Monetary Policy, Exchange Rate Flexibility
and Exchange Rate Pass-through*

Michael B. Devereux
University of British Columbia
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Abstract

This paper develops a dynamic general equilibrium model of a small open economy to investigate alternative monetary rules, differing primarily in the degree to which they allow for exchange rate flexibility. A central argument of the paper is that the nature of the trade-off between ‘fixed’ and ‘floating’ exchange rates may be quite different in mature industrial economies than in emerging market economies. The critical distinction is the degree to which movements in the exchange rate pass-through to domestic consumer prices. With very high exchange rate pass-through, all monetary rules face a significant trade-off between output (or consumption) volatility and the volatility of inflation. Policies which stabilize output require high exchange rate volatility which implies high inflation volatility. But with limited or delayed pass-through, this trade-off is much less pronounced. A flexible exchange rate policy which stabilizes output can do so without high inflation volatility. In addition, we argue that the best monetary policy rule in an open economy is one which stabilizes non-traded goods price inflation. Finally, we show that a policy of strict inflation targeting is much more desirable in an economy with limited pass-through.

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“The pass-through of exchange rates to inflation was much higher in Mexico than in Canada, Australia or New Zealand. And this has to do a lot with history, with credibility of monetary policies, and this is one of the big challenges that we are facing today in Mexico in the conduct of monetary policy. And we have to really build sufficient credibility so that this pass-through from exchange rate movements to inflation ceases to be such an automatic reaction.”

- Guillermo Ortiz, Governor, Central Bank of Mexico, June 24, 1999

This paper develops a dynamic general equilibrium model of a small open economy to investigate alternative monetary policies which differ in the degree to which they allow for exchange rate flexibility. Since the Mexican and Asian crises, there has been a very public debate about the costs and benefits of floating exchange rates for ‘emerging market’ economies. Some writers argue that the main moral to be derived from the crises of the 1990’s is that exchange rates should be allowed to float freely (Sachs, Tornell, and Velasco (1996), Chang and Velasco (1998), Obstfeld and Rogoff (1995)). Others dispute the benefits of floating exchange rates, since floating exchange rates may be associated with discretionary monetary policy and macroeconomic instability (Calvo 1999), or exchange rate volatility might disrupt financial markets that exhibit ‘liability dollarization’ (Eichengreen and Hausmann 1999), or floating exchange rates may be replaced with de facto exchange rate pegging (Calvo and Reinhardt, 2000), thus making an economy vulnerable to a currency crisis.

The aim of this paper is to identify the main trade-offs between policies which allow for exchange rate flexibility and policies that try to target the exchange rate. Our model is a two-sector, small open economy, where nominal rigidities are present in the form of sticky non-traded goods prices. The economy is subject to a series of external shocks, to which it must adjust, whatever is the exchange rate policy being followed.
A central argument of the paper is that the nature of the trade-off between ‘fixed’ and ‘floating’ exchange rates may be quite different in mature industrial economies like Canada or Australia, and emerging market economies such as Mexico, Brazil, or Malaysia. The critical difference between these examples is the degree to which movements in the exchange rate pass-through to domestic consumer prices. As suggested by the Ortiz quotation above, movements in exchange rates typically feed quickly into price levels in emerging market economies, or at least do so a lot quicker than in OECD economies. For stable, high income economies, a wealth of recent evidence (see Engel 2000 for evidence and references) has established that consumer prices show very little short-run response to movements in exchange rates. For the case of the UK, Canada, Mexico and Korea, Table 1 illustrates the results of a regression of monthly CPI inflation rates on lagged exchange rate changes vis a vis the US dollar. For Canada and the UK, the lagged exchange rate change has no explanatory power, at the monthly frequency, for CPI inflation. But for Mexico and Korea, the coefficient on lagged exchange rate changes is highly significant. The pass-through for Mexico is over 10 percent, but smaller for Korea. Thus, our working hypothesis is that exchange rate pass-through is very fast for emerging markets, but slow for advanced economies.

How does this change the nature of the monetary policy making problem? Much of the literature on monetary policy in open economies (Svensson 2000, Ball 1998, 2000) has been based on the premise that the rate of CPI inflation is instantaneously affected by movements in exchange rates. For policymakers concerned about inflation, this represents both an opportunity and a constraint on optimal monetary policies. But from the discussion in the last paragraph, we suggest that this hypothesis is not wholly accurate, except for emerging market economies.
Our methodology is to compare the properties of a series of different monetary rules, in face of exogenous external shocks to the small economy\(^1\). Two types of ‘Taylor rules’ are introduced, one which partially targets the nominal exchange rate, and one a standard Taylor rule. We also examine a rule which stabilizes the domestic rate of CPI inflation (strict inflation targeting), and a rule which pegs the exchange rate. Finally, we examine the properties of a rule which stabilizes the rate of non-traded goods inflation. This is the two-sector open economy analogue to the optimal monetary rule identified by Goodfriend and King (1997), in that it eliminates all variability in the real marginal cost for non-traded firms, and therefore attains the equilibrium of the hypothetical economy without nominal rigidities.

The main result that comes out of the analysis is that the trade-off between exchange rate regimes (or monetary policy rules) may be quite different for an emerging market economy with very high exchange rate pass-through than for an advanced economy with limited short-run exchange rate pass-through. In the emerging market case, a flexible exchange rate rule (such as the Taylor rule, or the rule that stabilizes non-traded inflation) will help to stabilize the real economy, in face of external shocks. By facilitating adjustment in both the real exchange rate and real interest rate, these rules can cushion the economy from the impacts of external shocks. We find that the best rule to achieve this is the mark-up-stabilization rule. But in order to stabilize GDP and consumption, the rule has to allow a high volatility in the nominal exchange rate, and therefore high inflation volatility. There is a clear trade-off between output/consumption volatility and inflation volatility. If the

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\(^1\) Monacelli (1999) has also contrasted monetary policy rules in an open economy with full pass-through to those with imperfect pass-through. Our model differs in a number of ways. We focus on a two sector ‘dependent economy’ model. We look at a wider range of shocks, and allow for a wider range of monetary policy rules, including fixed exchange rates. We also directly compare welfare across the different exchange rate regimes, as well as calibrating our model to the case of emerging market economies.
authorities are concerned with consumer price inflation\(^2\) (over and above non-traded goods inflation), then the flexible exchange rate regime brings some costs as well as benefits. Moreover, the same logic implies that a policy of strict inflation targeting is quite undesirable in an open economy, since it effectively amounts to a requirement of fixing the exchange rate. It stabilizes inflation at the expense of a lot of output instability.

The situation is quite different when pass-through is limited. We model this process by assuming that foreign firms follow a practice of setting prices in domestic currency, and only gradually adjusting to exchange rate changes. In this environment, we find that there is no trade-off between output volatility and inflation volatility. In fact, a flexible exchange rate can deliver lower output variance and lower inflation variance than a fixed exchange rate regime. The mark-up-stabilization rule minimizes the variance of output, consumption, and inflation, among all the rules considered.

The explanation of these results is easy to see. When exchange rates changes do not fully impact on consumer prices, then external shocks which cause exchange rate movements have a smaller effect on internal relative prices facing households, and a smaller effect on domestic inflation. As a result, both inflation and the real economy tend to be stabilized. At the same time, since exchange rates still immediately affect interest rates (through UIRP), the monetary policy rule under flexible exchange rates can still use nominal exchange rates to help stabilize the economy. Thus, in effect, the exchange rate can be used without inflationary consequences. The conclusion is that the monetary policy problem is much more favourable in an economy with limited pass-through, and in this tilts the balance strongly towards floating exchange rates.

\(^2\) Strictly speaking, in our model, there is no reason that consumers should be concerned with CPI
A corollary of these findings is that a policy of strict inflation targeting is much less costly in an economy with limited pass-through, since inflation can be stabilized while still allowing for a considerable degree of nominal exchange rate volatility.

A general finding of the paper, in comparing monetary rules, is that the rule that stabilizes non-traded goods price inflation performs the best. It is a simple, coherent rule, and just says that the authorities should not pay attention directly to the exchange rate or traded goods prices in setting interest rates. There is also an added attractive feature of the rule. A Taylor type rule in an open economy may be destabilizing in the presence of ‘internal shocks’ to the monetary policy decision making structure. If we thought of such shocks as related to ‘credibility’ or ‘risk-premium’ shocks, then there might be a case for a currency board or a dollarization in order to eliminate this type of instability. But the rule which stabilizes non-traded goods price inflation also automatically neutralizes such internal ‘monetary policy’ shocks. To the extent that such a rule can be made credible, it has an advantage over a pegged exchange rate, since it also helps to stabilize the economy in face of external shocks.

The paper is organized as follows. The next section develops the basic model, which is a two-sector dynamic small open ‘dependent economy’ model. The model is calibrated and simulations reported in Section 3. Section 4 discusses the difference between alternative monetary rules for the volatility of inflation, output, and other inflation, if the inflation rate of non-traded goods is stabilized. Realistically, however, it is highly likely that central banks will be concerned more generally with CPI inflation.

3 There is a parallel between a non-traded goods inflation rule and the central bank practice of focusing on ‘core inflation’, excluding goods whose prices display high short term volatility. To the extent that these goods, such as food and energy, are imported, the focus on non-traded goods inflation and core inflation may lead to similar results.
variables, and discusses welfare comparisons across regimes. Some conclusions follow.
Section 2.

Here we describe the model of a small open economy that will be used to compare alternative monetary policy rules. The structure is a very standard two sector ‘dependent economy’ model. Two goods are produced: a domestic non-traded good, and an export good, the price of which is fixed on world markets. This is probably the best representation of the macroeconomic environment of ‘emerging market’ economies. Although the real exchange rate is determined by domestic macroeconomic equilibrium, the economy has no international market power in traded goods.

A central aspect of the model is the presence of nominal rigidities. Price stickiness introduces a role for monetary policy and a non-trivial comparison between exchange rate regimes. But unlike the standard analysis of price stickiness in closed economy models (e.g. Goodfriend and King 1997, Rotemberg and Woodford, 1997), in a small open economy prices in the traded goods sector are determined by world prices. Non-traded goods prices are set in advance by domestic firms however, and adjust only gradually to shocks.

There are three types of actors in the economy; consumers, firms, and the monetary authority.

Consumers

The economy is populated by a continuum of consumer/households of measure unity. The representative consumer has preferences given by

\[ U = E_0 \sum_{t=0}^{\infty} \beta u(C_t, H_t, m_t) \]

where \( C_t \) is a composite consumption index, such that \( C_t = C_{N_t} C_{Mr} \), where \( C_{N_t} \) represents consumption of non-traded goods, and \( C_{Mr} \) is consumption of an imported
foreign good. $H_t$ is labor supply, and $m_t = M_t / P_t$ represents real balances, with $M_t$ being nominal money balances, and $P_t$ being the consumer price index. Let the functional form of $u$ be given by

$$u(C, H, m) = \frac{C^{1-\sigma}}{1-\sigma} - \eta \frac{H^{1+\psi}}{1+\psi} + \chi \frac{m^{1-\epsilon}}{1-\epsilon}$$

In addition, if we let composite consumption take the form

$$C_t = (a^{1/\rho} C_{N, t}^{1-1/\rho} + (1-a)^{1/\rho} C_{M, t}^{1-1/\rho})^{\rho - 1}$$

then the implied consumer price index is

$$P = (a^{1/\rho} P_{N, t}^{1-1/\rho} + (1-a)^{1/\rho} P_{M, t}^{1-1/\rho})^{1-\rho}.$$  

Finally, assume that consumption is differentiated at the individual goods level, so that $C_{j, t} = \left( \int_{0}^{1} C_{j, t} (i)^{-\lambda} \, di \right)^{1/(1-\lambda)}$, where $\lambda > 1$, $j=H,M$.

Consumers are assumed not to face any capital market imperfections.

Therefore, the consumer can borrow directly in terms of foreign currency at a given interest rate $i^*_{t+1}$ for period $t$. Consumers revenue flows in any period come from their supply of labour to firms for wages $W_t$, transfers $T_t$ from government, profits from firms in the non traded sector $\Pi_t$, return on capital that is rented to firms in each sector, domestic money, less their debt repayment from last period $D_t$. They then obtain new loans from foreign capital markets, and use these loans to consume, invest in new capital, and acquire new money balances. Their budget constraint is thus:

$$PC_t + (1+i^*_t^*)S_tD_t + P_t(I_{N_t} + I_{X_t}) + M_t$$

$$= W_tL_t + \Pi_t + S_tD_{t+1}^\rho + M_{t-1} + T_t + P_tR_{N_t}K_{N_t} + P_tR_{X_t}K_{X_t}.$$  

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4 Much of the recent post-crisis literature on emerging markets has stressed the imperfections and instability of capital markets. See e.g. Cespedes, Chang and Velasco (2000), Aghion, Bachetta and Banerjee (2000), Devereux and Lane (2000), Cook (2000), and others. But how much this should impact on the monetary policy problem is open to debate. Both Cespedes, Chang and Velasco (2000) and Devereux and Lane (2000) show that introducing collateral constraints on foreign investment financing, and a ‘currency mismatch’ in balance sheets does not affect the qualitative conclusions with respect to optimal monetary policy in an otherwise conventional model of a small open economy (e.g.
Capital stocks in the export and non-traded sectors evolve according to

\( K_{Xt+1} = \phi \left( \frac{I_{Xt}}{K_{Xt}} \right) K_{Xt} + (1 - \delta) K_{Xt} \)  

\( K_{Nt+1} = \phi \left( \frac{I_{Nt}}{K_{Nt}} \right) K_{Nt} + (1 - \delta) K_{Nt} \)  

where the function \( \phi \) satisfies \( \phi' > 0 \), and \( \phi'' < 0 \). This reflects the presence of adjustment costs of investment. Under this specification, capital cannot move between sectors at any given time period, but capital in each sector adjusts over time.

The household will choose non-traded and imported goods consumption to minimize expenditure conditional on total composite demand \( C_t \). Demand for non-traded and imported goods is then

\[ C_{Nt} = a \left( \frac{P_{Nt}}{P_t} \right)^{-\rho} C_t \quad C_{Mt} = (1 - a) \left( \frac{P_{Mt}}{P_t} \right)^{-\rho} C_t \]

The consumer optimum can be characterized by the following conditions.

\[ \frac{1}{1 + \bar{\delta}_{t+1}} C_t^{-\sigma} = \frac{E_t \beta S_{t+1}}{S_t} \frac{P}{P_{t+1}} C_t^{-\sigma} \]  

\[ \frac{W_t}{P_t} = \eta C_t^\sigma H_t^\psi \]  

\[ \left( \frac{M_t}{P_t} \right)^{-\sigma} = \chi C_t^{-\sigma} (1 - E_t d_t^{h_{t+1}}) \]  

\[ \frac{C_t^{-\sigma}}{\varphi'(i_{t+1})} = E_t \beta C_{t+1}^{-\sigma} \left( R_{Nt+1} + \frac{(1 - \delta + \varphi'(i_{t+1})i_{Nt+1})}{\varphi'(i_{Nt+1})} \right) \]  

\[ \frac{C_t^{-\sigma}}{\varphi'(i_{t+1})} = E_t \beta C_{t+1}^{-\sigma} \left( R_{Xt+1} + \frac{(1 - \delta + \varphi'(i_{t+1})i_{Xt+1})}{\varphi'(i_{Xt+1})} \right) \]  

such as the model here). Cook (2000), however, finds a different result, using an alternative specification.
where \( i_{Ni} = \frac{L_{Ni}}{K_{Ni}} \), etc. Equation (5) represents the Euler equation for optimal consumption. Equation (6) is the labour supply equation, while equation (7) gives the implicit money demand function. Money demand depends on domestic nominal interest rates. The domestic nominal discount factor is defined as

\[
(10) \quad d_{t+1}^h = \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} P_t \frac{P_{t+1}}{P_t}.
\]

Note that the combination of (5) and (10) gives the representation of uncovered interest rate parity for this model. Finally, conditions (8) and (9) describe the optimal investment choice for the household, where the consumer separately accumulates capital stock for use in the non-traded and traded goods sectors.

**Production Firms**

Production is carried out by firms in the non-traded and export sectors. The sectors differ in their production technologies. The non-traded sector uses labour and specific capital to produce. An individual firm \( i \) in the non-traded sector has technology

\[
(11) \quad Y_{Ni} = A_N K_{Ni}^\alpha L_{Ni}^{1-\alpha},
\]

where \( A_N \) is a productivity parameter.

Traded goods production uses both imported intermediate inputs \( I_{Mt} \) and domestic value added \( V_t \) to produce using the technology

\[
(12) \quad Y_{Xt} = \left( \phi V_t^{1-\phi} + (1-\phi) I_{Mt}^{1-\phi} \right)^{\phi^{-1}}.
\]

Domestic value-added is obtained from capital and labour according to

\[
(13) \quad V_t = A_N K_{Xt}^\gamma L_{Xt}^{1-\gamma}
\]

Cost minimizing behaviour then implies the following equations
\[ W_t = MC_{Nt}(1-\alpha) \frac{Y_{Nt}}{H_{Nt}} \]

\[ R_{Xt} = MC_{Nt} \alpha \frac{Y_{Nt}}{K_{Nt}} \]

\[ W_t = P_{Xt}(1-\gamma) \frac{V_t}{H_{Xt}} \left( \frac{Y_{Xt}}{V_t} \right)^{1-\theta} \]

\[ R_{Xt} = P_{Xt} \gamma \frac{V_t}{K_{Xt}} \left( \frac{Y_{Xt}}{V_t} \right)^{1-\theta} \]

\[ P_{IMt} = P_{Xt} \gamma (1-\theta) \left( \frac{Y_{Xt}}{I_{Mt}} \right)^{1-\theta} \]

where \( MC_{Nt} \) denotes the nominal marginal production cost for a firm in the non-traded sector (which is common across firms). Equations (14) and (16) describe the optimal employment choice for firms in each sector. Equations (15) and (17) describe the optimal choice of capital. Note that the price of the traded export good is \( P_{Xt} \).

Movements in this price, relative to \( P_{Mt} \) and \( P_{IMt} \), represent terms of trade fluctuations for the small economy. Finally, equation (18) represents the condition for the optimal choice of intermediate inputs.

**Price setting**

Firms in the non-traded sector set prices in advance. Following the method of Calvo (1983) and Yun (1995), assume that firms face a probability \((1-\kappa)\) in every period of altering their price, independent of how long their price has been fixed.

Following standard aggregation results, the non-traded goods price follows the partial adjustment rule

\[ P_{Nt}^{1-\kappa} = (1-\kappa) \tilde{P}_{Nt}^{1-\kappa} + \kappa P_{Nt-1}^{1-\kappa} \]
where \( \tilde{P}_N \) represents the newly set price for a firm that does adjust its price at time \( t \).

The evolution of \( \tilde{P}_N \) is then governed by (the approximation)

\[
(20) \quad \tilde{P}_N = (1 - \beta \kappa) MC_{N_t} + E_t \beta \kappa \tilde{P}_{N_{t+1}}.
\]

Taking a linear approximation of (17) and (18), assuming an initial steady state where the rate of change of \( P_{N_t} \) is constant, we can derive the familiar forward-looking inflation equation:

\[
(21) \quad \pi_{N_t} = \lambda mcn_t + E_t \pi_{N_{t+1}}
\]

where \( mcn_t \) represents the log deviation of real marginal cost in the non-traded sector, \( MC_{N_t} \) from its steady state level (of unity). Equation (19) is analogous to the forward-looking inflation equation in Clarida, Gali and Gertler (1999). The key difference here is that both marginal costs and inflation are specific to the non-tradeable sector.

**Monetary policy Rules**

Assume that the monetary authority uses a short term interest rate as the monetary instrument. Given the interest rate, the money supply will be determined endogenously by the aggregate demand for money arising from the consumer sector, (i.e. equation (5)). Thus, the analysis of monetary rules can ignore the money supply, since it is determined as a residual. It is important however that interest rate rules are set so as to ensure a unique price level and exchange rate, and to avoid the issue of `real indeterminancy' that can arise under some interest rate rules in sticky price models\(^5\). Under all calibrations of the model, as discussed below, a unique equilibrium is obtained.

The general form of the interest rate rule used may be written as

\(^5\)See Woodford (1999) for conditions on interest rate rules required for uniqueness in the price level. In addition, see Clarida, Gali, and Gertler (1999).
\[(d_{t+1}^h)^{-1} = \left( \frac{P_{N_t}}{P_{N_{t-1}}} \right)^{\mu_s} \left( \frac{P_t}{P_{t-1}} \right)^{\mu_x} \left( \frac{Y_t}{\bar{Y}} \right)^{\mu_y} \left( \frac{S_t}{\bar{S}} \right)^{\mu_s} (1 + \bar{T}) \exp(u_t) \]

where it is assumed that \( \mu_s \geq 0, \mu_x \geq 0, \mu_y \geq 0, \mu_s \geq 0 \). The parameter \( \mu_s \) allows the monetary authority to control the inflation rate in the non-traded goods sector around a target rate of \( \bar{\pi}_n \). The parameter \( \mu_x \) governs the degree to which the CPI inflation rate is targeted around the desired target of \( \bar{\pi} \). Then \( \mu_y \) and \( \mu_s \) control the degree to which interest rates attempt to control variations in aggregate output and the exchange rate, around their target levels of \( \bar{Y} \) and \( \bar{S} \), respectively. The term \( \exp(u_t) \) represents a shock to the domestic monetary rule. We discuss the nature of this in more detail below.

This function allows for a variety of monetary rules. When \( \mu_x = \mu_y = \mu_s = 0 \), and \( \mu_n \to \infty \), the monetary authorities pursue a policy of strict inflation targeting in the non-traded goods sector. From equation (19), we see that this will ensure that the real mark-up is constant. Intuitively, if the monetary policy acts so as to ensure there is never any need to adjust prices, then there are no consequences of price stickiness. This point has been made by Goodfriend and King (1997), and others. Therefore, this policy will replicate the real equilibrium of an economy with flexible prices.

When \( \mu_n = \mu = 0 \), the authority follows a form of Taylor rule, where interest rates are adjusted to respond to deviations of CPI inflation and aggregate output from some target levels. When \( \mu_n = 0 \), then the authority follows a modified Taylor rule in which the exchange rate is targeted in addition to CPI inflation and output. When \( \mu_n = \mu = \mu_s = 0 \) and \( \mu_x \to \infty \), the monetary authority pursues strict
CPI inflation targeting. Finally, when $\mu_x = \mu_y = \mu_\pi = 0$ and $\mu_s \to \infty$, the authority follows a pegged exchange rate.

**Optimal Monetary Policy**

What objective function should the monetary authorities have in this economy? Speaking generally, the model has a natural welfare index; the expected utility of households in the small economy. An optimal monetary policy would be one which maximizes expected utility. But recent literature on the analysis of monetary policy in dynamic sticky-price general equilibrium models has developed a more direct approach to the formulation of monetary policy objective functions. Goodfriend and King (1997) point out that, leaving out issues related to the Friedman rule (or, equivalently, assuming positive nominal interest rates), an optimal monetary policy should stabilize the mark-up of prices over marginal costs, ('real marginal cost'). This is explained as follows. The only way in which a sticky-price economy differs from a flexible price economy is that the mark-up of price over marginal cost is variable. With flexible prices, firms would set a constant and time-invariant mark-up (due to CES utility). A monetary rule which stabilizes the mark-up replicates the flexible price economy. If the equilibrium of the flexible price economy is Pareto efficient, then this must represent the optimal monetary rule. In fact, the flexible price economy will typically not have an efficient equilibrium, due to the presence of monopolistic competitive pricing. But since the monetary policy rule cannot affect the average mark-up of price over marginal cost in any case (at least in the linearized version analysed here), the best rule for monetary policy is to reduce the variance of the mark-up to zero, thereby replicating the flexible price economy.

Subsequent literature refined this rule (Clarida, Gali and Gertler 1999, Woodford 1999) by linking movements in the price-cost mark-up to deviations of
output from its ‘potential’ level, or the level that it would attain in a flexible price economy. Woodford (1999) shows in an economy where price-setting is staggered, inflation generates an additional welfare loss, independent of the gap between output and potential output (i.e. the unexploited gains from trade due to sticky prices). This loss arises from the dispersion in relative goods prices, leading to an inefficient allocation of resources between sectors. In this framework, Woodford’s analysis implies that expected utility may be approximated by a quadratic function of output deviations from potential output, and inflation deviations from zero. Both Woodford and Clarida, Gali and Gertler (1999) then point out that in the absence of direct shocks to the pricing equation, an optimal monetary policy would set inflation to zero. This would stabilize the mark-up of price over marginal cost, as suggested by Goodfriend and King, and simultaneously keep output at its potential level and reduce the dispersion of relative prices to zero.

In the present model, in the case of immediate pass-through from the exchange rate to imported goods prices, a monetary policy rule which ensured a constant price-cost mark-up for non-traded goods firms would replicate the equilibrium of a flexible price economy. In this case, an appropriate welfare index would be a combination of output deviations from potential, and inflation in the non-traded goods sector. This could be achieved by zero inflation in non-traded goods prices. In the economy with slow pass-through of exchange rate changes, the situation is more complicated, because even without sticky prices in the non-traded goods sector, monetary rules can have real effects through their impact on exchange rates. This may lead the monetary authority to be more generally concerned with CPI inflation, and nominal exchange rate variability. But derivation of an welfare objective for monetary policy along the
lines of Woodford is quite complicated, due to the presence of investment, the two sector structure, and imperfect pass through.

Rather than take a stand on the exact form of the monetary authority objective function, we consider the implications of alternative monetary regimes for volatility in the major macro aggregates, including output, consumption, and inflation volatility. As we see, in some cases we may make inferences about desirable monetary policy regimes without precise knowledge of the weights that the authority puts on inflation versus output volatility in its loss function. In addition, we also provide a ranking of alternative policies using household expected utility.

**Local Currency Pricing**

The law of one price must hold for both export goods, so that

\( P_{x_t} = S_t P^*_{x_t} \).

For import goods however, we allow for the possibility that there is some delay between movements in the exchange rate and the adjustment of imported goods prices. Note that this is still consistent with the constraint that the economy is small, and without market power in the traded goods sector. The assumption is that foreign suppliers may choose to follow a pricing policy which stabilizes the prices of imports in terms of local currency. Domestic consumers however, take the local currency price of imported goods as given.

Without loss of generality, we may assume that imported goods prices are adjusted in the same manner as prices in the non-traded sector. That is, a measure \( 1 - \kappa^* \) of foreign firms adjust their prices in every period. Thus, the imported good price index for domestic consumers moves as

\[
P^i_{m_t} = (1 - \kappa^*) \tilde{P}^i_{m_t} + \kappa^* P^i_{m_{t-1}}
\]
where \( \tilde{P}_{Mt} \) represents the newly set price for a foreign firm that does adjust its price at time \( t \).

The evolution of \( \tilde{P}_{Mt} \) is then governed by (the approximation)

\[
(25) \quad \tilde{P}_{Mt} = (1 - \beta \kappa^*) S_t P_{Mt}^* + E_t \beta \kappa^* \tilde{P}_{Mt+1}.
\]

The interpretation of (26) is that the foreign firm wishes to achieve an identical price in the home market as in the foreign market. But it may incur a lag in adjusting its price. The coefficient \( \kappa^* \) determines the delay in the ‘pass-through’ of exchange rates to prices in the domestic market. Using the same approach as with equation (20) and (21), we can derive the familiar inflation equation:

\[
(26) \quad \pi_{Mt} = \lambda (\tilde{s}_t - \tilde{p}_{mt}^*) + E_t \pi_{Mt+1}
\]

where \( \pi_{Mt} \) is the inflation rate in domestically denominated traded goods prices, and \( \tilde{s}_t \) and \( \tilde{p}_{mt}^* \) represent the log deviation of the exchange rate and foreign traded goods prices from steady state.

**Equilibrium**

In each period, the non-traded goods market must clear. Thus, we have

\[
(27) \quad Y_{Ni} = \alpha \left( \frac{P_{Ni}}{P_t} \right)^{-\rho} \left( C_t + I_{Ni} + I_{Xt} \right).
\]

Equation (27) indicates that demand for non-traded goods comes from consumers, both for consumption and investment demand. In a similar manner, we may describe the evolution of the economy’s net debt, \( D_t \), as

\[
(28) \quad S_t D_{t+1} = S_t D_t (1 + \gamma_t) - P_{Xt} Y_{Xt} + (1 - \alpha) \left( \frac{P_{Mt}}{P_t} \right)^{-\rho} \left( C_t + I_{Ni} + I_{Xt} \right)
\]

Labour market clearing for the household sector implies

\[
(29) \quad H_{Ni} + H_{Xt} = H_t.
\]
Finally, to recover the nominal price of non-traded goods and imported goods, we use the conditions

\[(30) \quad P_{Nt} = (1 + \pi_{Nt}) P_{Nt-1}, \]
\[(31) \quad P_{Mt} = (1 + \pi_{Mt}) P_{Mt-1}, \]

with the initial prices \( P_{Nt-1} \) and \( P_{Mt-1} \) being given.

The economy’s equilibrium may be described as the sequence of functions given by \( C(\theta_t), H(\theta_t), S(\theta_t), d^h(\theta_t), Y_N(\theta_t), Y_X(\theta_t), V_X(\theta_t), H_N(\theta_t), K_N(\theta_t), H_X(\theta_t), K_X(\theta_{t-1}), I_X(\theta_t), I_N(\theta_t), I_M(\theta_t), R_X(\theta_t), R_N(\theta_t), \pi_X(\theta_t), \pi_N(\theta_t), mcn(\theta_t), D(\theta_t), W(\theta_t), P_M(\theta_t), P_X(\theta_t), M(\theta_t) \) and \( P_{Nt}(\theta_t) \) Here \( \theta_t \) is the period \( t \) information set. This represents a system of 25 functions that correspond to the solutions of the 25 equations (3)-(18), (21), (22) (23), (26), and (27)-(31), given the CPI definition, and given the definition of the shock processes (discussed below).

The model is solved by linear approximation using the Schur decomposition method of Klein (2000).

**Section 3: Calibration and Solution**

We now derive a solution for the model, by first calibrating and then simulating using standard linear approximation techniques. The calibration parameter values are listed in Table 2. Most values are quite standard. Rather than calibrating to any single national data-set, we choose a set of `consensus’ parameter values that are generally applied to developing economies. In some instances, where there is no direct evidence, we use common parameter assumptions from the macro general equilibrium literature.

It is assumed that the inter-temporal elasticity of substitution in both consumption and real balances is 0.5. The consumption inter-temporal elasticity is
within the range of the literature, and the equality between the two elasticities ensures that the consumption elasticity of money demand equals unity, as estimated by Mankiw and Summers (1986). The elasticity of substitution between non-traded and imported goods in consumption is an important parameter, on which there is little direct evidence. Following Stockman and Tesar (1995), we set this to unity. The elasticity of labour supply is also set to unity, following Christiano, Eichenbaum, and Evans (1997). In addition, the elasticity of substitution between varieties of goods determines the average price-cost mark-up in the non-traded sector. Since we have no direct evidence on mark-ups for emerging market economies we follow standard estimates from the literature in setting a 10 percent mark-up, so that $\lambda = 11$.

Assuming that the economy starts out in a steady state with zero consumption growth, the world interest rate must equal the rate of time preference. We set the world interest rate equal to 6 percent annually, an approximate number used in the macro-RBC literature, so that at the quarterly level, this implies a value of 0.985 for $\beta$.

The factor intensity parameters are quite important in determining the dynamics of the model. Typically these types of parameters are calibrated in general equilibrium models by identifying the employment share of GDP. But since it is quite likely that this share differs across sectors, then it is necessary to obtain separate wage shares at the sectoral level. We follow Devereux and Cook (2000) in assuming that the non-traded sector is more labour intensive than the export sector. Specifically, we take labour share in the non-traded sector to be 70 percent of value added, while labour export sector value added is 30 percent of value added.

In combination with the other parameters of the model, the parameter $a$, governing the share of non-traded goods in the CPI, determines the share of non-
traded goods in GDP. Typically, this is significantly smaller for open developing economies than for OECD economies. Devereux and Cook (2000) and Devereux and Lane (2000), estimate, for Malaysia and Thailand, that the share of non-traded goods in total GDP is 55 percent and 54 percent, respectively. For Mexico, Schmitt and Uribe (2000) estimate a share of 56 percent. Roughly following these studies, we set \( a \) at .5 to imply a share of non-traded goods to GDP of 50 percent. In addition, we set the share of imported materials in export production to be equal to that of value-added, and we assume that the elasticity of substitution between value added and intermediate imports is 0.5.

To determine the degree of nominal rigidity in the model, the value \( \kappa \), governing the speed of price adjustment in non-traded goods, must be chosen. Again, in the absence of direct evidence on this, we follow the literature (e.g. Chari, Kehoe and McGratten 1998), and set \( \kappa = 0.75 \), so that prices completely adjust after approximately 4 quarters. As is standard practice, we set the adjustment cost of capital (elasticity of Tobin’s q with respect to the investment-capital ratio) so as to imply a standard deviation of investment relative to GDP in a reasonable range.

The degree to which exchange rate and foreign price shocks are ‘passed-through’ to domestic imported goods prices is governed by the parameter \( \kappa^* \). As discussed above, this is a difficult parameter to pin down empirically. Estimates of pass-through of exchange rate changes to imported goods prices tend to be different than the observed effects of exchange rate changes on more aggregated price indices. For instance, Goldberg and Knetter (1997) estimate that the median rate of pass-through in the US is 50 percent for US manufacturing industries. But other macro evidence for the US suggests the virtual absence of any effects of exchange rate changes on domestic goods prices (Engel 2000). Similarly Engel and Roger’s (1996)
study suggests little short run effects of exchange rate changes on relative goods prices between the US and Canada. Similar evidence has been established for European countries (Engel and Rogers 1999). This suggests that there is a considerable degree of ‘local-currency pricing’ in traded goods industries in OECD countries. Within the structure of the present model, this evidence would suggest that $\kappa^*$ is positive – foreign exporting firms do not immediately adjust their prices to exchange rate changes. In the absence of very precise estimates of $\kappa^*$ we follow a rule of thumb in setting $\kappa^* = \kappa$ for our calibration of an advanced economy. The rationalization for this number is that it accords with Engel’s (2000) finding that for the US and its major industrial trading partners, there is virtually no difference in the characteristics of the prices of traded and non-traded goods.

On the other hand, as suggested above, the pass-through from exchange rates to prices is likely to be much higher for emerging markets. Evidence from the Asian and Mexican crises indicate a very rapid transmission of exchange rate depreciation to imported goods prices. Again, however, precise estimates of the extent of pass-through have not been obtained. To fix ideas, we make the extreme assumption that the pass-through is immediate for our calibrated ‘emerging market’ economy. Thus, we set $\kappa^* = 0$ for the emerging market model. Therefore, the law of one price obtains at all times. Both foreign price shocks and exchange rate changes have immediate implications for local prices of imported goods.

**Shocks**

The model implies that the economy is exposed to three types of external shocks: a) shocks to foreign prices, b) shocks to the foreign interest rate, and c) terms of trade shocks. The first and third shocks are obviously inter-related. Conceptually, however, there is a difference between balanced movements in the world price level,
and shocks to the relative price of the domestic country export good. We let price shocks be represented by equal shocks to all foreign prices, i.e. to $P_{Mt}^*$ and $P_{Xt}^*$ and $P_{IMt}^*$. Terms of trade shocks are represented by shocks to $\frac{\Delta X_t}{\Delta M_t}$ and $\frac{\Delta X_t}{\Delta IM_t}$. Since in the model, shocks to these last two variables have almost identical effects, we assume that they are equivalent. Thus, the consumer and producer import price indices are assumed the same.

In the following section we will measure the size of these shocks for a group of Asian countries. At present, we wish to give an intuitive account of the basic properties of the model when subjected to each external shock.

**The impact of external shocks under alternative monetary regimes**

We now illustrate the workings of the model in response to the different external shocks, under each monetary rule. The monetary rules are categorized in Table 3. The mark-up rule stabilizes the rate of inflation in non-traded goods, as discussed above. Two ‘Taylor-type’ rules are also discussed, one of which targets the exchange rate. Finally, there is a strict CPI inflation targeting rule, and a pegged exchange rate rule.

**Interest Rate Shocks.**

Figure 1 describes the response of the economy to a foreign interest rate shock when pass-through from exchange rates to imported goods prices is immediate. The shock represents a 100 basis points rise in $i^*_f$, which is assumed to follow an AR(1) process with parameter $0.5^6$.

As discussed in Devereux and Cook (2000), the response to a foreign interest rate shock is to generate both an internal and external reallocation of resources in the
economy. The interest rate disturbance reduces domestic absorption, generating a current account surplus. The fall in absorption also forces a real exchange rate depreciation, leading to a reallocation of factors from non-traded towards export good production. Thus, there is both an internal and external ‘transfer’. For all monetary policy rules, the same phenomenon is observed; absorption falls, the trade balance improves, and overall GDP falls.

But the magnitude of the response to an interest rate disturbance is affected quite strongly by the monetary rule. The response of the economy under a strict inflation target and a pegged exchange rate regime is almost the same. Domestic absorption falls by much more than under the mark-up rule, or the two Taylor rules. Under the pegged exchange rate or the strict inflation target, the inflation rate is effectively stabilized. This means that the domestic real interest rate rises by the same magnitude as the exogenous foreign interest shock. On the other hand, the other three rules make use of the nominal exchange rate variability to cushion the real interest rate impact of the changes. The mark-up rule allows an immediate but transitory nominal exchange rate depreciation, which generates an expected appreciation. This dramatically limits the magnitude of the nominal interest rate rise. While the anticipated appreciation translates into an anticipated rate of CPI deflation, this is of a smaller magnitude than the anticipated appreciation itself. Figure 1g establishes that at the time of the shock, there is an expected real exchange rate appreciation, which reduces the real interest rate impact of the shock. But the expected real appreciation is much less for the fixed exchange rate rule and the price stability rule.

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The shocks are calibrated more directly in the computation below.
A clear implication of Figure 1, however, is that the monetary rules which provide stability in the real economy do so at the expense of inflation stability. The mark-up rule completely stabilizes the inflation rate in the non-traded goods sector, but requires high variability of the nominal exchange rate, and therefore generates a highly volatile overall price level. There is a trade-off between output stability and inflation stability. The trade-off can be seen most clearly by comparing the simple Taylor rule with the Taylor rule that includes an exchange rate response. The latter achieves a lower response of inflation, but at the expense of a higher first period fall in GDP.

Figure 2 illustrates the case of delayed pass-through. With delayed pass-through, changes in exchange rates feed into the consumer price index only at the rate of overall price adjustment. Under the case of fixed exchange rates, the degree of pass-through is irrelevant, so the results are identical to those in Figure 2. But for the mark-up rule, and the two versions of the Taylor rule, the effect of the lower pass-through is to stabilize the rate of inflation. Under the mark-up rule, the movement in inflation is only 10 percent of the movement with immediate pass through. This acts to stabilize the real economy, in two ways. First, the muted impact on internal relative prices reduces the degree of expenditure switching, and leads to a smaller contraction in non-traded goods production. But, in addition the lower response of inflation now allows for a lower real interest rate response to the foreign interest rate shock. Under the mark-up rule, for instance, the expected rate of deflation in the period of the shock is much less than in the immediate pass-through model. This cushions the real interest rate response.

A further implication of the limited pass-through model is that it opens up a substantial difference between a price stability rule and the pegged exchange rate rule.
The aggregate CPI can now be stabilized while still allowing significant movement in the nominal exchange rate. This implies, from Figure 2, that the goal of price stability is still consistent cushioning the nominal and real interest rate response to the shock. As a result, absorption and output under the price stability rule are much less variable than the pegged exchange rate rule.

Note that the flexible exchange rate monetary rules require very large nominal exchange rate variability. The nominal exchange rate response to the interest rate shock is higher than in the case of immediate pass-through. Thus, as observed in previous literature (Betts and Devereux 2000), limited pass-through tends to exacerbate exchange rate volatility. But it does so with less consequences, since exchange rates do not immediately feed into CPI inflation.

The conclusion from this case is that in the presence of limited pass-through of exchange rate changes to import prices, there is no trade-off between output stability and inflation stability, at least in the response to interest rate shocks. A flexible exchange rate policy of the type analysed here can cushion the output response to an external interest rate shock without requiring more inflation instability. In fact, the (absolute) response of inflation is greater under a fixed exchange rate (which forces a deflation) than under the flexible exchange rate mark-up rule. Moreover, a rule following a goal of strict CPI price stability is still consistent with a stabilizing role for the nominal exchange rate.

**Terms of Trade Shocks**

Figure 3 and 4 describe the response of the model to terms of trade shocks. The shock is a one percent fall in the terms of trade that persists with AR(1) coefficient 0.5. Figure 3 describes the model with immediate pass-through, while Figure 4 illustrates the case of delayed pass through. We see that the general
conclusions of the previous sub-section apply. With immediate pass-through, the mark-up monetary rule stabilizes output and absorption, but does so by generating a high response of the exchange rate and of CPI inflation. The mark-up rule allows for a sharp, but transitory nominal depreciation. The anticipated appreciation allows for a fall in the real and nominal interest rate. By contrast, the Taylor rule implies a persistent nominal depreciation. The nominal interest rate rises, and the real interest rate is unchanged. Again, the price stability rule and the pegged exchange rate rule are essentially the same.

With limited pass-through, Figure 4 shows that the real effects of the terms of trade shock are mitigated, (for all rules except the pegged exchange rate). Given the very low inflation impact of the nominal depreciation, the Taylor rule becomes much more expansionary. In fact, all rules except the pegged exchange rate now generate a fall in the nominal interest rate. In terms of stabilizing output, consumption, and investment in response to the terms of trade deterioration, the Taylor rule and the price stability rule are essentially equivalent when there is limited pass-through.

Again, note that the nominal exchange rate responds by substantially more when there is limited pass-through, while inflation responds by substantially less. Thus, again, the trade-off between output stability and inflation stability disappears.

Price Shocks

Figure 5 and 6 illustrate the impact of foreign price shocks. The price shock is modelled as a shock to the growth rate of foreign goods prices (both export and import goods), which leaves the terms of trade unchanged. Thus, letting $\Delta P^*_t = \rho_1 \Delta P^*_t + \varepsilon_t$, the Figure illustrates the impact of a negative one-unit shock to $\varepsilon_t$ with $\rho_1 = 0.5$. The effect of this shock can be thought of as a combination of a
level shift in the foreign price, and a rise in the foreign real interest rate. For the
monetary rules which do not concern themselves with the nominal exchange rate
(mark-up, Taylor, and Price Stability Rule), the only impact of the price shock is as a
real interest rate increase. These rules require a permanent increase in the nominal
exchange rate to offset the fall in the foreign price level. But in terms of real effects,
for these rules, the results are the same as in Figure 1 and 2. For the pegged exchange
rate and the Taylor rule with exchange rate response however, the nominal exchange
rate is either kept constant, or is forced to return to its initial position. Both rules
therefore imply a domestic deflation, to restore equilibrium, and both require a greater
fall in output that the other rules. In the case of external price shocks, note that
nominal exchange rate stability is no longer consistent with inflation stability. The
absolute response of inflation is greatest under a pegged exchange rate.

Again, as before, the effect of delayed pass through is to reduce the
inflationary impact of the foreign prices shocks, while also stabilizing the real
economy. Note that even a pegged exchange rate achieves some inflation stability
following a foreign price shock, when pass-through is limited, since the direct impact
of the price shock is not immediately felt in consumer prices.

**Internal Shocks**

A common criticism of floating exchange rates is that they may be associated
with destabilizing ‘internal’ shocks arising from domestic monetary policy
uncertainty. In the standard Mundell-Fleming analysis, the presence of domestic
nominal disturbances may tip the balance in favour of an exchange rate peg, since
such shocks can be effectively eliminated by fixing the exchange rate. Recently,

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7 To see why the real interest rate must increase, imagine that the nominal exchange rate depreciated to
keep the CPI constant in response to the declining path of foreign prices. This would leave the
expected inflation rate unchanged, but would imply a positive expected rate of depreciating, increasing
the nominal (and therefore real) interest rate.
Calvo (1999) and Mendoza (2000) have made the point that monetary policy instability in Latin America may offer a strong case for the desirability of Currency Boards or Dollarization.

What does our model imply about the effects of internal shocks? We may model such shocks as disturbances to interest rates associated with the rule (22). Such disturbances can be entirely offset by an exchange rate peg, since then the interest rate must adjust to continually equal the foreign interest rate. By contrast, under a Taylor rule, such monetary shocks affect real output and consumption.

But the mark-up rule, by stabilizing non-traded goods prices, also completely insulates the economy from internal shocks to the interest rate process! This is easy to see. Since the mark-up rule replicates the equilibrium of a flexible price economy, it supports an economy where monetary neutrality holds. Shocks to the nominal interest rate process do not affect real interest rates, or any real magnitudes. Thus, the mark-up rule provides exactly the same insulation from internal interest rate shocks as does a pegged exchange rate. But since the mark-up rule does a much better job of insulating the economy from external shocks, it is therefore much preferable to a peg, at least when the authority does not display an extreme dislike of inflation volatility (in the case of full pass-through).

Section 4. Quantitative Analysis of the effects of alternative monetary rules.

In this section we investigate quantitative and welfare implications of alternative monetary rules. This requires us to take a stand on the magnitude and importance of the shocks. The approach taken is as follows. The interest rate shock is identified as the US prime rate. This is a reasonably good measure of the 'foreign interest rate' that is faced by emerging markets. Of course there may be country specific risk premia affecting the borrowing costs of many emerging markets. Calvo
(1999) also suggests that these country risk premia may themselves be related to the monetary regime – reflecting the degree of perceived international confidence in the monetary or fiscal regime within a country. But there are significant difficulties in the measurement of these premia. As a consequence, we abstract from these. While it is likely that the analysis therefore underestimates the magnitude of interest rate shocks affecting emerging markets, this would not affect the trade-off between fixed and floating exchange rates substantially, as greater interest rate volatility would both increase the stabilization benefits of floating exchange rates, but increase the implied inflation variability also.

Terms of trade shocks are measured as the ratio of export to import price deflators. We take an average terms of trade for Asia, from IFS. Finally, we measure imported goods price shocks as the US dollar price of import goods for Asia, again from the IFS. The three variable system, consisting of prime, US dollar import prices, and terms of trade are estimated as an autoregressive system. The results are contained in Table 4. These results are then used to calibrate the shock processes for the model.

Table 5 illustrates the difference between the various monetary rules for the volatility of GDP, the real exchange rate, consumption, investment, inflation, marginal cost, and the nominal exchange rate. The top panel shows the results in the case of immediate pass-through, while the bottom panel shows the case of limited pass-through. With full pass-through, there is an inverse relationship between output/consumption volatility and inflation/nominal exchange rate volatility. The mark-up rule minimizes output and consumption volatility, but produces very high inflation and nominal exchange rate volatility. Output and consumption volatility is
highest under a pegged exchange rate, but inflation volatility is very small under this rule. In addition, the difference between a peg and a strict inflation target is quite small.

The model also suggests that the quantitative effects of exchange rate flexibility may be substantial. Using a Taylor rule stabilizes output by about 60 percent, and stabilizes consumption by about 18 percent, relative to a fixed exchange rate. Stabilizing non-traded goods inflation reduces output volatility by two thirds, and consumption volatility almost by half, although inflation volatility is doubled, relative to the pegged exchange rate.

When pass-through is lagged, the results are sharply different. Now the rule that stabilizes non-traded goods inflation minimizes both output/consumption volatility and inflation volatility. Thus, on this dimension, the mark-up rule dominates a pegged exchange rate. Output and consumption volatility is lower for the three rules that do not target the exchange rate. There is also much less of a difference between the mark-up rule, and Taylor rule, and the Price Stability rule as regards overall output volatility.

Note that the Table illustrates, as suggested in the previous section, that nominal exchange rate volatility is much higher with lagged pass-through, for the `floating exchange rate’ rules. Nominal exchange rate volatility increases by 15 –20 percent in all cases. At the same time, the real exchange rate, measured as the domestic relative price of non-traded goods, is far less volatile, as both nontraded prices and export good prices adjust much more slowly in response to all shocks.

Finally, the Table also includes welfare calculations across monetary rules. These are calculated by averaging repeated draws of utility over 100 quarters,

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8 Asia is Hong Kong, India, Indonesia, Korea, Pakistan, Papua NG, Singapore, Sri Lanka, and
evaluated at the consumers discount factor\(^9\). In the case of immediate pass-through, the mark-up rule and the Taylor rule are almost equivalent, although the mark-up rule results in slightly higher utility. Both rules are clearly better, in utility terms, than the Taylor rule with exchange rate response, the pegged exchange rate rule, or the price stability rule. With delayed pass-through, again, the mark-up rule leads (marginally) to highest utility. Utility is higher in this case for the mark-up rule, the Taylor rule and the Price Stability rule. Note in addition, that with delayed pass through, the price stability rule gives utility almost the same as the mark-up rule and the Taylor rule. Thus, in utility terms, a price stability rule does much better in a regime of limited pass-through.

These results confirm the general message of the paper; the fixed versus floating exchange rate trade-off is substantially different in an economy with high pass-through of exchange rates to traded goods prices than in an economy where pass-through is delayed. Given that pass-through is likely to be much faster in emerging markets, for reasons of policy credibility or small size, this makes the choice of fixed versus flexible exchange rates quite different for emerging markets than for advanced economies.

**Conclusions**

We have described the monetary policy trade-off between regimes which target the exchange rate and those which allow the exchange rate to adjust freely. Our main result is that the trade-off depends sharply on whether there is a high degree of pass-through from exchange rates to import good prices. A secondary result is that a

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\(^9\) As in other literature (e.g. Obstfeld and Rogoff 1995), the utility of real balances are ignored in this calculation. The utility estimates could be transformed into consumption equivalent comparisons across the different policy regimes. But as is well known in this literature (e.g. Lucas 1987), the magnitude of welfare differences across different regimes in business cycle models is extremely small. Thus, we merely report the rankings of utility across regimes.
policy of strict inflation targeting is much easier to implement in an economy with lagged pass-through, since the CPI can be stabilized without destabilizing the real economy. Finally, we outline a simple and efficient monetary policy rule for an open economy that is a natural extension of work in the closed economy literature with sticky prices. This rule is just to stabilize the non-traded goods price level.
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<table>
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<tr>
<th>Country</th>
<th>Constant</th>
<th>Lagged ER change</th>
<th>S.E.E</th>
<th>R²</th>
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<td>0.0458</td>
<td>0.001</td>
<td>0.001</td>
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<td></td>
<td>(7.75)</td>
<td>(0.71)</td>
<td></td>
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</tr>
<tr>
<td>UK</td>
<td>0.001**</td>
<td>0.005</td>
<td>0.0002</td>
<td>0.0004</td>
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<tr>
<td></td>
<td>(6.53)</td>
<td>(0.74)</td>
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</tr>
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<td>Mexico</td>
<td>0.0056**</td>
<td>0.1125**</td>
<td>0.004</td>
<td>0.18</td>
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<td></td>
<td>(14.34)</td>
<td>(5.27)</td>
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</tr>
<tr>
<td>Korea</td>
<td>0.0017**</td>
<td>0.029**</td>
<td>0.0002</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>(9.49)</td>
<td>(6.55)</td>
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(Dependent variable is monthly CPI inflation rate) Sample 1990(1)-2000(7)
### Table 2: Calibration of Model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
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<tbody>
<tr>
<td>( \sigma )</td>
<td>2</td>
<td>Inverse of elasticity of substitution in consumption</td>
</tr>
<tr>
<td>( \varepsilon )</td>
<td>2</td>
<td>Inverse of elasticity of substitution in real balances</td>
</tr>
<tr>
<td>( \beta )</td>
<td>0.985</td>
<td>Discount factor (quarterly real interest rate is ( \frac{(1-\beta)}{\beta} ))</td>
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<tr>
<td>( \rho )</td>
<td>1.0</td>
<td>Elasticity of substitution between non-traded goods and import goods in consumption</td>
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<tr>
<td>( \eta )</td>
<td>1.0</td>
<td>Coefficient on labour in utility</td>
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<tr>
<td>( \psi )</td>
<td>1.0</td>
<td>Elasticity of labour supply</td>
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<tr>
<td>( \gamma )</td>
<td>0.7</td>
<td>Share of capital in export sector</td>
</tr>
<tr>
<td>( \delta )</td>
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<td>Quarterly rate of capital depreciation (same across sectors)</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>0.3</td>
<td>Share of capital in non-traded sector</td>
</tr>
<tr>
<td>( \vartheta )</td>
<td>0.5</td>
<td>Share of value added in export good production</td>
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<tr>
<td>( \phi )</td>
<td>0.5</td>
<td>Elasticity of substitution between intermediate inputs and value added in export good production</td>
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<td>( \lambda )</td>
<td>10</td>
<td>Elasticity of substitution between varieties (for both goods)</td>
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<td>( a )</td>
<td>0.5</td>
<td>Share on non-traded goods in CPI</td>
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<tr>
<td>( \kappa )</td>
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<td>Probability of non-traded firms price remaining unchanged</td>
</tr>
<tr>
<td>( -\frac{\phi^* I}{\phi' K} )</td>
<td>0.5</td>
<td>Elasticity of q with respect to I/K ratio (inversely related to investment adjustment costs)</td>
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Table 3: Monetary Rules

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<tr>
<th></th>
<th>$\mu_{\pi\pi}$</th>
<th>$\mu_{\pi}$</th>
<th>$\mu_y$</th>
<th>$\mu_z$</th>
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<td>Mark-up</td>
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<td>0</td>
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<tr>
<td>Taylor</td>
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<td>1.5</td>
<td>.5</td>
<td>0</td>
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<td>Taylor (e rate)</td>
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<td>.5</td>
<td>1</td>
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<tr>
<td>Peg</td>
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<td>0</td>
<td>0</td>
<td>$\rightarrow \infty$</td>
</tr>
<tr>
<td>Price Stability</td>
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Table 4
VAR estimates: Asia

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<th>Variable</th>
<th>Prime</th>
<th>D(logPm)</th>
<th>Dlog(Px/Pm)</th>
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<td>Prime(-1)</td>
<td>0.89</td>
<td>-0.002</td>
<td>0.0</td>
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<tr>
<td></td>
<td>(31.1)</td>
<td>(-1.61)</td>
<td>(0.3)</td>
</tr>
<tr>
<td>Dlog(Pm(-1))</td>
<td>6.2</td>
<td>0.35</td>
<td>0.047</td>
</tr>
<tr>
<td></td>
<td>(1.97)</td>
<td>(2.75)</td>
<td>(0.48)</td>
</tr>
<tr>
<td>Dlog (Px/Pm(-1))</td>
<td>5.63</td>
<td>0.13</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>(1.3)</td>
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<td>0.017</td>
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Residual Covariance Matrix

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<th>Prime</th>
<th>Dlog(Pm)</th>
<th>Dlog(Px/Pm)</th>
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<td>.0027</td>
<td>.0009</td>
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<td>Mark-up</td>
<td>Taylor</td>
<td>Taylor (e rate)</td>
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<td>---------</td>
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<tr>
<td><strong>Full Pass through</strong></td>
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<td>0.9</td>
<td>1.1</td>
</tr>
<tr>
<td>$\sigma_{err}^2$</td>
<td>3.9</td>
<td>2.8</td>
<td>1.9</td>
</tr>
<tr>
<td>$\sigma_c^2$</td>
<td>1.5</td>
<td>1.9</td>
<td>2.0</td>
</tr>
<tr>
<td>$\sigma_s^2$</td>
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<td>2.3</td>
<td>1.1</td>
</tr>
<tr>
<td>$\sigma_i^2$</td>
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<td>4.5</td>
<td>1.8</td>
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<td><strong>Expected Utility</strong></td>
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<td><strong>Limited Pass-Through</strong></td>
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<td>-55.6771</td>
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Figure 1: Output

Figure 1b: Investment

Figure 1c: Consumption

Figure 1d: Trade Balance

Figure 1e: Inflation

Figure 1f: Nominal Interest Rate

Figure 1g: Real Exchange Rate

Figure 1h: Nominal Exchange Rate

Figure 1: Interest Rate Shock
Full Pass-through
Figure 2: Interest Rate Shock
Delayed Pass-through
Figure 3: Terms of Trade Shock
Full Pass-through
Figure 4: Terms of Trade Shock
Delayed Pass-Through
Figure 5: Foreign Price Shock
Full Pass-through
Figure 6: Foreign Price Shock
Delayed Pass-through