natalucci (2003) develop a closely related alternative to modeling this risk premium.

The risk premium consists of four elements:

- The first term in the equation says that the risk premium is an increasing function of the ratio of external debt to GDP. This friction in the international capital markets is required to ensure stationarity of the external debt-to-GDP ratio.²⁷
- The second and third terms relate the risk premium negatively to exports and positively to imports, so that a weakening of the current account raises the risk premium.
- The last term captures the adverse impact of currency depreciation on the domestic currency value of external debt—the balance sheet effect. As the debt service burden on borrowers rises, the risk premium increases. For a financially vulnerable economy, the adverse impact of depreciation through the balance sheet effect must outweigh the beneficial effects of depreciation on the current account so that depreciation has a net harmful effect on activity. This imposes restrictions on the values of the parameters in the risk premium equation.²⁸

Monetary Policy

Monetary policy is described by the alternative reaction functions presented in the main text.

Equilibrium Identities

Total output of the economy is the sum of the domestic consumption and exports of the domestically produced good, together with the exports of the exported endowment commodity:

$$\hat{y}_t = \frac{\bar{c}}{\bar{y}} \hat{c}_t + \frac{\bar{x}^d}{\bar{y}} \hat{x}_t + \frac{\bar{x}^{CM}}{\bar{y}} \hat{x}_t^{CM} \quad (14)$$

where:

$\frac{\bar{c}}{\bar{y}}$, $\frac{\bar{x}^d}{\bar{y}}$ and $\frac{\bar{x}^{CM}}{\bar{y}}$ are shares of consumption, exports of domestically produced good, and exports of the endowment commodity in total production.

The balance of payments or economy-wide constraint is built adding up the consumer, government, and firm resource constraints:

²⁷ See Schmidt-Grohé and Uribe (2003).

²⁸ See Céspedes, Chang, and Velasco (2002) and Morón and Winkelried (2005).

$$\begin{aligned}
\frac{\bar{c}}{\bar{y}} \hat{c}_t &= \hat{y}_t - \bar{q}(1 - \alpha_y)(\hat{y}_t + \hat{q}_t) \\
&+ \frac{\bar{b}^*}{\bar{y}} \frac{1}{(1 + \bar{i}^*)\bar{\phi}} [\pi_{t+1}^* + \hat{b}_{t+1}^* - (\hat{q}_{t+1} - \hat{q}_t) - (1 + \hat{i}_t^*) - \hat{\phi}_t] \\
&- \frac{\bar{b}^*}{\bar{y}} \hat{b}_t^*
\end{aligned} \tag{15}$$

The net change in foreign debt should be equal to the current account, which is composed of the trade balance and interest payments abroad.

Model Calibration

Differences in the calibration of the financially robust advanced and the financially vulnerable emerging economies are shown in Table A1 and reflect the following considerations:

- Domestic financial development. In the emerging economy, the share of “rule-of-thumb spending” based on current income is set at 30 percent, compared to 0 percent in the advanced economy, to reflect limited access of agents to borrowing opportunities and greater use of quantitative credit rationing rather than use of retail interest rates. Better access to borrowing and saving opportunities in advanced economies is also reflected in higher persistence in spending behavior, with the persistence coefficient set at 0.5 versus 0.3 in emerging economies.
- External financial constraints. More limited capital mobility and international asset substitutability in vulnerable emerging economies is reflected in: (1) a risk premium with a substantially higher coefficient related to the level of the external debt-to-GDP ratio (0.05 compared to 0.01 for the advanced economy (based on Schmidt-Grohé and Uribe, 2003)); and (2) a higher coefficient on the current account balance (0.3 compared to 0.2 for the advanced economy).²⁹ In addition, the balance sheet vulnerability of the emerging economy is reflected in a much higher elasticity of the risk premium with respect to exchange rate movements than in the advanced economy (0.5 compared to 0.05).

A crucial implication of these parameter configurations is that currency depreciation in the financially robust advanced economy will be expansionary as the stimulus to net exports will outweigh any adverse balance sheet effects. In contrast, currency depreciation has a net contractionary effect in the vulnerable emerging economy as the stimulus to net exports is more than offset by the adverse impact on balance sheets and, consequently, on consumption and investment.

²⁹ The risk premium elasticity with respect to imports and exports are assumed to be equal for each country type on the presumption that capital market participants do not distinguish between whether a movement in the current account balance reflects changes in imports or exports.

- Openness. The share of imports in production rather than GDP (following McCallum, 2006) is set at 25 percent for advanced economy and at 30 percent for the emerging economy, consistent with international evidence.
- Policy credibility. In the robust advanced economy, price formation is based on a purely forward-looking approach to formation inflation expectations ($\mu = 0$). Implicitly, this assumes that agents know and believe the central bank's policy rule. In the emerging economy, price formation is assumed to be much more backward looking ($\mu = 0.8$), reflecting limited credibility of the central bank's commitment to an inflation objective (following Rudebusch and Svensson, 1998; Erceg and others, 2003; and Argov and others, 2007).

Table A1. Parameter Calibration of the Advanced and Emerging Economy Models

	Advanced Economy	Emerging Economy
Utility function		
Subjective Discount rate	$\beta = 0.988$	$\beta = 0.988$
Coefficient of relative risk aversion	$\sigma = 1$	$\sigma = 2$
Parameter of the labor supply (disutility)	$\nu = 2$	$\nu = 2$
Habit coefficient	$\gamma = 0.5$	$\gamma = 0.3$
Share of rule-of-thumb consumers	$\lambda = 0$	$\lambda = 0.3$
Production function		
Factor (input) elasticity of substitution in production function	$\sigma_s = 1$	$\sigma_s = 1$
Weight of imported factor (degree of openness)	$\alpha = 0.25$	$\alpha = 0.3$
Exports		
Elasticity of home exports to exchange rate	$\tau = 5$	$\tau = 5$
Elasticity of commodity exports to exchange rate	0	0
Price-setting		
Probability of not reoptimizing	$\theta = 0.75$	$\theta = 0.75$
Degree of indexation (for firms that are not reoptimizing)	$\mu = 0$	$\mu = 0.8$
Elasticity of demand	$\varepsilon = 6$	$\varepsilon = 6$
Mark-up	$[\varepsilon/(\varepsilon - 1)] = 1.2$	$[\varepsilon/(\varepsilon - 1)] = 1.2$
Wage-setting		
Rigid wages (Dummy_WR)	D_WR = 0	D_WR = 0
Parity condition and risk premium		
Elasticity of country risk premium to foreign debt	0.01	0.05
Elasticity of country risk premium to exports	0.20	0.3
Elasticity of country risk premium to imports	0.20	0.3
Elasticity of risk premium to real exchange rate (balance sheet)	0.05	0.5
Exchange rate smoothing	0.6	0.6
Monetary Policy		
Interest rate smoothing in Taylor rule	0.7	0.7
Parameter related to inflation gap	$0.25 \leq \text{coeff.} \leq 3.11$	$0.26 \leq \text{coeff.} \leq 3.15$
Parameter related to output gap	$-0.28 \leq \text{coeff.} \leq 2.57$	$-0.28 \leq \text{coeff.} \leq 2.61$
Parameter related to exchange rate	0.6	0.6
Aggressiveness	6.5	6.6
Shock Inertia		
Shock persistence	Rho_R=0.8	Rho_R=0.8

Evidence on the Performance of Alternative Frameworks

This section reports the performance of alternative hybrid monetary policy rules in financially robust advanced and financially vulnerable emerging economies. It reviews existing model-based analyses of hybrid rules and then discusses the simulations and findings using the model described above.

Existing Studies of Hybrid Policy Rules

Taylor (2001) reviews the limited number of studies that had looked at the issue of whether it would be appropriate to take the exchange rate explicitly into account in monetary policy in an open economy.³⁰ He concludes there was little evidence that including a systematic response to exchange rate movements would improve macroeconomic performance, even in an open economy. He attributes this to two principal factors: (1) even in the plain vanilla framework, monetary policy already responds to the indirect impact of exchange rate movements on output and inflation, and (2) the appropriate response to exchange rate movements should depend on the cause of the movement. He suggests that adding a mechanistic response to exchange rate movements in policy reaction function could worsen performance, depending on the typical array of shocks affecting the economy. Both Taylor (2000) and Mishkin (2000), however, recognize that more research was needed in this area before drawing any strong conclusions.

More recent research has begun to examine whether differences in economic and financial structure between emerging and more advanced economies may explain the “fear of floating” evident in many emerging and developing economies and may justify including systematic dampening of exchange rate movements in the central bank policy reaction function.³¹ Below is a brief summary of some of the main findings for each of hybrid inflation-targeting exchange rate frameworks.

Open-Economy Inflation Targeting

Model-based analyses generally find little benefit from including the exchange rate in the monetary policy reaction function. Indeed, several studies argue that including the exchange rate worsens macroeconomic performance. However, in some other studies, including the exchange rate in the reaction function is found to be beneficial if the economy is financially fragile or if the central bank is very uncertain of how the exchange rate is determined:

- Céspedes, Chang, and Velasco (2004) consider the impact of exchange rate movements in economies with a high degree of dollarization and constrained access to international borrowing opportunities. In such circumstances, exchange rate movements can give rise to strong balance sheet effects opposite to the normal

³⁰The main studies included Batini and others (2001), Ball (1999), and Svensson (2000)

³¹See, for example, Céspedes and others (2000), Morón and Winkelried (2005), Cavoli and Rajan (2006), and Leiderman and others (2006).

competitiveness effects of exchange rate movements. Which effect dominates depends on each country's situation. However, the authors find that exchange rate flexibility outperforms a fixed exchange rate regime.

- Morón and Winkelried (2005) compare optimal hybrid reaction functions in financially vulnerable and financially robust economies. In general, the optimized rules for a vulnerable economy place much less weight on smoothing output and more weight on dampening exchange rates than in a robust economy. The analysis does not directly compare the performance of such hybrid rules against otherwise similar rules excluding exchange rate terms. Nonetheless, the finding that some exchange rate smoothing is involved in the optimal rules appears to imply that rules excluding exchange rate smoothing perform less well in minimizing inflation and/or output volatility. It is not clear, however, why some exchange rate smoothing appears optimal for both the vulnerable and robust economies.
- Cavoli and Rajan (2006) compare variations on plain vanilla and hybrid Taylor rules for a financially vulnerable economy (calibrated to the Thai economy). Key results of interest are that: (1) in optimally weighted, open-economy Taylor rules (including an exchange rate term), the optimal weight on the exchange rate is low; (2) open-economy Taylor rules may well lead to greater macroeconomic volatility than plain vanilla Taylor rules; and (3) the emphasis put on the level of the real exchange rate versus changes in the exchange rate has important consequences for macroeconomic outcomes. It is not clear, however, whether these results would carry over to a model with more forward-looking behavior, including more forward-looking policy formulation.
- Batini, Levine, and Pearlman (2007), using a calibrated model of the Peruvian economy with dollarization and financial "frictions," compare fixed and flexible exchange rate regimes. They find that a fixed exchange rate delivers much poorer performance. They conclude that, because dollarization weakens the output gap channel of transmission relative to the exchange rate channel, nothing should be done to limit the flexibility of the exchange rate in order to achieve the inflation target.
- Ravenna and Natalucci (2008) use a model loosely calibrated to the transition economies of Eastern Europe to examine the implications of the Balassa-Samuelson effect. They find that when the economy is experiencing a prolonged period of more rapid productivity growth in the tradables than in the non-tradables sector, macroeconomic performance is much better with a flexible exchange rate than with a rule involving a high degree of exchange rate management.
- Leitemo and Söderström (2005) and Wollmershäuser (2006) both consider the performance of alternative policy rules when there is uncertainty surrounding the determination of the exchange rate. Although not specifically an emerging economy issue, uncertainty about the determination of the exchange rate may be even greater in such economies than in more advanced economies. The authors of both papers find a small gain from including the exchange rate in the reaction function when there is no uncertainty about exchange rate determination. However, when

uncertainties are introduced, Leitemo and Söderstöm find that a Taylor rule is slightly more robust than an open-economy rule, while Wollmershäuser finds that open-economy rules are more robust to a wider range of exchange rate uncertainties.

Inflation Targeting with an Exchange Rate Band

It is unclear how well this type of framework compares with a more conventional inflation-targeting framework in terms of macroeconomic performance:

- Lahiri and Végh (2001) suggest that an exchange rate band may be appropriate if nominal exchange rate movements and higher interest rates have output costs and if intervention is costly. In such circumstances, a fairly free float within an exchange rate band may be optimal, at least in response to some kinds of shocks.
- Morón and Winkelried (2005) examine such a policy in their model of a financially vulnerable economy and find that it tends to outperform a policy involving a more linear response to exchange rate movements. The authors note, however, the analysis fails to take into account the impact that limiting exchange rate movements will have on the behavior of economic agents. In particular, if the central bank limits the range of exchange rate movement, this could encourage agents to increase their foreign currency liabilities, accentuating the vulnerability of the economy. This would make the economy particularly vulnerable to real shocks shifting the equilibrium real exchange rate.

Exchange-Rate-Based Inflation Targeting

McCallum (2006) compares the performances of plain vanilla and exchange-rate-based approaches to inflation targeting in an economy with varying degrees of openness. The first key finding is that, as the degree of openness increases, an exchange-rate-based approach to inflation targeting does much better than the standard interest-rate-based approach in stabilizing output, with no adverse consequences for inflation variability. The second key finding is that, in the interest-rate-based approach, the variability of the interest rate is low while that of the exchange rate is high, whereas in the exchange rate-based approach, the opposite occurs. These results suggest, broadly, that in a very open economy, smoothing the exchange rate rather than interest rates may contribute to reducing output volatility.

Simulation Method

Construction of Volatility Tradeoff Frontiers

The volatility trade-off frontiers shown in the main text are constructed as follows:

- For each of the two types of country models, 10 variants of each alternative policy reaction function were constructed, each with a slightly different weighting on the inflation and output objectives, as shown in Table A2. The sum of the coefficients on the two objectives was held constant, as were the coefficients on the exchange rate objective and the lagged instrument term.

Table A2. Reaction Function Coefficients

	Inflation	Output
1	0.25	2.57
2	0.57	2.26
3	0.89	1.94
4	1.20	1.62
5	1.52	1.31
6	1.84	0.99
7	2.15	0.67
8	2.47	0.36
9	2.79	0.04
10	3.11	-0.28

- Each country model, with each variation of the parameterization of the alternative policy rules, is then simulated in response to each of three kinds of shocks: demand, cost-push, and risk premium shocks.
- Each simulation involves a 200-period run. In each period, the model is subjected to a shock drawn from a normal distribution.³² For each kind of shock, the 200-period simulation is replicated 50 times.³³
- These simulations provide 50 time series with 200 observations for each kind of shock, each policy rule variant, and each of the 29 endogenous variables. Of these, the variables of most interest are inflation, output, the interest rate, the exchange rate, and the current account balance. The standard deviation of the time series for each variable is then computed, between the 100th and 120th observation, and then averaged over each of the 50 replications to produce a representative standard deviation for each variable in response to each kind of shock and policy variant.³⁴

The same kind of simulation exercises could be carried out for variations of the weight of the exchange rate objective as opposed to the output, inflation, or instrument smoothing objective. In this analysis, however, inflation and output smoothing are considered to be the ultimate objectives of monetary policy, whereas smoothing of the policy instrument or an exchange rate objective are to be evaluated in terms of their performance in achieving the foremost policy objectives.

³²The shocks have a mean of zero and a standard deviation of one. Thus, the shock could be interpreted as a 1 percent shock with the responses of the variables being percentage deviations from steady state (Galí, 2003).

³³Each simulation run uses a different initial seed for the random number generation so that each run is genuinely different. The same set of seeds, however, are used for each kind of shock to ensure that differences in results for the different kinds of shocks are not attributable to the particular random draws.

³⁴The selection of the 100th–120th observations is to ensure that the observations in the sample are dominated by cross-sectional rather than longitudinal variation and also that they are free from the influence of initial conditions.

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Appendix: The Small Open-Economy Model

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