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DO CONTRACTIONARY DEPRECIATIONS MAKE A DIFFERENCE?

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DO CONTRACTIONARY DEPRECIATIONS MAKE A DIFFERENCE? [1]

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1 This paper has benefited from comments received at a presentation at the ECB. The views expressed here do not necessarily reflect those of the ECB. All errors are the author's.

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CONTENTS

Abstract

The link between exchange rates and interest rates features prominently in the theoretical and empirical literature on small open economies. This paper revisits this relationship using a simple model that incorporates the role of exchange rate pass-through into domestic prices and distinguishes between cases of expansionary and contractionary depreciations. The model results show that the correlation between exchange rates and interest rates, conditional on an adverse risk premium shock, is negative for expansionary depreciations and positive for contractionary ones. For this type of shock, interest rates are found to be raised to prevent the contractionary effect of a depreciation regardless of whether the latter effect is strong or mild. Interest rates are predicted to also rise in response to an adverse net export shock in contractionary depreciation cases, and to be lowered in the case of expansionary ones.

Keywords: Transmission mechanism; Emerging market economies; Exchange rate; Monetary policy

JEL Classification: E52, E58, F31, F41

Non-technical summary

In recent years, there has been a special interest in the link between exchange rates and interest rates in both advanced and developing countries. This is understandable, given the important role these variables play in determining developments in the nominal and real sides of the economy, including the behaviour of domestic inflation, real output, exports and imports. Among emerging market economies, this interest is further spurred by the fact that many of them have recently introduced changes in their monetary and exchange rate policies, moving to inflation targeting frameworks which operate officially under flexible exchange rate regimes. Exchange rate variability - in itself and *vis-à-vis* interest rate variability - has in recent years risen compared to previous periods characterised by far more rigid exchange rate regimes, even if the extent of such fluctuations is still a matter of debate.

This paper revisits the relationship between exchange rates and interest rates in small open economies. It extends the previous literature by using a simple model that incorporates the role of exchange rate pass-through into domestic prices and distinguishes between cases of expansionary and contractionary depreciations. In doing so, it builds on the modeling approach of Gerlach and Smets (2000). The theoretical analysis is preceded by a brief discussion about some of the relevant evidence on emerging economies, which highlights some of the specificities that may lead in many EMEs to contractionary depreciations. In discussing the main results of the model, I illustrate its workings by drawing from previous calibrations for small open economies.

The model results show that, in response to an adverse risk premium shock, exchange rates and interest rates exhibit a negative correlation when depreciations are expansionary, and a positive correlation when they are contractionary. For this type of shock, interest rates are found to be raised to prevent the contractionary effect of a depreciation not only if the latter effect is (unrealistically) strong, as found by Eichengreen (2005), but also when such effect is mild. Interest rates are predicted to also rise in response to an adverse net export shock in contractionary depreciation cases, and to be lowered in the case of expansionary ones. As with the risk premium shock, the correlation between exchange rates and interest rates is negative for expansionary depreciations and positive for contractionary ones. The exact timing of such response of interest rates and exchange rates depends on the nature of the reaction of aggregate demand to the value of the domestic currency. Overall, interest rates are found to react differently to shocks depending on whether depreciations are expansionary or contractionary.

1 Introduction

In recent years, there has been a special interest in the link between exchange rates and interest rates in both advanced and developing countries. This is understandable, given the important role these variables play in determining developments in the nominal and real sides of the economy, including the behaviour of domestic inflation, real output, exports and imports. Among emerging market economies (EME), this interest is further spurred by the fact that many of them have recently introduced changes in their monetary and exchange rate policies, moving to inflation targeting frameworks which operate officially under flexible exchange rate regimes. Exchange rate variability - in itself and *vis-à-vis* interest rate variability- has in recent years risen compared to previous periods characterised by far more rigid exchange rate regimes, even if the extent of such fluctuations is still a matter of debate. Some middle-income Asian countries have all declared that their currencies have floated in post-Asian-crisis period, accompanied by a switch to inflation targeting. Such moves were taken by South Korea in 1998, Indonesia in 2000, Thailand in 2000, and the Philippines in 2001. In Latin America, inflation targeting has been adopted with Chile in 1990 (together with an exchange rate float only since 1999), Mexico and Colombia in 1999, Brazil in 2000, and Peru in 2002. Among Eastern and Central European countries, EU new member states Czech Republic and Poland have also moved to comparable monetary and exchange rate policy frameworks (in 1998 and 1999, respectively), while South Africa and Israel count among other middle-income inflation targeters.[1]

The relationship between exchange rates and interest rates plays a key role in both empirical and theoretical modeling. Regarding empirical methods, identified vector autoregressions (IVAR) have recently allowed for simultaneous interaction between exchange rates and interest rates in an attempt to credibly identify monetary and risk premium shocks. Building on work

[1] See, *e.g.*, Amato and Gerlach (2002), Carare and Stone (2003) and Fraga *et al.* (2003).

by Smets (1997), Smets and Wouters (1999), Kim and Roubini (2000) and Cushman and Zha (1997), a number of papers have addressed this matter in the context of EMEs (see, *e.g.*, Ma'ckowiak, 2003, Fung, 2003, and Aguirre and Schmidt-Hebbel, 2005). These studies aim at minimising reliance on *ad hoc* modeling conventions, focusing on the central issue of distinguishing between variation generated by deliberate policy action and variation generated by disturbances outside of the policy process. This literature has reached a level of maturity, examining a range of more tightly restricted identifications and considering larger and internationally linked versions of the models. It normally uses modern macroeconomic theory to justify the results obtained in IVARs.

In the case of EMEs both theoretical and empirical work should take into consideration the specificities of these economies regarding the behaviour of interest rates and exchange rates. Authors such as Calvo (2001), Calvo and Reinhart (2001 and 2002) and Eichengreen (2005) have insisted that there are a number of important differences between advanced economies and EMEs. These differences include the presence of liability dollarisation, credibility problems, a high degree of exchange rate pass-through[2] and non-stationarities in the inflationary process. Calvo and Reinhart (2002) find that these specificities of EMEs are responsible for a relatively small degree of exchange-rate flexibility in these economies - what the authors label "fear of floating".[3] Eichengreen (2005) models the lack of exchange rate flexibility by looking at interest rate reactions aimed at offsetting variability in foreign exchange markets. Balance sheet effects that raise the domestic-currency real

[2] Ca' Zorzi *et al.* (2004) find that not all EMEs display degrees of exchange rate pass-through above those seen in advanced economies. In particular, while pass-through tends to be high in countries in Eastern and Central Europe and Latin America, it is relatively low in many Asian economies.

[3] This means that, despite the recently proclaimed switch to floating exchange rates, the evidence seems to suggest a reversion to some degree of exchange rate management, albeit one which seems to be less tight than before the crisis. In this regard, some analysts have found considerable discrepancies between the *de jure* exchange rate classifications and *de facto* regimes (see *e.g.* Reinhart and Rogoff, 2004).

value of external liabilities have in recent years particularly attracted the attention of analysts, who look for mechanisms through which a weakening in domestic currencies could lead to contractions in economic activity (that is, the existence of "contractionary devaluations"). According to Eichengreen (2005), Mohanty and Klau (2004) and Cavoli and Rajan (2005a), this effect could be interpreted as an overall negative effect of weaker real exchange rates on output in the aggregate demand schedule. This is consistent with Calvo's (2001) view that periods of weak exchange rates may lead to widespread bankrupcies. Céspedes *et al.* (2000) develop instead a narrower focus on the role of liability dollarisation on output via its effect on risk premia, finding that it is unlikely for weaker exchange rates to induce a recession.[4] The empirical literature has generally found that devaluations/depreciations are contractionary, even after including a number of different controls (see Ahmed, 2003, who also reviews the previous empirical literature).

The present paper revisits the link between interest rates and exchange rates in small open economies under flexible exchange rates, distinguishing between cases when depreciations are expansionary and contractionary. By doing the latter, I extend the previous literature analysing the role of the exchange rate in the conduct of monetary policy in small open economies, which has mostly assumed that depreciations are expansionary.[5] Depreciations are defined to be contractionary when weak real exchange rates have an overall negative effect on output in the aggregate demand schedule. I set up a simple macroeconomic model, which builds on Gerlach and Smets' (2000)

[4] For further discussion about liability dollarisation, see simulations in Morón and Winkelried (2003).

[5] This literature includes Ball (1999 and 2002), Svensson (2000), Taylor (1999), McCallum and Nelson (1999 and 2000), and Galí and Monacelli (2005). Taylor (2000 and 2001) presents an interesting discussion. For other applications, see Bharucha and Kent (1998), Leitemo and Söderström (2005) and Leitemo (2006). In all of these models, monetary policy affects inflation directly via the price effects of currency movements, as well as indirectly via output (which in turn is impacted by both interest and exchange rate changes). Drawing, as I do here, from Gerlach and Smets' (2000) model has the advantage of simplifying the dynamic structure, with the indirect effect of interest rates on inflation via output taking place contemporaneously.

framework. As in the original specification, I use backward-looking inflationary expectations[6] and forward-looking financial markets. I incorporate the role of exchange rate pass-through into domestic prices, in addition to considering both cases when depreciations are expansionary and contractionary. I derive results under the assumption of full information. My modelling approach also relates to previous work by Detken and Gaspar (2003) and Eichengreen (2005) in the following ways. It shares with the latter the backward-lookingness of the goods markets, while it is comparable with the former in its forward-looking features concerning financial markets.[7] Both Detken and Gaspar (2003) and Eichengreen (2005) assess the situation of adverse balance sheet effects as eliciting a lower response of output to exchange rates. In this case, there is less of a case for raising interest rates in the face of adverse real and financial shocks. Moreover, Eichengreen (2005) explicitly analyses contractionary depreciations. Given that the present paper studies a similarly wide parameter range for the reaction of output to exchange rates, I in the following concentrate on comparing my results with those of Eichengreen (2005).

The main results of the paper are the following. I confirm Eichengreen's (2005) finding that the covariance between exchange rates and interest rates, conditional on adverse risk premium shocks, is negative for expansionary depreciations and positive for contractionary ones. More specifically, I find that interest rates are raised to limit the adverse effect of depreciations on real output not only if the latter effect is (unrealistically) strong enough - as found by Eichengreen (2005) - but also when it is relatively mild. In the case of an adverse net export shock, the dominant feature regarding interest rates is that they are predicted to also rise in response to the shock in contractionary depreciation cases, and to be lowered in the case of expansionary ones. As with

[6]For related environments which combine backward- and forward looking price-setting behaviour with persistence, while also allowing for open economy features such as exchange rate pass-through, see McCallum and Nelson (1999 and 2000) and Svensson (2000).

[7]Neither Detken and Gaspar (2003) nor Eichengreen (2005) encompasses the other model. In particular, the Phillips curve is entirely forward-looking in the former and fully backward-looking in the latter.

the risk premium shock, the covariance between exchange rates and interest rates is negative for expansionary depreciations and positive for contractionary ones. The exact timing of such response of interest rates and exchange rates depends on the nature of the reaction of aggregate demand to the value of the domestic currency. Overall, interest rates are found to react differently to shocks depending on whether depreciations are expansionary or contractionary. In particular, exchange rate smoothing by means of interest rates - which in the literature falls under the category of "fear of floating" - is thus shown to originate in optimal policy under flotation, as also reasoned in Detken and Gaspar (2003) and Edwards (2002).

Section 2 briefly discusses some of the empirical evidence concerning the behaviour of exchange rates and interest rates in EMEs. In doing so I focus on two aspects, namely, the literature on *de facto* classifications on exchange rate regimes and the analysis of some historical episodes during which some Asian and Latin American countries were hit by shocks to the risk premium and international trade. Section 3 presents a simple small open economy model which assumes full information and forward–looking financial markets. I derive the optimal feedback rule of a central bank which cares about output and inflation, obtaining the closed form solution solve for equilibrium trajectories. The feedback monetary policy rule relates interest rates to exchange rates. I illustrate the workings of the model by attaching numerical values to the parameters, following calibrations used in previous work for small open economies. Finally, Section 4 presents some concluding remarks.

2 Discussion of some of the evidence

Despite the increasing literature on the macroeconomic transmission mechanism in EMEs, not much is known about structural responses of macro variables in these economies, partly due to the only recent introduction of suitable empirical methods and the insufficient theoretical understanding of the channels involved. This section explores some of evidence on whether interest rates be used by policymakers to smooth or even reverse the effect of macroeconomic shocks on exchange rates, thereby contributing to explain why many EMEs with official floats in practice display what is frequently referred to as "fear of floating". The focus is on two aspects, namely, the literature questioning *de jure* classifications on exchange rate regimes and the study of some historical episodes during which some Asian and Latin American countries were hit by shocks to the risk premium and international trade.

The IMF has for a long time followed that practice of classifying exchange rate regimes by simply reporting member countries' self-selected views about how their exchange rate are determined. Over the last ten years, such *de jure* classifications have indicated the tendency for an increasing number of countries to choose either a pegged exchange rate regime or permit their currency to float freely, in what would supposedly represent a move toward a "corner" solution. A burgeoning literature has recently questioned the notion of such a "bipolar" configuration of exchange rate regimes. First, some of the skeptics have pointed to a "fear of floating" whereby countries that declare themselves floaters nevertheless intervene regularly to prevent full flexibility of the exchange rate. The key paper in this area is Calvo and Reinhart (2002). They use a cross-section of 153 countries that includes data on the volatility of interest rates, nominal exchange rates, money aggregates, international reserves, and commodity prices. They report that exchange rate variability in official floating regimes in EMEs is smaller than in a benchmark of advanced countries - such as the US - normally seen as displaying fully floating exchange rates. In addition, they find that the volatility of interest rates, money aggregates and international reserves is larger than in the benchmark, which leads them to conclude that EMEs use monetary policy to limit the volatility of exchange rates. Second, other authors have pointed out that some countries display an aversion to truly fixing their exchange rate, preferring instead to allow for the contingency that the existing peg may be altered either if it becomes too costly to defend, or macroeconomic conditions require a realignment of some kind (Willett 2003). In parallel, a related literature has recently proposed the need of and/or developed *de facto* exchange regime classification as opposed to IMF-type *de jure* one. This literature includes, for instance, Bénassy-Quéré *et al.* (2004), Bubula and Otker-Robe (2003), Calvo and Reinhart (2002), Ghosh *et al.* (1997), Levy-Yeyati and Sturzenegger (2002), Reinhart and Rogoff (2004) and Shambaugh (2004).

De facto classifications of course share the view that the *de jure* classifications on exchange rate regimes may be misleading, but this does not mean that they always coincide. One interesting case, discussed in Siklos (2005), is that of Reinhart and Rogoff's (2004) classification of Australia, Canada and New Zealand. These small open economies are acknowledged by most to have followed floating exchange rate regimes. However, Reinhart and Rogoff (2004) define Canada over the period 1970-2001 as operating under a de facto moving band around the US dollar. In their same study, Australia is classified as freely floating since December 1983 and as having a managed float since 1974, and New Zealand is defined as having a managed float since 1985 and a *de facto* moving band around the Australian dollar between 1973 and 1985.

In line with the previous literature on *de facto* classifications on exchange rate regimes, some studies have analysed the behaviour of individual variables such as exchange rates and interest rates in EMEs against the benchmark of small open advanced economies. These studies normally find that in those EMEs that have abandoned hard pegs the variability of exchange rates - in itself and with respect to that in interest rates - has increased markedly in recent years, while still being below that observed in the benchmark cases (see, *e.g.*, IMF, 2004, and Cavoli and Rajan, 2005b, as well as the literature cited in these studies). One such analysis is presented in Eichengreen (2004), who explores Korean exchange rate and monetary policies. He finds that, despite wider fluctuations in the won now compared with the period prior to the Asian crisis, the Bank of Korea has attempted to control its movements, indicating that Korean policymakers care about the exchange rate – and not only because its movements provide information relevant for the inflation forecast. Finally, some studies have found that exchange rates play a role, together with more standard arguments such as economic activity and inflation, in interest rate rules for EMEs (see, *e.g.,* Caputo, 2004).

In the rest of the section, I have a closer look at the connection between interest rates and exchange rates in some EMEs, in order to try to assess more specifically how these two variables are related. I consider some historical episodes that are characterised by sharp fluctuations in nominal and sometimes real macroeconomic variables. These episodes consist of the experience of some Asian EMEs at the time of the Asian crisis (1997-1998), that of some Latin American countries at the time of the Asian crisis (1997), the Russian default (1998) and a couple of periods of financial turmoil in Brazil (1999 and 2002-2003).[8] I use these case studies as motivation for theoretical discussions about the link between exchange rates and interest rates featuring in the next section of the paper. In order to motivate further investigations in this way, I must attach some tentative structural interpretations to co-movements between these (and sometimes, other) variables. Over recent years, considerable consensus have emerged as to which were some of the key forces at play in these episodes, in particular regarding the nature of the financial and real shocks impacting the economies at those times. This helps limit the arbitrariness of the judgemental assumptions involved in the assessment of the state of the economies under study. Another caveat with the analysis in this section is that one could argue that the episodes discussed here are something special in

[8]Some of these episodes proved to be a watershed in exchange rate policies in the EMEs directly involved, with countries like Brazil, Chile, Korea and Thailand officially endorsing fully floating regimes in the aftermath of such financially turbulent periods. See, *e.g.,* IMF (2004), where these moves to float are classified as either "voluntary" (Chile, Korea) or "crisis-driven" (Brazil, Thailand).

themselves and that little is learned from studying them for more normal periods. However, monetary policy reactions, even during periods of heightened instability, appear to have eventually produced some of the intended effects. In any case, it must be stressed that there is no presumption that the current section is in itself a validation of the theoretical analysis that will follow, but rather serves as motivation for it. Even more, the theory motivated by this evidence in the present paper is explicitly designed to yield implications which stand the chance of being rejected by such structural empirical methods. In future empirical work, suitable methods that take into account the latest available theory could be used to more systematically unveil structural stylised facts involving the link between interest rates and exchange rates in EMEs.

Figures 1 through 3 show the behaviour of real effective exchange rates (REER) and short-term interest rates - together with some other macroeconomic variables - for the episodes analysed in this section. Figure 1 reports data characterising the situation in some Asian EMEs, namely, Malaysia, South Korea (henceforth Korea) and Thailand, during the Asian crisis (1997-1998). The Asian crisis is best characterised as triggered by a mixture of confidence crisis in a few countries, which then spread - through trade and, depending on the country, also financial channels - to other countries within and outside the region. Part of the responsibility for the confidence crisis is to be assigned to weak fundamentals, and especially sizeable current account deficits in the three selected countries.[9] Figure 1 shows that, as a result of the crisis, exchange rates weakened considerably over the second half of 1997. Interest rate hikes were instrumental in reversing the drop in exchange rates over 1998 (top and bottom left panels). The exception to this is Malaysia, which imposed capital controls in August 1997, while still experiencing exchange

[9] In 1996, that is, the full year right before the Asian crisis, current account deficits (as a percentage of GDP) reached 4.2% in Korea, 4.9% in Malaysia, and 7.9% in Thailand (ADB, 1999).

rate depreciations until it finally re-pegged its currency against the US dollar in September 1998 (IMF, 1999).[10] The crisis became over time not simply driven by an adverse financial shock, but also by one directly hitting the real economy via international trade spillovers. This idea receives support from data on international trade in Emerging Asian economies, which shows that competitive depreciations and reduced real income eventually induced falls in both exports and imports across the region. Concentrating on our three countries, Figure 1 shows that the volume of international trade[11] eventually contracted before starting to rebound once the worst of the crisis was over (top and bottom left panels). While the recovery in exports began in 1998, imports started rebounding only in 1999, indicating that the region's exports and imports co-moved but not to the point of eliminating role of macroeconomic factors affecting exchange rates, interest rates and real output. In sum, the crisis can be thought of as starting as an adverse financial shock (that is, an increase in the risk premium), while it eventually turned into an adverse real shock to net export volumes. Interest rate hikes were instrumental in reversing the initial depreciation in the exchange rate.

Figures 2 and 3 refer to some Latin American experiences. Figure 2 shows some developments in the region in the aftermath of the Asian crisis (1997-1999). In 1997, and as a consequence of the Asian crisis itself, interest rates were hiked as a response to financial contagion from Asia, with the outcome of strengthening the Brazilian exchange rate (first oval, top panel). At the time of the Russian crisis (summer of 1998), the currencies of Chile and Brazil depreciate and interest rates go up (second oval, top panel, and oval, central panel). The largest South American countries were during this period going through a process of reduction in domestic absorption, which implied a fall in imports

[10] The Malaysian approach differed from that implemented in Thailand, where the authorities introduced a two-tier currency regime in July 1997, unifying it only in January 1998 as some capital control measures were introduced (IMF, 1999).

[11] Trade volumes for exports and imports are measured as merchandise trade in US dollars deflated by US CPI (both series taken from IMF's *International Financial Statistics*). I also tried other measures that turned out to convey the same general message.

including those from neighbouring countries (rectangle, bottom panel). This added to global conditions leading to a deterioration in the terms of trade (ECLAC, 2000). For this reason, the period is best characterised as one of joint adverse financial and real (net export) shocks. Figure 2 also illustrates the workings of the Brazilian economy at the time of the 1999 crisis (third oval, top panel). During this episode, a confidence crisis induces a depreciation of the real. Interest rate are raised with the aim of stabilising the domestic currency. The process of depreciation *cum* monetary tightening is eventually unwound. Finally, Figure 3 characterises the behaviour of the exchange rate and interest rate in the period of Brazilian financial turbulence in 2002-2003. The area labelled A corresponds to the period marked by a domestic energy shortfall. This supply shock is normally understood to have dominated real-side developments during this period, being more important than financial contagion and reduced net exports arising from neighbouring Argentina's default and exchange rate crisis of end 2001-early 2002 (ECLAC, 2002).[12] At that time, the real depreciated while interest rates declined slightly.[13] In contrast, area B corresponding to late 2002 and early 2003 is defined by a strictly domestic confidence crisis, fuelled by concerns about fiscal deficits and political transition. As with Brazil's experience in early 1999, interest rate hikes helped unwind and eventually reverse the downward course in the value of the real.

In sum, the analysis of these case studies does not provide us with an entirely clear picture of the workings of EMEs. It appears however to be the case that, in response to adverse risk premium shocks, the exchange rate has tended to depreciate on impact, thereafter strengthening alongside interest rate hikes. This has been the case of Brazil in three episodes considered above,

[12] Argentina's depreciation did however largely explain the strengthening of the real in effective terms in the first quarter of 2002, that is the period right before that captured in area A of Figure 3.

[13] In what follows, I do not discuss the consequences of this supply shock, as the focus instead is on shocks to risk premia and international trade.

namely, the turbulent periods of 1997, 1999, and 2002-2003. The situation is less clear-cut when it comes to shocks characterised by a fall in net exports, which in the cases analysed before, has taken place alongside adverse shocks to risk premia. In the case of Korea and Thailand at the time of the Asian crisis, the picture is similar to the case of an adverse risk premium shock alone, that is, the exchange rate appreciated as interest rates were raised. In contrast, in the cases of Chile and Brazil at the time of the 1998 Russian crisis, interest rates were hiked even as the exchange rate depreciated. The discrepancy in responses to a mixture of similar risk premium and net export shocks could be rationalised in four different ways. First, one could argue that the two shocks considered here work in opposite directions with regard to the exchange rate, explaining why in some cases the latter depreciates while in others it strengthens. Second, responses to either one or both of the shocks analysed here depend on the structural characteristics of the economies under study in ways that vary substantially from one to the other. Third, it could be that the two shocks under study happened to take place at the same time as another shock (or a combination thereof) was hitting the economy in a way that explains the discrepancy. Fourth, it could be that reactions to shocks are accompanied by non-fundamental behaviour of a completely random nature, thereby failing to follow any predictable pattern. One can tentatively conclude that both further empirical and theoretical work is needed to better interpret case studies such as those analysed here. I now turn to the latter type of activity, setting up a simple macroeconomic model which will help me clarify some of the issues arising from the analysis of the previous case studies.

3 A simple model

In order to investigate the link between interest rates and exchange rates, let us consider a simple small open economy model. I allow for depreciations to be either expansionary or contractionary. The economy specialises in the production of a single good. Four equations describe the behaviour of the private sector:

$$\pi_t = E_{t-1}\pi_t + \alpha\left(y_t - \varepsilon_t^S\right) - \gamma(e_t - E_{t-1}e_t) \quad (1)$$

$$y_t = -\beta r_t - \delta e_t + \varepsilon_t^D \quad (2)$$

$$r_t = -E_t e_{t+1} + e_t + \varepsilon_t^f \quad (3)$$

$$r_t = R_t - E_t\pi_{t+1} \quad (4)$$

where all variables, except the interest rate, are in logarithms and expressed as deviations from steady state values. Constants have been normalised to zero. All parameters are assumed to be positive, with the exception of δ, which can adopt any real value. The value of δ is negative in a contractionary depreciation and positive in an expansionary depreciation. All shocks are of the zero-mean, constant variance, type, and are uncorrelated with each other. They are also allowed to be serially correlated, as is made clear below.

Equation (1) is a simple aggregate supply schedule which states that prices (p_t) are determined by the last period's expectations of the current price level and two other terms, namely, an output gap (y_t) term and an exchange-rate pass through term in which the real exchange rate (e_t) affects prices via import prices.[14] Note that an increase in e_t denotes an appreciation of the real exchange rate. In (1), the more open the economy, the stronger the pass-through effects of exchange rate changes on consumer prices. Expression (2) states that aggregate demand is decreasing in the (short-term) real interest rate (r_t). Output is also allowed to depend positively or negatively on real exchange rate as explained before.[15] Equation (3) is an uncovered interest parity condition representing foreign exchange market equilibrium under per-

[14] Appendix A provides a formal derivation of the aggregate supply schedule.

[15] Appendix B sets up a framework from which the aggregate demand schedule used here can be derived.

fect capital mobility. The shock ε_t^f is interpreted as a risk premium term. Finally, (4) is the Fisher equation defining the real interest rate.

The central bank minimises an intertemporal loss function given by

$$E_t \sum_{i=0}^{\infty} \rho^i L_{i+1}$$
$$\text{where } L_t = \alpha^2 (y_t - \varepsilon_t^S)^2 + \chi(\pi_t - \tilde{\pi}_t)^2 \tag{5}$$

Policy makers thus care about both deviations of output from its potential level, $y_t - \varepsilon_t^S$, and deviations of inflation from the target (or objective), $\pi_t - \tilde{\pi}_t$. The central bank has no incentive to surprise the private sector with inflation even in the presence of supply shocks. As a result there will be no inflation bias. In addition, the loss function implies that the central bank cares about an index of prices including both domestic and imported goods. This is consistent with standard central bank in EMEs to focus on changes in the CPI, which includes both types of goods.

I assume that the public knows α, β and δ, the distribution of the disturbances ε_t^S, ε_t^D and ε_t^f, and that it observes the nominal interest and exchange rates. I also assume that there is *full information*, in the sense that the central bank, producers and foreign exchange market participants all observe current output, prices and nominal exchange rates. With this information, and knowledge of the structure of the model, they are in a position to deduce the sources of the shocks that hit the economy. A state-contingent reaction function is then feasible. Using (1), the central bank's full information reaction function can be rewritten as

$$L = [\pi_t - E_{t-1}\pi_t + \gamma(e_t - E_{t-1}e_t)]^2 + \chi(\pi_t - \tilde{\pi}_t)^2 \tag{6}$$

To solve the model, it is convenient to think of the central bank as choosing π_t to minimise its loss function. The first-order condition valid for optimal policy under discretion is

$$\pi_t = (1-\varphi)[E_{t-1}\pi_t - \gamma(e_t - E_{t-1}e_t)] + \varphi\tilde{\pi}_t \tag{7}$$

where $\varphi \equiv \chi/(1+\chi)$. Imposing rational expectations, we have

$$E_{t-1}\pi_t = E_{t-1}\tilde{\pi}_t \tag{8}$$

that is, expected inflation equals expected targeted inflation.

Substituting (8) back into (7), I obtain the following expression for the optimal inflation rate, π_t^{opt}:

$$\pi_t^{opt} = -(1-\varphi)\gamma(e_t - E_{t-1}e_t) + \varphi\tilde{\pi}_t + (1-\varphi)E_{t-1}\tilde{\pi}_t \tag{9}$$

The central bank thus chooses an inflation rate equal to the term capturing the effect of unexpected exchange rate fluctuations on prices, plus a weighted average of the private sector's expectations of the inflation target and the actual inflation target.

The associated inflation forecast error is

$$\pi_t - E_{t-1}\pi_t = \varphi(\tilde{\pi}_t - E_{t-1}\tilde{\pi}_t) \tag{10}$$

If the inflation target is fixed over time and is credible, the price forecast errors are zero and the variance of output is given by the variance of the supply shocks.

I derive the central bank's reaction function in terms of two alternative representations of the policy instrument found in the literature, namely, the real short-term interest rate and a real monetary conditions index (MCI). It is worth stressing that, in the present context, the difference between these two representations is of notation, not substance. As will become more clear later, the MCI is particularly useful to derive some results. To begin with, using

(1), (2), and (10), the expression for the MCI is found to be

$$(1-\omega)r_t + \omega e_t \equiv MCI_t^{opt} = \theta\varepsilon_t^{xd} - \frac{\theta\varphi}{\alpha}(\tilde{\pi}_t - E_{t-1}\tilde{\pi}_t) - \frac{\theta\varphi\gamma}{\alpha}(e_t - E_{t-1}e_t) \quad (11)$$

where $\varepsilon_t^{xd} \equiv \varepsilon_t^D - \varepsilon_t^S$ and $\theta \equiv 1/(\beta+\delta)$. The left-hand side of (11) defines the MCI as a weighted average of the real interest rate and the real exchange rate, where the weight on the exchange rate, ω, depends solely on the elasticities of aggregate demand to the exchange and interest rate. Equation (11) can be interpreted as an optimal reaction function and states that the MCI should rise (policy should be tightened) to offset positive unexpected excess demand pressures and should fall if the inflation target is relaxed or the real exchange rate is stronger than expected.[16] Finally, note that all coefficients in (11) are influenced by the relative importance attached to achieving the inflation target in the central bank's objective function.

Derivation of the optimal feedback rule for the real interest rate is less immediate than that of the MCI expression, as it requires consideration of the dynamic properties of the model. In order to proceed, I need to make assumptions regarding the stochastic processes driving the shocks to the economy. For simplicity, I assume that the inflation target adopts a fixed and credible value of $\tilde{\pi}$, and that the risk premium shock, ε_t^f, and the disturbances underly-

[16] The last two terms in (11) deserve further discussion. Taken altogether, they relate to Ball's (2002) idea that policymakers should target not current inflation but "long-run inflation". He argues that targeting a level of inflation adjusted for temporary exchange rate movements leads to more stable output and inflation than targeting ordinary inflation. Applied to the present environment, the last two terms in (11) could be viewed as just one single term referring to deviations of a different inflation target, $\pi_t^* \equiv \tilde{\pi}_t + \gamma e_t$, from its expected value. (Ball's definition differs from this one in that involves the lagged rather than the current exchange because in his model prices react to exchange rate movements with a lag.)

In addition, Gerlach and Smets (2000) argue that exchange rate pass-through enhances the role of exchange rates in the MCI if the central bank targets CPI inflation. This can also be shown here by putting the extra term in the LSH of (11) involving e_t together with the one pre-multiplied by ω in the RHS of this expression, which would raise the share of e_t in the MCI.

ing the excess demand shock, ε_t^{xd},all follow first-order autoregressive processes with uncorrelated disturbances. In consequence, I can write: $\varepsilon_t^f = \rho_f \varepsilon_{t-1}^f + \xi_t$, in the former case, and $\varepsilon_t^{xd} = \rho \varepsilon_{t-1}^{xd} + \eta_t^{xd}$ grouping terms for shocks hitting excess demand.[17] Substituting (3) into (11) yields

$$e_t = (1-\omega) E_t e_{t+1} - \frac{\theta\varphi\gamma}{\alpha}(e_t - E_{t-1}e_t) + \theta\varepsilon_t^{xd} - (1-\omega)\varepsilon_t^f \qquad (12)$$

Examination of (12) leads to the conclusion that the model has a forward solution for the case when $\mid 1-\omega \mid < 1$, and a backward solution for the case when $\mid 1-\omega \mid > 1$. In the rest of the section, I solve for each case in turn.

3.1 Forward solution for case when $\mid 1-\omega \mid < 1$

The condition $\mid 1-\omega \mid < 1$ amounts to two different ranges for the values of δ, namely, $\delta \in (-\infty, -2\beta) \cup (0, \infty)$. The forward solution to expectational difference equation (12) in the absence of bubbles is given by

$$e_t = \frac{1}{\beta(1-\rho)+\delta}\left[\varepsilon_t^{xd} - (1-\sigma)\eta_t^{xd}\right] - \frac{\beta}{\beta(1-\rho_f)+\delta}\left[\varepsilon_t^f - (1-\sigma)\xi_t\right] \quad (13)$$

where $\sigma \equiv \alpha/(\alpha+\theta\varphi\gamma)$. Next, I derive the central bank's reaction function in terms of the policy instrument, which I take to be the real interest rate. It is worth stressing, though, that, given that inflation expectations are anchored at $\tilde{\pi}$, the choice of real versus nominal interest rates proves to be insubstantial, as they are equal when measured as deviations from steady-state. Equations (3) and (13) lead to

[17] Coefficient ρ is actually a linear combination of primitive autoregressive coefficients ρ_h, ρ_x and ρ_S. (For notation, see Appendix B.) In what follows, the value of ρ simply collapses to zero (in my analysis of a risk premium shock) or ρ_x (in the study of the net export shock). Similarly, ε_t^{xd} equals zero or $(1-\varpi)\eta_t^x$ for all t, respectively.

$$r_t^{opt} = \frac{1}{\beta(1-\rho)+\delta}\left[(1-\rho)\varepsilon_t^{xd} - (1-\sigma)\eta_t^{xd}\right] + \frac{1}{\beta(1-\rho_f)+\delta}\left[\delta\varepsilon_t^f + (1-\sigma)\xi_t\right] \quad (14)$$

Thus, the central bank raises interest rates in response to a positive excess demand shock and an unfavourable risk premium shock. Note that (9), (14) and (11) all describe the central bank's optimal policy. Equation (9) characterises optimal policy in terms of the goal variable of the central bank, but does not give any guidance as to how to achieve the inflation target. Under condition $\mid 1-\omega \mid < 1$, expressions (14) and (11) capture exactly the same monetary policy decisions in two different formulations. Exchange rate shocks in ε_t^f show explicitly in the equation for the interest rate instrument, but do not enter the optimal MCI rule. The effect of risk premium shocks on the MCI is captured indirectly by the third term in the RHS of (11). The latter term reflects the result that a, say, weaker than previously anticipated exchange rate will lead to a tighter MCI.[18]

Let us now illustrate the workings of the model by means of simulations. In order to do so, I attach numerical values to the parameters, following calibrations used in previous work for small open economies. Given the dearth of similar exercises for EMEs, the core of these parameter values is taken from calibrations for small open advanced economies. The values of α, β and γ are taken from Ball (1999) to equal 0.4, 0.6 and 0.2, respectively. For key parameter δ, I choose three different values: 0.2 as in Ball (1999) for the analysis of economies exhibiting expansionary depreciations, and two negative values for the study of contractionary depreciations: -1.5 for simulations in the present subsection satisfying $\delta < -2\beta$, and -0.1 for use in the next subsection. The latter value for δ is close to Cavoli and Rajan's (2005a) estimate of -0.09

[18] In the absence of the exchange rate pass-through term in (1), the third term in the RHS of (11) would not be there. In such case, risk premium shocks would have no impact on the MCI.

for contractionary-depreciation Thailand. I draw from McCallum and Nelson (1999 and 2000) for parameters of shock persistence. The two I use in the present paper are $\rho_f = 0.5$ and $\rho_x = 0$. I also reset McCallum and Nelson's value for ϖ (see Appendix B) to 0.8 from 0.89, to capture the fact that many EMEs are very open to international trade. Finally, in light of the absence of a similar estimate for small open economies, I use Barro and Broadbent's (1997) estimate for χ, obtained using US data. Their value of $\chi = 2.58$ is recalibrated to 0.41 in the present paper, taking account of the presence of α^2 in (5).

I study impulse responses of interest rates and exchanges rates to two shocks in turn, one real (a favourable net export shock raising η_t^{xd}) and the other a pure portfolio disturbance shock (an adverse risk premium shock pushing ξ_t up). I analyse these simulations for the two cases mentioned before, namely, those of a positive δ and a rather negative δ ($\delta < -2\beta$).[19] Figure 4 shows, for positive δ, the cumulated impulse responses to both a one percent adverse risk premium shock (top panel) and a one percent favourable net export shock (bottom panel). Figure 5 reports the corresponding cumulated impulse responses for $\delta < -2\beta$.

For an economy exhibiting conventional expansionary depreciations, Figure 4 (top panel) indicates that an adverse risk premium shock drives the interest rate up and the real exchange rate down. A risk premium shock causes a real exchange rate depreciation with consequent inflationary effects via pass-through. Owing to its (conventional) positive impact on output via "pro-competitiveness" effects, the currency depreciation has incipient positive output effects. In view of the unambiguous inflationary pressures stemming from this shock (via both the exchange rate pass-through and aggregate supply channels), the monetary authority raises interest rates. It is worth stressing that this monetary policy response is optimal from the perspective of inflation

[19] I leave the study of the remaining possible values of δ for the next subsection.

and output stabilisation. It is thus not to be mistakenly interpreted as a "fear of floating".[20] It is worth mentioning that the dynamic behaviour in interest rates and exchange rates is driven by the autoregressive process in the risk premium.

Figure 4 (bottom panel) shows that a favourable net export shock drives both the interest rate and real exchange rate up. This is a foreign shock that is not in itself of the financial but the real-sector variety. It can be viewed as a positive terms-of-trade or external demand shock. The responses of the interest rate and real exchange are probably best understood by looking at the MCI expression (11). The MCI has to be raised following a hike in η_t^{xd}, which is in this case achieved by some monetary tightening *cum* exchange rate appreciation. The interest rate hike puts a limit to the increase in aggregate demand, while also being instrumental to the strengthening of the exchange rate via the UIP schedule. The latter strengthening in turn helps ease excess demand and inflationary pressures. Unlike the dynamics described for the case of a risk premium shock, interest rates and the exchange rate go back to steady-state after the first period due to the assumption that $\rho_x = 0$.

I now turn to the study of an economy exhibiting large contractionary depreciations in the sense that δ adopts a rather large negative value ($\delta < -2\beta$). Figure 5 (top panel) indicates that an adverse risk premium shock induces a rise in both interest rates and the real exchange rate. A risk premium shock causes a real exchange rate depreciation with consequent inflationary effects via the pass-through. Compared with the case of a positive δ, the shock would in addition have an incipient contractionary impact on aggregate demand. Interest rates are hiked in the present case to a point where exchange rates end up stronger. This is the adequate monetary response since a higher exchange rate both damps down inflationary pressures and stabilising the real

[20] In particular, the real exchange rate actually depreciates in this case, which indicates that monetary tightening stops short of pushing the value of the currency up, which is what an unconventional contractionary depreciation would induce in this model.

economy by, say, strengthening balance sheets.

Figure 5 (bottom panel) reports that a favourable net export shock drives both interest rates and the real exchange rate down. In the conventional case, a positive shock that raises export demand must be offset by a stronger exchange rate. The result is the opposite here because the appreciation would exacerbate, rather than ease, the excess demand conditions in the goods market.[21] The economy instead settles in an equilibrium characterised by an exchange-rate depreciation which reduces demand. This depreciation still accommodates for a fall in the interest rate as required by the UIP condition (augmented in this case with the risk premium shock).

In sum, I confirm Eichengreen's (2005) finding that the covariance between exchange rates and interest rates, conditional on adverse risk premium, is negative for expansionary depreciations and positive for contractionary ones. The latter result means that, in the face of adverse risk premium shocks, the authorities in economies exhibiting contractionary depreciations jack up interest to the point of even strengthening the value of domestic currency. This is consistent with the evidence presented in the previous section. Interest rates are predicted to also rise in response to an adverse net export shock in economies where $\delta < -2\beta$, and to be lowered in the case of expansionary depreciations. The inconclusive finding in the previous section that net export shocks may produce more ambiguous effects receives no correspondence in the theoretical analysis. Indeed, net export shocks are here found to produce the clear-cut prediction that interest rates and exchange rates should both rise in response to an adverse net export shock in contractionary depreciation cases, and to go down in the case of expansionary ones. In particular, exchange rate smoothing

[21] For the configuration of parameter values chosen for Figure 5 (bottom panel), an exchange rate appreciation would also add to the inflationary pressures directly stemming from the shock. The reason for this is that the indirect impact of exchange rates on prices via aggregate demand is stronger than the direct one, that is, $\alpha\delta > \gamma$. This additional mechanism tends to be of secondary importance, though. Indeed, even if the sign of this particular effect had the opposite sign, the main result for interest rate and exchange rate would still obtain.

by means of interest rates - which in the literature falls under the category of "fear of floating" - is thus shown to originate in optimal policy under flotation, as previously reasoned in Detken and Gaspar (2003) and Edwards (2002).

In the last paragraph of the previous section, I outlined four candidate explanations for the inconclusive results arising from historical responses to net export shocks. Given that all countries studied here experienced contractionary depreciations, it is only worth checking for a correspondence between facts and theory for the case $\delta < -2\beta$. In that case, adverse external shocks of both the financial and real-side varieties would produce the same results for interest rates and exchanges rates, namely, both of these variables should go up. This is consistent with the experience of Korea and Thailand during 1997-1998. However, the experiences of Chile and Brazil in 1998, when exchange rates depreciated but interest rates went up, are hard to reconcile with the model predictions. Furthermore, in light of both the robustness of the results to parameter values and the lack of any role for theoretically justified non-fundamental factors, I am led to conclude that other shocks hitting the economy at the same time could be responsible for the discrepancies in EMEs' historical responses to an apparently similar configuration of shocks.

Before reaching a final conclusion on these matters, it is however important to analyse the model results for the range of δ not yet explored. So far I have investigated either positive or very negative values for this key parameter. Eichengreen (2005) characterises very negative values of δ as an "unrealistic" situation. In the next subsection I complete the analysis by turning the attention to economies that are prone to contractionary depreciations of a milder type.

3.2 Backward solution for case when $\mid 1-\omega \mid > 1$

The condition $\mid 1-\omega \mid > 1$ refers to the following range of parameter values for δ: $\delta \in (-2\beta, 0)$. In this case, the system is fundamentally backward looking, and the solution to equation (12) is

$$\begin{aligned} e_t &= \left(\frac{1}{1-\omega}\right)^{\tau} e_{t-\tau} - \frac{1}{\beta}\sum_{s=1}^{\tau}\left(\frac{1}{1-\omega}\right)^{s-1}\varepsilon_{t-s}^{xd} + \sum_{s=1}^{\tau}\left(\frac{1}{1-\omega}\right)^{s-1}\varepsilon_{t-s}^{f} + \zeta_t \\ &+\sum_{s=1}^{\tau-1}\left(\frac{1}{1-\omega}\right)^{s-1}\left(\frac{1}{1-\omega} - \frac{\varphi\gamma}{\beta\alpha}\right)\zeta_{t-s} + \left(\frac{1}{1-\omega}\right)^{\tau-1}\frac{\varphi\gamma}{\beta\alpha}\zeta_{t-\tau} \qquad (15) \end{aligned}$$

where ζ_t is a sunspot defined by $e_t = E_{t-1}e_t + \zeta_t$. This variable is an expectational error, uncorrelated - by construction - with the information set, such that $E_{t-1}\zeta_t = 0$. Note that ζ_t is serially uncorrelated, and not necessarily correlated with the innovations of ε_t^{xd} and ε_t^{f}. In other words, this shock may not be a fundamental shock and is purely extrinsic to the economy. A number of different solutions are thus perfectly admissible, with the properties of the economy being rather different depending on the volatility of the sunspot variable and thus that of the real exchange rate via (15).

Use of (11) and (15), following the reasoning leading to expression (14) in the previous subsection, allows us to characterise the central bank's reaction function in terms of the real interest rate.

In assessing impulse responses of interest rates and exchanges rates, I consider the same two shocks as in the previous subsection, that is, an adverse risk premium shock and a favourable net export shock. In doing so, I neglect for simplicity the sunspot.[22] Future empirical work could help establish the degree of empirical relevance of the sunspot as a factor merely amplifying fundamental economic behaviour or rather having a more substantial impact on financial and real variables.[23]

Figure 6 (top panel) shows that an adverse risk premium shock leaves both

[22] The current value of the sunspot ζ_t appears in equation (11). This means that the MCI simplifies in the case of a backward solution to the model. Therefore, the term involving $e_t = E_{t-1}e_t$ in (11) drops out even if it is allowed for in (1). In addition, this means that UIP condition (3) now becomes $r_t = -e_{t+1} + e_t + \varepsilon_t^f$.

[23] One example of an empirical test for sunspot equilibria is Jeanne and Masson (2000).

the interest rate and real exchange rate unchanged in the first period.[24] The reason for this is twofold. First, the MCI (a linear combination of the interest rate and exchange rate) is unresponsive to ε_t^f in (11) when no consideration of the sunspot is made. Second, also in the absence of non-fundamental factors, e_t displays a fully backward-looking behaviour in (15). Starting from the second period, the results do not change qualitatively from those discussed for the strong variety of contractionary depreciation. The shock ε_t^f induces a rise in both interest rates and the real exchange rate. The exchange rate depreciation raises inflation via the pass-through, while also creating contractionary pressures on aggregate demand. In the end, the rise in interest rates makes exchange rates stronger, contributing to limit inflationary pressures while offsetting negative forces threatening the real side of the economy. It is worth stressing that, on top of the dynamics induced by the autoregressive risk premium process, the interest rate and exchange rate are also affected, from the second period onwards, by the behaviour described in (15).

As can be seen in Figure 6 (bottom panel), a favourable net export shock raises the interest rate and leaves the real exchange rate unchanged in the first period. There are two reasons for this result. First, the MCI raises in response to an increase in ε_t^x in (11), one more ignoring the sunspot. Second, the real exchange rate is unchanged in line with the backward-looking nature of e_t in (15). The initial interest rate increase offsets the excess demand in the goods market and thereby the inflationary pressures stemming from the shock. Starting from the second period, the results are qualitatively the same as those taking place on impact in the case $\delta < -2\beta$, but this time extended over a longer time horizon. The reason for this extension is that the exchange rate dynamics in (15) generates persistence in both e_t and, via (11), r_t.[25] Such

[24] The constancy in the interest rate in the first period should not be taken to reflect smoothing. In particular, it does not stem from an explicit objective of partial adjustment in the policy rule. On interest rate smoothing, see Sack and Wieland (2000), and Ball (2002).

[25] This persistence is of a different nature from that resulting from autocorrelated error terms, as is the case with risk premium disturbances throughout the paper.

dynamics has no consequences in terms of excess demand or inflation, given that the macroeconomic effects of the exchange-rate depreciation and the fall in the interest rate simply offset each other.

Summarising, the correlation between exchange rates and interest rates, conditional on an adverse risk premium shock, is positive for mildly contractionary depreciations, with both of these variables going up in response to the shock. This result is the same as previously obtained for strongly contractionary ones, except that in the case discussed in the present subsection such positive correlation is delayed to the second period onwards, with both the interest rate and real exchange rate being left unchanged in the first period. The comparison between the two types of contractionary depreciations is not as straightforward in the case of a net export shock. For a favourable such shock, the dominant feature still is that of a positive correlation between exchange rates and interest rates, with both going down as a consequence of the shock. There are, however, two differences with respect to the case $\delta < -2\beta$ discussed in the previous subsection. First, in the present case when $\delta \in (-2\beta, 0)$ the falls in exchange rates and interest rates is delayed to the second period onwards, instead of taking place on impact. Second, also in this latter case, interest rates are raised and the exchange rate is left unchanged in the first period. In any case, economies experiencing either mildly or strongly contractionary depreciations share the result that interest rates are lowered - either on impact or at a later stage - in response to a favourable net export shock.

The result that the dominant features of economies prone to mildly and strongly contractionary depreciations are similar is new. More specifically, the model predicts that interest rates will be raised to limit the adverse effect of a depreciation on real output arising from either financial or real adverse shocks. In contrast, Eichengreen (2005) reports that interest rates are raised to limit the adverse effect of a depreciation on real output if the latter effect is (unrealistically) strong enough, but not in the case of mildly contractionary depreciations.

From a technical point of view, the difference in results for mildly contractionary depreciations between this paper and Eichengreen's (2005) arises from the characterisation of foreign exchange markets. Both papers look at factor $1 - \omega = \beta/(\beta + \delta)$, albeit from different angles. Eichengreen is looking for a sign condition in line with the static nature of his foreign exchange market equilibrium relationship. He thus ranks the strength of contractionary depreciations depending on whether δ is larger or smaller than $-\beta$. Instead, as has been made clear above, I look at a stability condition in accordance with the forward looking character of my UIP condition (3). For this reason, I distinguish between mildly and strongly contractionary depreciations depending on whether $\mid 1 - \omega \mid < 1$ or $\mid 1 - \omega \mid > 1$. In the former case, negative values of δ are constrained to values below -2β and the model solution is forward, while in the latter δ lies in the interval $(-2\beta, 0)$ and the model solution is backward.

Finally, let us go back to the inconclusive results arising from historical responses to net export shocks, an issue that was discussed in the last paragraph of the previous section. The theoretical results in subsection 3.1 pointed to the tentative conclusion that other shocks hitting the economy at the same time could have driven EMEs in different directions in response to an apparently similar pattern of shocks. The results obtained in the present subsection suggest that this simple view needs to be qualified in the case of countries prone to mildly contractionary depreciations. Indeed, from the perspective of the current subsection, two other factors may be important. First, the timing of the response of interest rates and exchange rates is not the same for strongly and mildly contractionary depreciations. Second, the latter type of depreciations open the possibility that non-fundamental factors play a role, which if materialised could allow for differential responses even in economies that share their main structural features.

4 Concluding remarks

The present paper studies the connection between interest rates and exchange rates in small open economies under flexible exchange rates, distinguishing between cases when depreciations are expansionary and contractionary. This is an attempt to bridge the gap between theory and some of the empirical evidence in EMEs. In particular, the paper addresses interest rate behaviour in response to shocks that have an impact on the value of domestic currency under different assumptions about the link between exchange rates and aggregate demand. Despite the importance of this topic, it is not yet satisfactorily understood. The analysis proposed aims at reaching a better understanding of economies operating under floating exchange rates, which often face difficult decisions as to how to balance the advantageous shock-offsetting properties of such a regime with financial stability considerations arising from fluctuations in asset prices.

The present study could also help develop a set of "reasonable" results that could be used as a benchmark in empirical analysis. More specifically, the analysis of impulse responses to different shocks could then be compared to those resulting from structural vector autoregressions, contributing for instance to characterise depreciations as either expansionary or contractionary. Given the importance given in recent work to informational assumptions in order to identify such sort of empirical models, the current model might need to be extended by introducing relevant sorts of informational imperfections. In any case, having clearer ideas about what can be realistically expected from impulse responses in EMEs would simplify the search for "reasonable" results, minimising the occurrence of "wrong signs" in empirical investigations.

The generalisation of the analysis to include the case of contractionary depreciations is in part motivated by evidence that many EMEs exhibit lower exchange rate flexibility than expected from their official regimes. It is generally understood that the interest rate response constitutes a major - and arguably *the* major - policy response in an economy prone to contractionary depreciations. Two other policy measures contribute to the presence of managed, as opposed to freely, floating exchange rate regimes, namely, foreign exchange intervention and capital controls. Generally, these two measures are considered to be far from explaining the full story. Foreign exchange interventions are found to be effective to dampen volatility under special circumstances, or when they are sizeable, which is rarely observed on a sustained fashion (see, *e.g.,* Tapia and Tokman, 2004, and Munro and Spencer, 2004). With regard to capital controls, it is generally recognised that there are limits to their effectiveness as market participants can often find ways to circumvent them. Combined use of foreign exchange intervention and capital controls may however allow for smoother fluctuations in interest rates and exchange rates (Patnaik, 2003).

The model results presented here are obtained using a simple open-economy framework that could be extended in a number of directions. *First,* the model adopts a rather basic dynamic structure, which could be modified for instance by allowing for a quicker impact of the exchange rate on prices via pass-through than via aggregate demand, by introducing a lagged output term in the aggregate demand equation, etc. Future work could further explore the differential economic impact of alternative lag specifications. This would be a welcome development because different countries appear to react to shocks differently at different time horizons. *Second,* the model simply uses a short term interest rate. This could be extended by adding information from the term structure. Neumeyer and Perri (2005) notwithstanding show that the short term interest rate is very relevant for macroeconomic behaviour in EMEs, due to its impact on the activity level via the cost of working capital. *Third,* the introduction of non-linearities may play an important role in achieving a deeper understanding of the link between interest rates and exchange rates. For instance, the theoretical analysis of Lahiri and Vegh (2001) explores the asymmetric responses between large and small shocks affecting exchange rates. Empirically, however, Caputo (2004) does not find very compelling evidence of non-linear behaviour in estimated policy rules for Chile. Non-linearities are beyond the purpose of the present study, which instead derives a full set of general results from a linear model drawing from the mainstream small open-economy approach. One message conveyed here is that the standard linear model, when extended to allow for the possibility of contractionary depreciations, produces testable implications about the relationship between interest rates and exchange rates that stand the chance of matching the empirical evidence for EMEs. Future theoretical and empirical work could more clearly establish to what extent linear models of the type used here can explain the main features of EMEs, as well as ascertaining whether non-linearities can contribute to our understanding of the problem. *Fourth,* the inflation targeting horizon could be expanded from the current period into a more distant future. Too many periods ahead might not be an adequate representation of some economies including EMEs, the latter having targeted in many instances inflation up to one year ahead. From a theoretical standpoint, Leitemo (2006) favours an optimal forecast-targeting horizon that is relatively short (one year). *Fifth,* the fundamental analysis presented in this paper could be extended to the exploration of non-fundamental behaviour. In particular, it is possible that sunspots play a role in the case of countries exhibiting mild contractionary depreciations. Further progress is needed to empirically establish whether and by how much these non-fundamental phenomena are relevant in the determination of interest rates and exchange rates. Moreover, the theory could investigate the scope of irrational behaviour under different specifications of the model, for example by assessing if non-fundamental factors stand the chance to drive the economy if monetary authorities have imperfect information about macroeconomic variables.

Appendix A: Derivation of aggregate supply schedule

This Appendix derives aggregate supply schedule (1) from assumptions about changes in the prices of domestic goods and imports. I draw from Romer (1999) and Gerlach and Smets (2000). Domestic-goods inflation is given by:

$$\pi_t^h = E_{t-1}\pi_t + \alpha' y_t + \varepsilon_t^h \quad \text{(A.1)}$$

In this equation π_t^h can be rationalised by prices responding to output while also being set as a mark-up over wages, with the latter given one period in advance and determined by expected inflation.

To determine import-price inflation, I assume that foreign firms desire constant real prices in their home currencies. This implies that their desired real prices in local currency are $-e_t$. Like domestic firms, they also adjust their prices based on expected inflation.

Thus import inflation is:

$$\pi_t^f = E_{t-1}\pi_t - (e_t - E_{t-1}e_t) \quad \text{(A.2)}$$

Finally, aggregate inflation is the average of equations (A.1) and (A.2) weighted by the shares of imports and domestic goods in the price index. If the import share is γ, this yields expression (1) with $\alpha \equiv (1-\gamma)\alpha'$ and $\varepsilon_t^S \equiv (1-\gamma)\varepsilon_t^h$.

Appendix B: Derivation of domestic demand schedule

Here I propose a framework from which the domestic demand equation of section 3 can be derived. The derivation starts with the resource constraint:

$$y_t = \varpi d_t + (1-\varpi)x_t \quad \text{(A.3)}$$

where y_t is output, d_t is domestic spending, x_t is net exports, and ϖ is the weight of domestic demand in total output. Equation (A.3) states that output

is the weighted sum of domestic spending and net exports.

I assume the variables in (A.3) are determined by

$$d_t = -\beta r_t + \delta_1 e_t + \varepsilon_t^d \quad (A.4)$$

$$x_t = -\delta_2 e_t + \varepsilon_t^x \quad (A.5)$$

Domestic spending depends on the real interest rate and on shocks such as shifts in fiscal policy or consumer confidence (ε_t^d). Moreover, it is assumed to exhibit a non-negative relationship with the real exchange rate - that is, $\delta_1 \geq 0$ - owing to balance sheet-type effects. Net exports depend negatively on the real exchange rate and shocks capturing unexpected shifts in external demand, trade policy or foreign competition (ε_t^x). Both ε_t^d and ε_t^x are allowed to be serially correlated, but are assumed to be uncorrelated with each other. Substituting equations (A.4) and (A.5) into (A.3) leads to (2), where $\varepsilon_t^D \equiv \varpi\varepsilon_t^d + (1-\varpi)\varepsilon_t^x$ is the composite shock hitting domestic demand, and the sign of $\delta \equiv \varpi\delta_1 + (1-\varpi)\delta_2$ is as follows:

$$\delta \begin{cases} > 0 & (i.e., \varpi\delta_1 < (1-\varpi)\delta_2) & \text{for expansionary depreciation} \\ < 0 & (i.e., \varpi\delta_1 > (1-\varpi)\delta_2) & \text{for contractionary depreciation} \end{cases}$$

The non-standard contractionary depreciation case may result if the depreciation depresses domestic demand (say, by weakening the economy's balance sheets) with more intensity that it renders domestic goods more competitive. The conventional expansionary depreciation takes place in the opposite case.

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Figure 1. Asian EMEs during the Asian crisis (1997-1998)

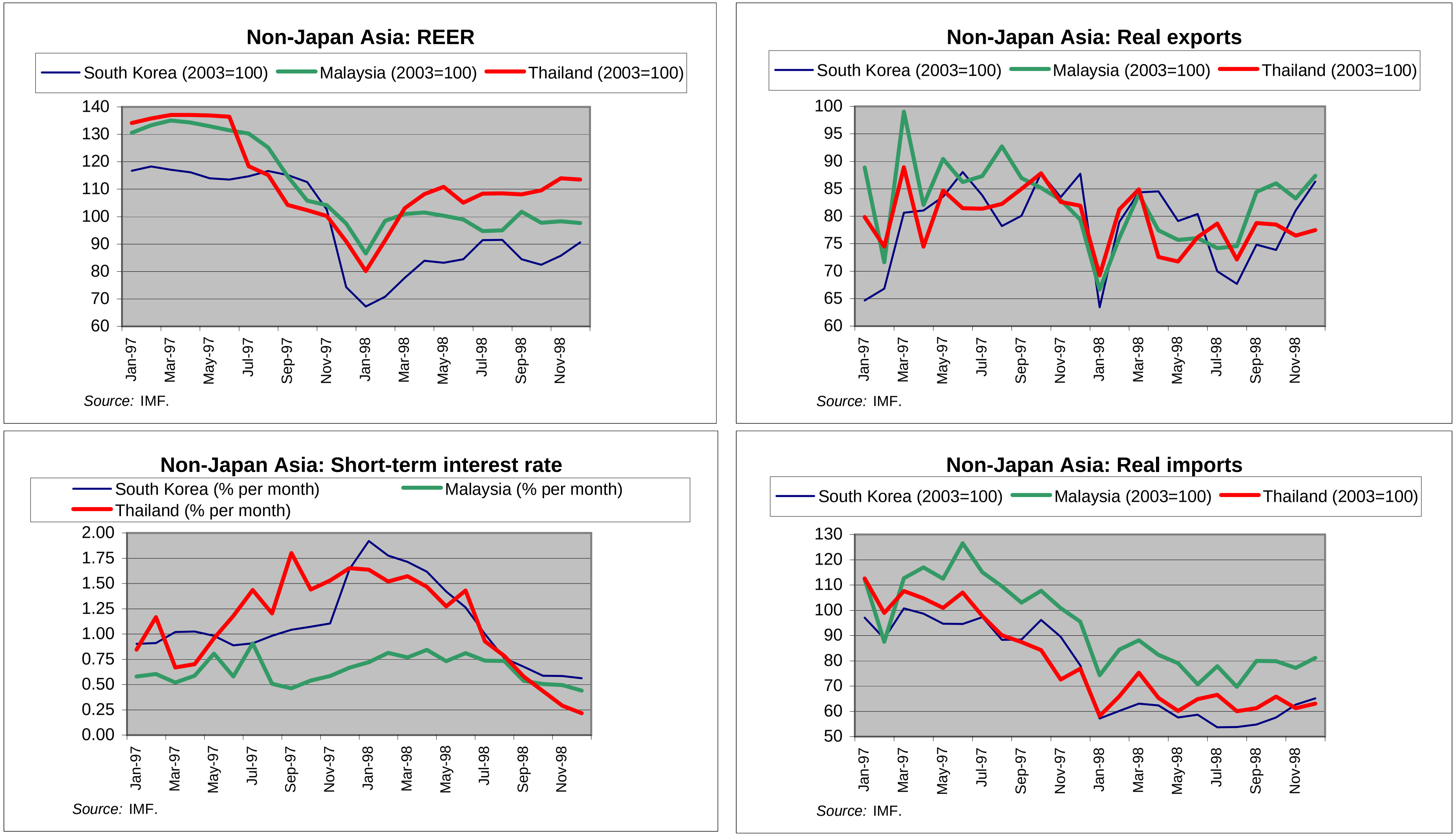
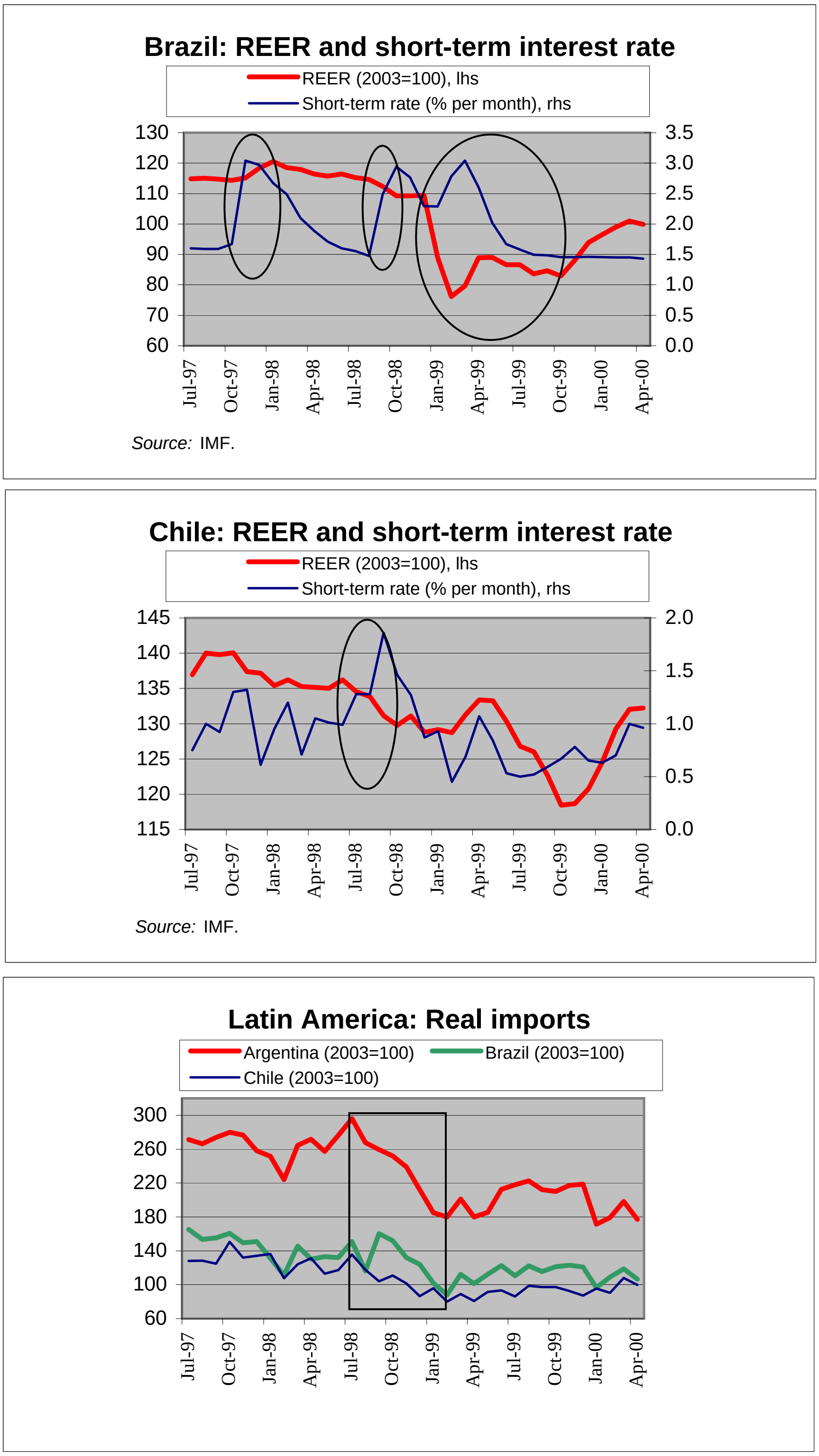


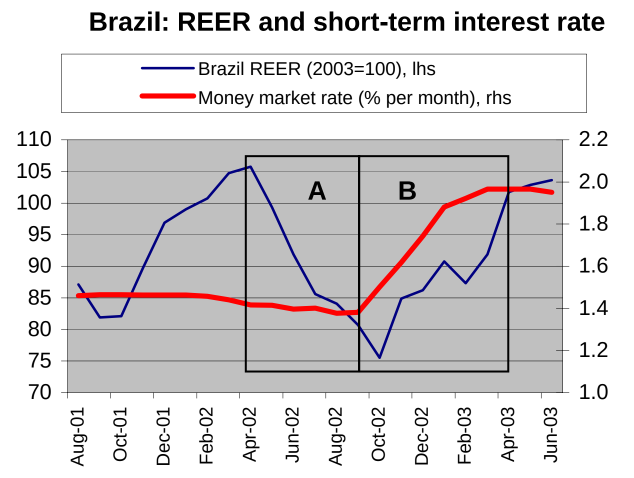
Figure 2. Latin America in the aftermath of the Asian crisis (1997-1999)



Source: IMF.

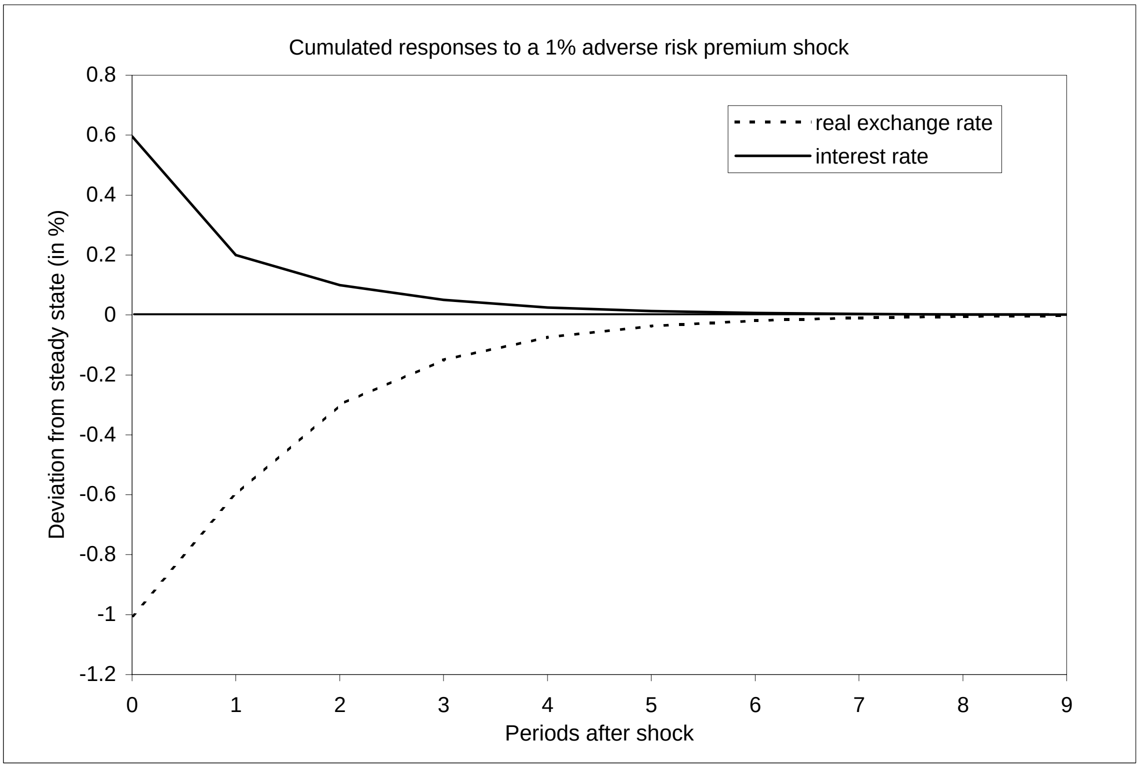
Source: IMF.

Figure 3. Brazil's financial turbulence (2002)



Source: IMF.

Figure 4. Impulse responses of interest rate and real exchange rate (δ = 0.2)



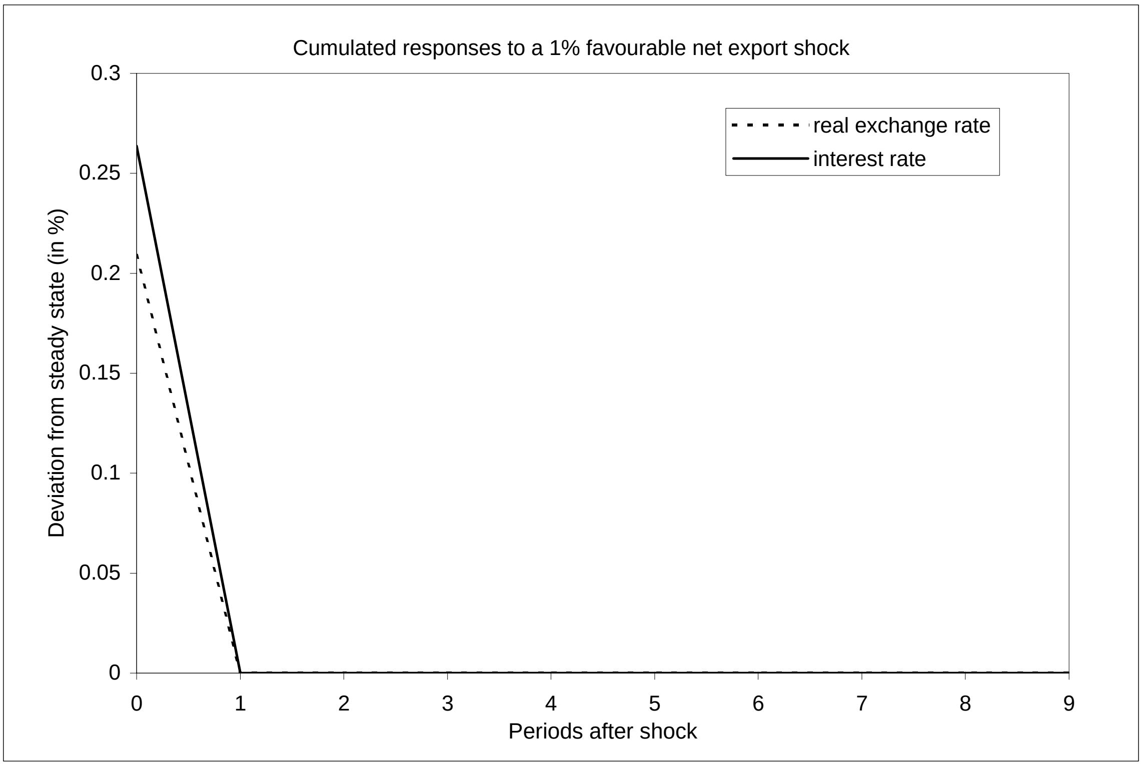
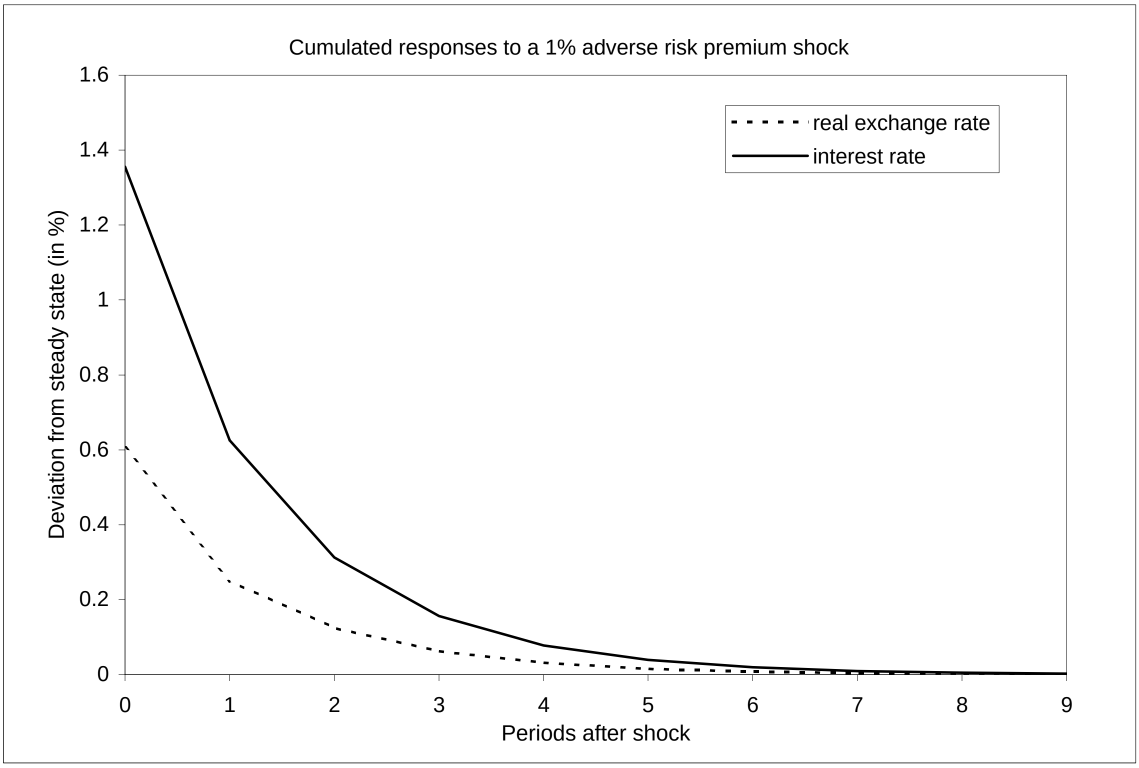


Figure 5. Impulse responses of interest rate and real exchange rate (δ = -1.5)



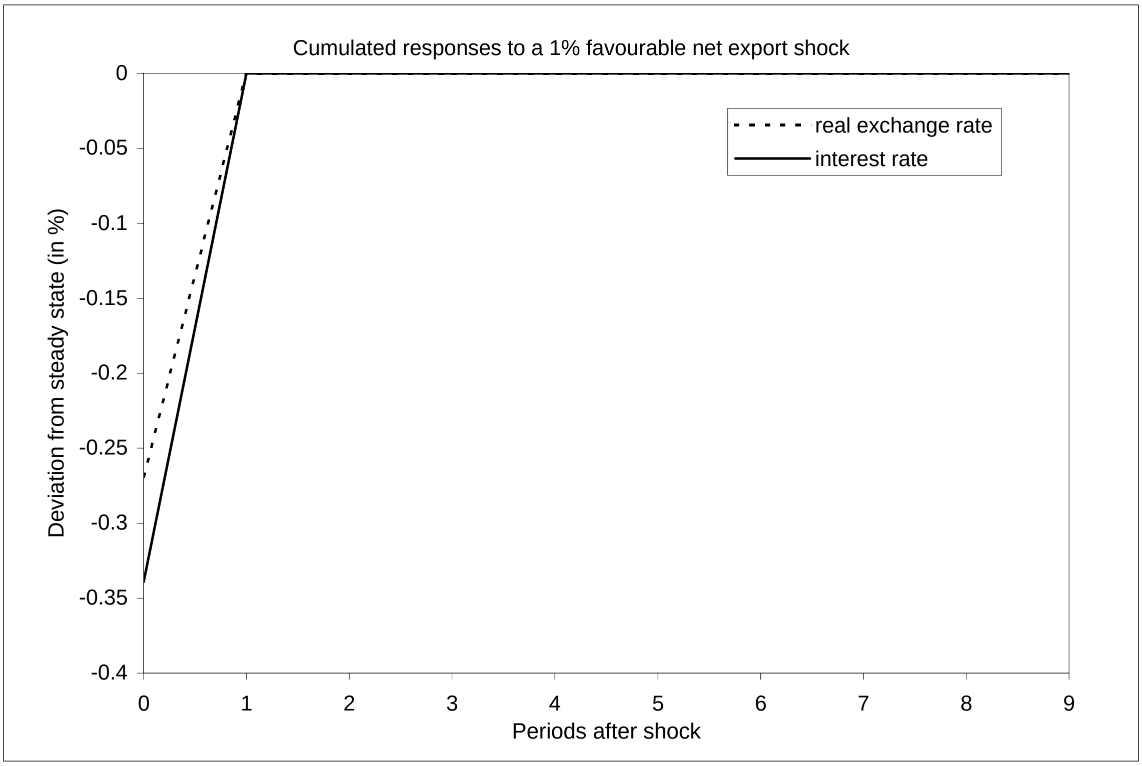
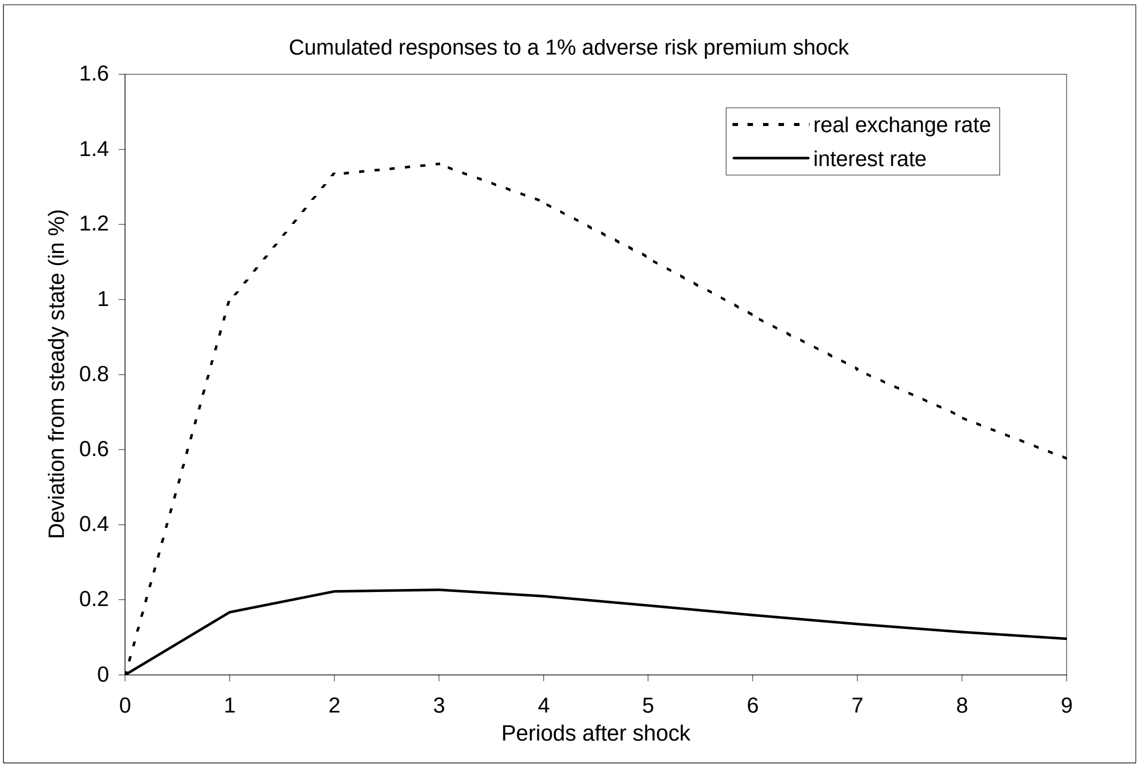
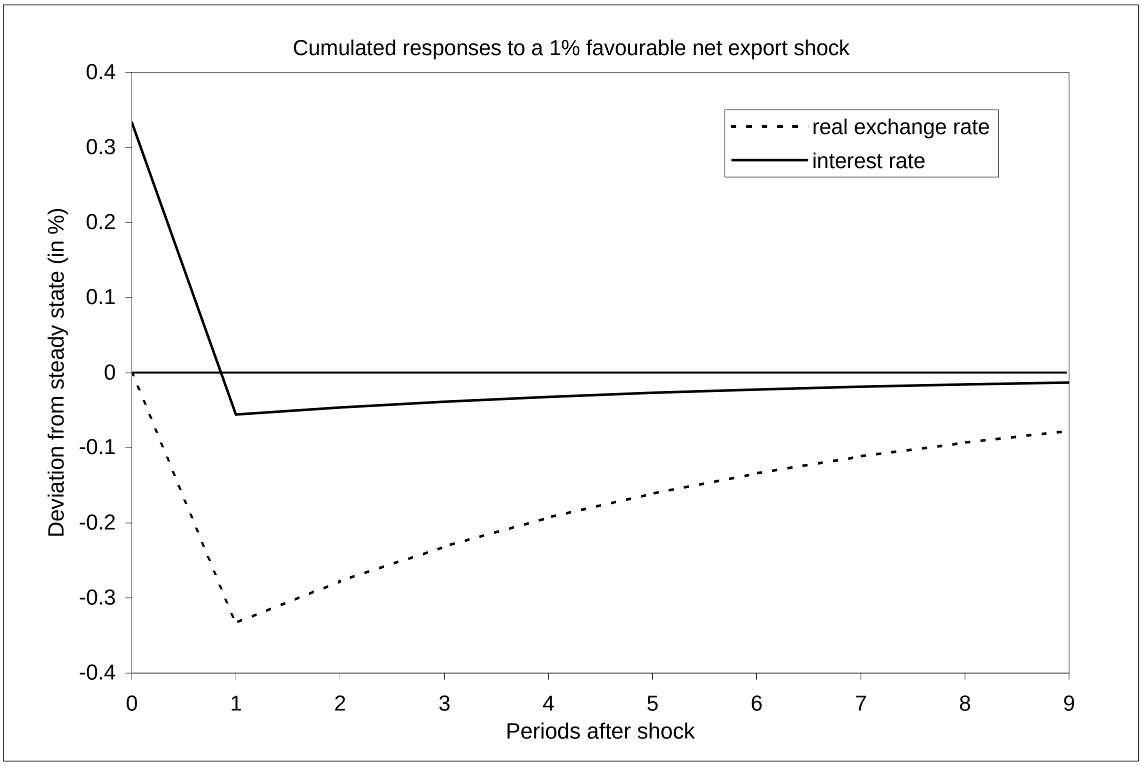


Figure 6. Impulse responses of interest rate and real exchange rate (δ = -0.1)





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