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Monetary Policy Divergence, Net Capital Flows, and Exchange Rates: Accounting for Endogenous Policy Responses [*]

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Abstract

This paper measures the effect of monetary tightening in key advanced economies on net capital flows and exchange rates around the world. Measuring this effect is complicated by the fact that the domestic monetary policies of affected economies respond endogenously to the foreign tightening shock. Using a structural VAR framework with quarterly panel data we estimate the impulse responses of domestic policy variables and net capital flows to a foreign monetary tightening shock. We find that the endogenous responses of domestic monetary policy depends on each economy's capital account openness and exchange rate regime. We develop a method to plot counter-factual impulse responses for net capital outflows under the assumption that domestic interest rates are held constant despite foreign monetary tightening. Our results suggests that failing to account for the endogenous response of domestic monetary policy biases down the estimated elasticity of net capital flows to foreign interest rates by as much as ¼ for floaters and ½ for peggers with open capital accounts.

JEL codes: F3, F4, E5

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1 Introduction

As monetary policy in key advanced economies begins to normalize after having persisted at exceptionally accommodative levels for nearly 10 years, it is natural to ask what effect this normalization will have on world financial markets. In particular, what is the effect of monetary tightening on the volume of net capital flows and exchange rates around the world? How do the affected economies respond to foreign monetary tightening, and how does the response vary across economies? And finally, how can one disentangle the impact of foreign monetary normalization from that of the domestic policy responses on net capital inflows and exchange rates?

These questions may appear simple, but the measurement is not, because any attempt to quantify the impact of foreign monetary tightening on net capital flows and exchange rates is complicated by the fact that the response of domestic monetary policy in recipient countries is endogenous. The existing literature implies that, all else equal, higher interest rates in countries such as the United States reduce the net capital inflows to recipient economies.[1] However, the extent of capital flight and currency depreciation depends not just on the foreign monetary shock, but also on the domestic policy responses that are endogenous to the foreign shock. In fact, central banks are likely to raise their policy interest rates—by more than warranted by domestic macroeconomic conditions—in response to foreign monetary tightening to stem capital flight, and to sell foreign exchange reserves to tame the depreciation of their currencies. Moreover, the endogenous policy response is likely to vary across countries depending on their capital account and exchange rate regimes.

Due to these complications, failing to account for the endogenous response of domestic monetary policy to foreign tightening is likely to understate the impact on capital flows

[1] See Eichengreen and Rose (2004), Eichengreen and Mody (1998), Forbes and Warnock (2012), Fratzscher (2012), Ghosh, Qureshi, Kima, and Zalduendo (2014), Ahmed and Zlate (2014), Byrne and Fiess (2016)). In particular, the "taper-tantrum" episode of 2013 demonstrated that the mere expectation of future monetary tightening in the United States can lead to a near sudden stop in net capital inflows to emerging markets (see Mishra, Moriyama, and N'Diaye (2014), Aizenman, Binici, and Hutchison (2014), Eichengreen and Gupta (2014), and Ahmed, Coulibaly, and Zlate (2017))

and exchange rates, since the domestic response mitigates the full impact of the foreign shock. Moreover, by not accounting for important cross-sectional differences in the type and intensity of domestic policy responses, the literature is likely to miss the heterogeneous impact of foreign monetary tightening across recipient countries.

To rigorously quantify the impact of foreign monetary tightening on capital flows and exchange rates, we follow a two-step approach using a structural vector auto-regressive (SVAR) framework with panel data from 84 advanced and emerging market economies at the quarterly frequency from 1972:Q2 to 2016:Q4. The seven variables included in the SVAR framework include not just the foreign interest rate relevant to each recipient country, the net capital outflows, and the change in exchange rates, but also variables reflecting the domestic policy responses (interest rates and foreign reserve accumulation), as well as domestic macroeconomic variables that guide monetary policy (output growth and inflation). Our two-step approach is as follows. First, we estimate the impulse responses of net capital outflows and exchange rates to the foreign monetary tightening shock. In addition, instead of assuming that domestic monetary policy is exogenous to the foreign shock, we also compute the endogenous response of domestic monetary policy that mitigates the impact of foreign monetary tightening on capital flows and exchange rates. Second, we develop a method to construct counterfactual impulse responses of net capital outflows and exchange rates to the foreign shock assuming that the domestic policy interest rate is held constant, which we compare to the observed impulse responses shown earlier.[2] Importantly, to examine the variation in policy responses across country groups, we repeat the exercise for four country groups given by the interaction between floating/fixed exchange rate regimes and open/closed capital accounts, using the corresponding classifications from Klein and Shambaugh (2015) and Chinn and Ito (2008).

Additional challenges to our approach arise from the fact that (i) recipient countries in

[2]For the use of a SVAR framework to document the effect of monetary policy shocks and construct counterfactuals, see Boivin and Giannoni (2006); however, we implement the SVAR framework in an international context and construct counterfactuals by calibrating shocks to offset the domestic policy response.

the sample depend on different base countries; and (ii) central banks use a heterogeneous toolbox, e.g., to normalize monetary policy in recent years, the Federal Reserve tapered and actually stopped large-scale asset purchases in October 2014, has raised the federal funds rate four times since December 2015, and signaled the intention to reduce the holdings of Treasury and agency securities in June 2017.[3] To overcome these challenges, we pair recipients with base countries like in Shambaugh (2004), and use the pairings to determine the relevant foreign interest rate and exchange rate for each country in the sample. Also, to take into account the heterogeneity in monetary policy tools used since the Global Financial Crisis, we include the shadow short-term interest rates for the United States, the eurozone, the United Kingdom, and Japan from Krippner (2013), which reflect the recent pattern of unconventional monetary policy in these countries.

Our results are as follows. First, as expected, countries with relatively open capital accounts and those with fixed exchange rate regimes respond with stronger increases in domestic policy rates to foreign monetary tightening. Second, the net capital outflows increase in response to foreign monetary tightening, but surprisingly, the relative magnitude of the increase is counter-intuitive across country groups: among floaters, the magnitude of outflows does not vary with the open vs. closed nature of the capital account; among peggers, the outflows are actually lower with an open capital account. Thus, our first two results suggest that the endogenous response of domestic monetary policy, which varies dramatically across country groups, masks the differentiated impact of foreign monetary tightening on net capital outflows. Third, to illustrate the full effect of foreign monetary tightening, we compute counterfactual impulse responses for net capital outflows that abstract from the endogenous response of domestic monetary policy. The results show that if one abstracts from the domestic policy response, foreign monetary tightening would appear to trigger more net capital outflows from countries with open capital account and from those with fixed ex-

[3] In mid-2017, officials from the European Central Bank alluded to a possible slowdown of quantitative easing in the near future. And officials from the Bank of England have begun to suggest a possible interest rate increase as soon as November.

change rate regimes. Fourth, our results also shed light on the exchange rate effect of foreign monetary tightening, which leads to more currency depreciation and a larger decrease in foreign exchange reserves for floaters with open capital accounts relative to those with closed capital accounts.

1.1 Literature

This paper contributes to the literature in a number of ways. First, our results add to the literature on the drivers of cross-border capital flows. Namely, the estimates from regressions of capital inflows on interest rates in recipient and source countries, or on their differential, may be subject to a reverse causation bias to the extent that a slowdown in capital inflows prompts the local central bank to raise the policy rate. The bias would cause the estimation to understate the elasticity of capital flows to interest rates, especially for countries that are more prone to responding to foreign monetary tightening. According to the trilemma, these are the countries with more open capital accounts and fixed exchange rate regimes. Our paper illustrates the existence of this bias specifically for such countries and provides a way to overcome it.

Second, our results contribute to the literature on the effectiveness of capital account restrictions. It seems that controlling for the endogenous response of domestic monetary policy is crucial to identify the effect of capital account restrictions on the behavior of capital flows during monetary policy shocks. Failing to account for the endogenous policy response may lead some papers to conclude that capital account restrictions do not affect the behavior of capital flows (see Clements and Kamil (2009), Ostry, Ghosh, Habermeier, Chamon, Qureshi, and Reinhardt (2010), Forbes and Warnock (2012), Ghosh, Qureshi, Kima, and Zalduendo (2014)).

Third, our results are consistent with the policy trilemma, which states that a country cannot at the same time have (1) an independent monetary policy, (2) a fixed exchange rate regime, and (3) an open capital account (see Mundell (1963) and Fleming (1962)).

Our finding of a stronger monetary policy response in countries with open capital accounts and fixed exchange rates is consistent with Aizenman, Chinn, and Ito (2016), who show that financial conditions in peripheral economies are more closely linked to those in center economies for especially peripheral countries with financial openness or fixed exchange rates. More generally, our findings are consistent with studies that document the tendency for countries to mimic the monetary actions of a base-currency central bank like the Federal Reserve. Usually, the intention is to forestall a shift in capital flows that would lead to a sharp appreciation or depreciation of the currency. For instance, Shambaugh (2004), Obstfeld, Shambaugh, and Taylor (2005), and Klein and Shambaugh (2015) regress changes in the policy interest rate in one country on changes in a base country's interest rate. These papers find that the coefficient in this regression is significantly higher in countries with a pegged currency than in those with a floating currency, and in countries with open than with closed capital account. Also, unlike in Rey (2013), our results suggest that the exchange rate regime makes a difference for the endogenous response of monetary policy, which is stronger for peggers. Pasricha, Falagiarda, Bijsterbosch, and Aizenman (2015) show in a SVAR framework that active use of capital controls can lead to greater monetary policy autonomy, and Davis and Presno (2017) show the same in a DSGE model.

Fourth, our paper is related to the literature documenting the macroeconomic effects of different trilemma choices (see Aizenman, Chinn, and Ito (2011); Forbes and Klein (2015)). The sizeable responses of domestic monetary policy to foreign monetary tightening, which could lead to as much as 20 basis points of additional increase in interest rates over two years for floaters and 50 basis points for peggers to every 100 basis points of foreign tightening, place urgency on considering the effects of reduced monetary policy autonomy on domestic output and inflation.

The rest of this paper is organized as follows. Section 2 introduces the econometric setup for the structural VAR and presents the dataset. Section 3 discusses the results, which contrast the observed impulse responses for net capital outflows and exchange rates to the counterfactual impulse responses that shut down the endogenous response of domestic monetary policy. Section 4 concludes.

2 Econometric methodology and data

We calculate impulse responses using a structural VAR model with panel data:

$$\mathbf{B}_0\mathbf{Y}_t = \mathbf{B}(L)\,\mathbf{Y}_{t-1} + \boldsymbol{\varepsilon}_t \tag{1}$$

where $\mathbf{Y}_t$ has seven rows that correspond to the variables: the year-over-year (YoY) change in the GDP deflator (π_t), the YoY change in real GDP (y_t), net capital outflows excluding reserves (o_t), the foreign policy interest rate (r_t^f), the home policy interest rate (r_t), reserve accumulation (fx_t), and the YoY change in the exchange rate relative to the base country currency (xr_t). $\boldsymbol{\varepsilon}_t$ is made up of structural white-noise shocks. Net capital outflows excluding reserves and reserve accumulation are both normalized by GDP.

To estimate the structural VAR, we first pre-multiply both sides of this equation by $\mathbf{B}_0^{-1}$ to obtain the reduced-form VAR:

$$\mathbf{Y}_t = \mathbf{A}(L)\,\mathbf{Y}_{t-1} + \mathbf{u}_t \tag{2}$$

We then perform a Cholesky decomposition of the covariance matrix of the reduced form residuals, $\mathbf{u}_t\mathbf{u}_t' = \mathbf{B}_0^{-1}\left(\mathbf{B}_0^{-1}\right)'$, in order to identify the lower-triangular matrix $\mathbf{B}_0$.

Identification through the recursive Cholesky identification scheme requires one to specify an ordering of variables. This ordering depends on which shocks are assumed to have a contemporaneous (rather than delayed) effect on different variables in the model. In this paper, we are only concerned with shocks to the foreign policy interest rate. Thus, we assume that the first four variables in $\mathbf{Y}_t$, the change in the price deflator, the change in real GDP, and private net capital outflows are not affected contemporaneously by shocks to the foreign policy rate, while the home policy rate, reserve accumulation and the exchange rate are affected by current shocks to the foreign policy rate. Furthermore, we assume that the foreign policy rate is not affected contemporaneously by shocks to the home policy rate.

For the first set of results presented in the next section, we will simply consider the effect of a shock to the foreign policy rate, given by $\boldsymbol{\varepsilon}_1 = [0,0,0,1,0,0,0]$. The goal is to document the increases in the home-country policy rate triggered by a shock to the foreign policy rate. Subsequently, for the second set of results, we will construct counterfactual impulse responses for net capital outflows and exchange rates obtained under the assumption that the home policy rate is held constant despite the increase in the foreign policy rate.

In more detail, the counterfactual impulse responses are obtained by introducing an additional shock to the home policy rate in each period, which is calibrated to ensure that the home policy rate remains constant despite the foreign policy shock. To illustrate the methodology, begin by consider the structural VAR in (1):

$$\mathbf{B}_0 \begin{bmatrix} \pi_t \\ y_t \\ o_t \\ r_t^f \\ r_t \\ fx_t \\ xr_t \end{bmatrix} = \mathbf{B}(L) \begin{bmatrix} \pi_{t-1} \\ y_{t-1} \\ o_{t-1} \\ r_{t-1}^f \\ r_{t-1} \\ fx_{t-1} \\ xr_{t-1} \end{bmatrix} + \boldsymbol{\varepsilon}_t \tag{3}$$

In period $t = 1$, there is a shock to the foreign policy rate. Since $\mathbf{B}_0$ is lower triangular, this shock will affect contemporaneously the values of the home policy rate, reserve accumulation, and the exchange rate. In the counterfactual scenario, we introduce an additional structural shock $\tilde{\boldsymbol{\varepsilon}}_t$, which is assumed to only affect the home policy rate, hence every element of the vector $\tilde{\boldsymbol{\varepsilon}}_t$ is zero except for the fifth element:

$$\begin{bmatrix} \tilde{\pi}_1 \\ \tilde{y}_1 \\ \tilde{o}_1 \\ \tilde{r}_1^f \\ 0 \\ f\tilde{x}_1 \\ x\tilde{r}_1 \end{bmatrix} = \mathbf{B}_0^{-1} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \mathbf{B}_0^{-1} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ \tilde{\varepsilon}_1 \\ 0 \\ 0 \end{bmatrix} \tag{4}$$

where a tilda "~" indicates the response of a variable under the counterfactual scenario that incorporates the counterfactual shock to the home policy rate. To calibrate the counterfactual shock to the home policy rate, we pre-multiply each side of the above equation by a row vector with seven elements, where each element is set at zero except for the fifth element, which is set at one. By doing so, the above equation becomes:

$$-\mathbf{B}_0^{-1}(5,4) = \mathbf{B}_0^{-1}(5,5)\,\tilde{\varepsilon}_1 \tag{5}$$

where $\mathbf{B}_0^{-1}(i,j)$ is the value in the ith row and the jth column of the matrix $\mathbf{B}_0^{-1}$, and $\tilde{\varepsilon}_1$ is the counterfactual shock to the home policy rate in the first period that would be necessary to hold the home policy rate constant following the shock to the foreign policy rate.

This counterfactual shock to the home policy rate continues in subsequent periods $t > 1$ in order to keep the home policy rate constant:

$$
\begin{bmatrix} \tilde{\pi}_1 \\ \tilde{y}_1 \\ \tilde{o}_1 \\ \tilde{r}^f_1 \\ 0 \\ f\tilde{x}_1 \\ x\tilde{r}_1 \end{bmatrix} = \mathbf{B}_0^{-1}\mathbf{B}\left(L\right) \begin{bmatrix} \tilde{\pi}_{t-1} \\ \tilde{y}_{t-1} \\ \tilde{o}_{t-1} \\ \tilde{r}^f_{t-1} \\ 0 \\ f\tilde{x}_{t-1} \\ x\tilde{r}_{t-1} \end{bmatrix} + \mathbf{B}_0^{-1} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ \tilde{\varepsilon}_t \\ 0 \\ 0 \end{bmatrix} \tag{6}
$$

Again, one can highlight the fifth equation in this VAR by pre-multiplying it by the row vector with seven elements, where each element is zero except for the fifth element, which is one:

$$
-\left[0\ 0\ 0\ 0\ 1\ 0\ 0\right]\mathbf{B}_0^{-1}\mathbf{B}\left(L\right) \begin{bmatrix} \tilde{\pi}_{t-1} \\ \tilde{y}_{t-1} \\ \tilde{o}_{t-1} \\ f\tilde{x}_{t-1} \\ \tilde{r}^f_{t-1} \\ 0 \\ x\tilde{r}_{t-1} \end{bmatrix} = \mathbf{B}_0^{-1}\left(5,5\right)\tilde{\varepsilon}_t \tag{7}
$$

This approach gives the series of counterfactual shocks to the home policy rate $\tilde{\varepsilon}_t$ that would be necessary to hold the home policy rate constant following a shock to the foreign policy rate.

2.1 Data

The full list of countries included in the panel VAR is presented in Table 1. For each country in our sample, the table provides the base foreign country used to pick the relevant foreign policy rate and the foreign currency against which to compute the exchange rate.[4] To measure the effect of interest rate divergence on capital flows and exchange rates, it is helpful (but not mandatory) to designate such a "base" foreign country for each country in our sample, which is considered as the source of the exogenous shock. Many studies have used the U.S. dollar as the base currency and the U.S. Fed Funds rate as the base country interest rate throughout the sample. However, it is plausible that the primary international relation for some of the counties in our sample is not with the United States, so to accurately measure the effect of interest rate divergence on capital flows, we designate a different base foreign country for each country in our sample.

We pair our countries to base countries like in Shambaugh (2004). When a country pegs or partially pegs its currency to a base country's currency, the designation is straightforward (e.g., the peg of the Hong Kong dollar to the U.S. dollar). However, when the country does not peg, the designation is not trivial and requires a judgement call. Shambaugh (2004) bases this choice on historical relationships (e.g., designating the French currency as the base currency for many African countries) or on the basis of a nearby dominant economy (e.g., Malaysia is the base country for Singapore, Australia is the base country for New Zealand, and India is the base country for Sri Lanka and Nepal).

In the main results of the paper, we use the base countries as shown in Table 1. In the appendix, we instead assume that the U.S. is the base country for every country in our sample. Quantitatively, the effect of a shock to the foreign interest rate on net capital flows is slightly smaller when we simply assume that the United States is the base country for all countries in the sample, but qualitatively the results are unchanged.

The data on private net capital flows and reserves accumulation at the quarterly frequency are from the IMF balance of payments (BPM6). Private net capital flows and reserve accumulation are both normalized by GDP. We also use the base foreign country's and the domestic country's policy interest rates, as well as the year-over-year change in exchange

[4] USA: U.S. dollar; DEU: German currency (mark and then euro); FRA: French currency (franc and then euro); AUS: Austrialian dollar; IND: Indian rupee; MYS: Malaysian ringgit

rates.

Country-quarter observations are divided into 4 categories: (1) those corresponding to countries with a floating currency and an open capital account, (2) those with a floating currency and a closed capital account, (3) those with a fixed currency and an open capital account, and (4) those with a fixed currency and a closed capital account. The distinction of whether a country has a fixed or floating exchange rate regime in a given year is taken from Klein and Shambaugh (2015), whereby a country has a fixed currency in a given year if the movement in the exchange rate relative to the base country currency in a given year does not exceed 5%.

The distinction between country-quarters with open vs. closed capital account regime is based on the Chinn and Ito (2008) index of capital account openness normalized on a 0-1 scale, where 0 indicates a closed capital account and 1 indicates an open capital account. In a given year, a country is considered to have an open capital account if the value of the Chinn-Ito index for that year is greater than 0.5, and it is considered to have a closed capital account if the index is less than 0.5.

Both the currency index and the Chinn and Ito (2008) capital account openness index are annual, but the data in the VAR is at a quarterly frequency. Therefore, the values of the currency index and capital account openness index in a given year are assumed to apply to every quarter of that year. Also, it should be noted that the four groups include country-quarter observations, since a given country can transition between groups over time. For a country that moves toward liberalizing its capital account during the sample period, the country-quarter observations for that country may fall into the closed capital account groups early in the sample period, but switch to one of the open capital account groups later in the sample period.

3 Results

3.1 Results from Structural VARs

The responses of the home policy interest rate, the exchange rate, net capital outflows (excluding reserves), and reserve accumulation to a 1 p.p. shock to the foreign policy rate are presented in figures 1-4. Figure 1 presents the shock responses for countries with a floating currency and an open capital account, figure 2 presents the responses for countries with a floating currency and a closed capital account, figure 3 is for countries with an exchange rate peg and an open capital account, and figure 4 is for countries with an exchange rate peg and a closed capital account.

The impulse responses in figure 1 show that for a country with a floating currency and an open capital account, following the 1 p.p. increase in the foreign interest rate, the home central bank raises the policy rate by 0.1 p.p. on impact and the increase in the home policy rate peaks at about 0.2 p.p. after about 2 years. There is about a 0.5% depreciation in the home currency, and the ratio of net capital outflows to GDP increases by more than 0.15 p.p. Meanwhile, the stock of central bank reserves falls by a little more than 1 percent of GDP.

The impulse responses in figure 2 show that in a country with a floating currency but a relatively closed capital account, the central bank does not change the home country policy rate on impact (as opposed to a 0.1 p.p. increase in the country with the open capital account) but after 2-3 years, the central bank has raised the policy rate by about 0.2 p.p., similar to the increase in the country with the floating currency and an open capital account. Similarly, there is about a 0.5% depreciation in the home currency. The increase in net outflows is a little more than 0.15% of GDP, and central bank reserves fall by about 0.15% of GDP, slightly more than the country with an open capital account.

Next we turn to countries with a fixed exchange rate in figures 3 and 4. The central bank in a country with a fixed exchange rate raises the policy rate by nearly 0.5 p.p. regardless of the capital account regime. However, this increase is faster in the country with an open capital account, taking place over 2-3 years. Furthermore, the depreciation in the currency is small in both sets of countries. Net capital outflows increase by less than 0.1% of GDP in countries with a pegged currency and an open capital account, and they increase by around 0.15% of GDP in countries with a pegged currency and a relatively closed capital account. Meanwhile, central bank reserves fall by around 1% of GDP in both sets of countries.

The most substantial differences across the four groups of countries in figures 1-4 concern the responses of the home country policy interest rate. In countries with a floating currency, the home country policy rate increases by about 0.2 p.p. following the 1 p.p. shock to the foreign interest rate, while in a country with a pegged currency the response of the home country policy rate is about 0.5 p.p. increase.

The fact that the home country policy rate is much less responsive to shocks to the foreign policy rate in a country with a floating currency is shown again in variance decomposition results in table 2. The table shows the percent of the forecast error variance of the home policy rate in each of the four groups of countries that is explained by shocks to each of the 7 variables in the model at 1-5 year forecast horizons.

In countries with a floating currency and an open capital account, less than 4% of the forecast error variance of the home policy rate at a 5 year horizon is explained by shocks to the foreign policy rate. For countries with a floating currency and a closed capital account this share falls below 1%. Meanwhile the share of the variance in the home policy rate explained by shocks to the foreign policy rate is much higher in countries with a pegged currency. In countries with a pegged currency and a relatively closed capital account the share is 13%, and in countries with a pegged currency and an open capital account this share rises to 28%.

3.2 Results from Counterfactual VARs

In response to an increase in the foreign policy rate, the home country central bank may raise their policy interest rate in an attempt to mitigate some of the increase in net capital outflows (a.k.a. fall in net inflows) resulting from the divergence between the home and foreign interest rates. It is therefore natural to ask how successful this policy was in stemming the fall in net inflows? What would net capital flows have been in the absence of an increase in the home country policy rate?

The counterfactual VAR model results discussed in this section can be used to plot the responses of net capital outflows in each of the four country groups under the alternative scenario where the home country policy interest rate does not respond to the foreign policy interest rate shock. As described in the last section, we compute the counterfactual impulse responses by calibrating a series of shocks to the home country policy rate that would keep the home policy rate unchanged. The calibration of these is described in equation (7).

The calibrated shocks to the home country policy interest rate that would be necessary to keep the home country policy rate constant following the shock to the foreign interest rate are shown in figure 5. The counterfactual shock necessary to keep the home policy rate constant is largest in the group with a pegged currency and an open capital account. Similarly in a country with a pegged currency, the presence of capital account restrictions (or lack of thereof) has a large effect on the size of the counterfactual shock. This result reflects the fact that the desire to raise the home policy rate following the foreign shock is strongest when a country has a pegged currency and an open capital account, and that capital account restrictions reduce the pressure on the home interest rate.

Apart from the first period, the size of the counterfactual shock necessary to keep the home interest rate constant is always larger in a country with a pegged currency. On the contrary, the counterfactual shock is smallest in the group with a floating currency and a closed capital account. This pattern reflects the fact that the pressure to raise the home policy rate following the shock to the foreign policy rate is weakest in countries that allow for their currency to float and implement capital account restrictions.

The path of net capital outflows (excluding reserves) following a shock to the foreign policy rate is presented in figure 6. The responses are shown twice, with the blue solid line showing the responses when the home policy rate is allowed to change, as in figures 1-4. The red dashed line are the counterfactual responses when the additional series of shocks to the home policy rate is fed into the model to keep the home policy rate constant.

In this setup, the gap between the red and blue lines in the figure represent the amount of the increase in net capital outflows that is mitigated by the endogenous response of domestic monetary policy in affected economies. Controlling for the capital account regime (across columns), this gap is larger for the set of countries with a fixed exchange rate rather than floating exchange rates. Alternatively, controlling for the exchange rate regime (across rows), this gap is larger for countries with an open capital account than with a closed capital account regime.

Thus, our results suggest that the endogenous responses of domestic monetary policy mitigate a greater portion of the response of net capital outflows for countries with open capital accounts. Within countries with open capital accounts (panels 1 vs. 3), the endogenous policy response mitigates a greater portion of the net capital outflows for peggers. Therefore, among countries with open capital accounts, by failing to account for the endogenous response of domestic monetary policy would bias down the estimated elasticity of net capital flows to changes in foreign interest rates by as much as 1/4 for floaters (panel 1) and by 1/2 for peggers (panel 3).

4 Conclusion

This paper shows that measuring the elasticity of net capital flows and exchange rates to foreign monetary policy shocks is complicated by the endogenous responses of domestic monetary policy in affected economies. In response to the current wave of monetary policy tightening in key advanced economies, such as the United States, the eurozone, and the United Kingdom, central banks in peripheral economies are likely to raise their policy interest rates in order to curtail a fall in capital inflows and currency depreciations. However, the extent to which central banks will raise their policy rates in such a scenario is likely to depend on factors like the capital account and exchange rate regimes. Our results suggest that failing to account for the endogenous response of domestic monetary policy would bias down the estimated elasticity of net capital flows to changes in foreign interest rates by as much as a quarter for floaters and one half for peggers with open capital accounts.

Raising the domestic interest rate is not the only policy response of central banks to foreign monetary tightening, since central banks can also sell foreign exchange reserves to arrest currency depreciation. Aizenman and Sun (2012) document and explain the size of reserve depletion in many emerging markets during the Global Financial Crisis. Davis (2017) uses a regression framework like that in Klein and Shambaugh (2015) to show that countries with high levels of foreign exchange reserves are less likely to move their domestic interest rate in response to a change in the foreign interest rate. Our results already show the extent to which various countries choose to let their currencies depreciate vs. sell foreign exchange reserves in response to the foreign interest rate shock. Therefore, one interesting expansion of our framework would be to consider that the response of foreign exchange reserves is itself an endogenous policy response, and examine if accounting for this additional endogenous policy action affects the response of net capital flows in the context of foreign monetary tightening shocks.

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Table 1: Countries in the panel VARs.

Argentina (USA)	Thailand (USA)
Armenia (USA)	Turkey (USA)
Australia (USA)	Uganda (USA)
Azerbaijan (USA)	Ukraine (USA)
Bangladesh (USA)	Uruguay (USA)
Bolivia (USA)	Venezuela (USA)
Bosnia and Herzegovina (USA)	Vietnam (USA)
Brazil (USA)	Yemen (USA)
Cambodia (USA)	Albania (DEU)
Canada (USA)	Austria (DEU)
Chile (USA)	Belgium (DEU)
China (USA)	Croatia (DEU)
Colombia (USA)	Czech Republic (DEU)
Egypt (USA)	Denmark (DEU)
El Salvador (USA)	Estonia (DEU)
Ethiopia (USA)	Finland (DEU)
Fiji (USA)	France (DEU)
Georgia (USA)	Greece (DEU)
Germany (USA)	Hungary (DEU)
Guatemala (USA)	Iceland (DEU)
Guinea (USA)	Ireland (DEU)
Honduras (USA)	Italy (DEU)
Hong Kong (USA)	Latvia (DEU)
India (USA)	Lithuania (DEU)
Indonesia (USA)	Macedonia (DEU)
Israel (USA)	Netherlands (DEU)
Japan (USA)	Norway (DEU)
Jordan (USA)	Poland (DEU)
Kazakhistan (USA)	Portugal (DEU)
Korea (USA)	Romania (DEU)
Kyrgyz Republic (USA)	Slovak Republic (DEU)
Malaysia (USA)	Slovenia (DEU)
Mexico (USA)	Spain (DEU)
Moldova (USA)	Sweden (DEU)
Mozambique (USA)	Switzerland (DEU)
Nicaragua (USA)	United Kingdom (DEU)
Pakistan (USA)	Madagascar (FRA)
Paraguay (USA)	Morocco (FRA)
Peru (USA)	New Zealand (AUS)
Philippines (USA)	Nepal (IND)
Russia (USA)	Sri Lanka (IND)
South Africa (USA)	Singapore (MYS)

Table 2: Variance decomposition, share of the variance of fluctuations in the domestic policy rate that are explained by shocks to each variable.

Float, Open

$Horizon$	π_t	y_t	o_t	r_t^f	r_t	fx_t	xr_t
4 quarters	4.0	5.2	0.7	1.3	87.9	0.7	0.1
8	8.8	12.3	3.4	2.4	71.3	1.3	0.6
12	12.7	16.8	5.8	3.2	59.2	1.4	1.0
16	15.6	19.3	7.4	3.6	51.4	1.4	1.3
20	17.8	20.6	8.4	3.9	46.6	1.3	1.5

Float, Closed

$Horizon$	π_t	y_t	o_t	r_t^f	r_t	fx_t	xr_t
4 quarters	6.3	6.3	0.8	0.1	85.1	1.3	0.0
8	8.2	12.5	0.7	0.3	75.6	2.6	0.0
12	9.0	15.7	1.1	0.5	70.6	3.0	0.2
16	9.2	17.3	1.5	0.5	68.0	3.1	0.3
20	9.4	18.2	1.8	0.6	66.6	3.1	0.3

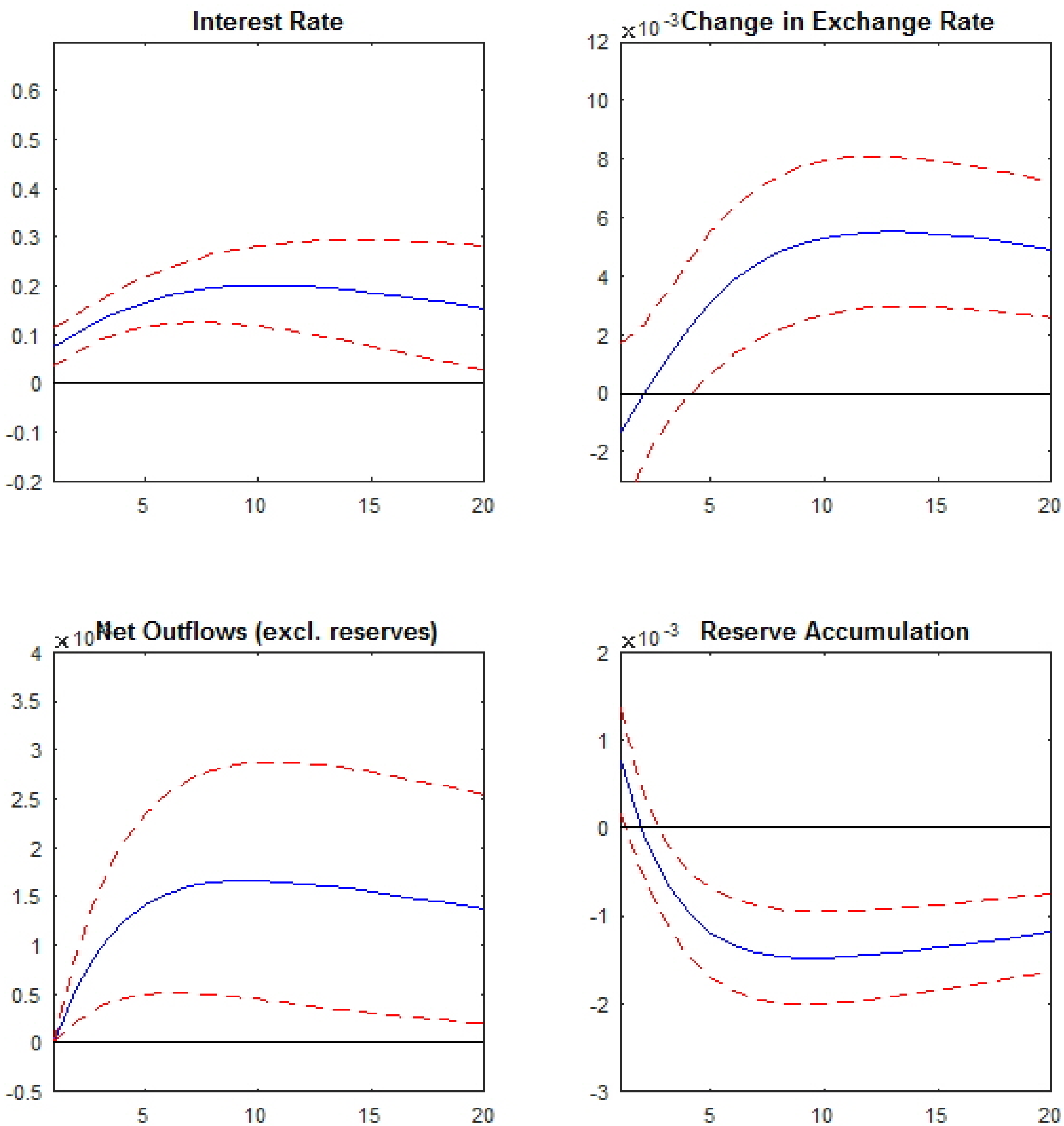
Peg, Open

$Horizon$	π_t	y_t	o_t	r_t^f	r_t	fx_t	xr_t
4 quarters	0.9	5.7	0.1	5.5	87.1	0.3	0.5
8	1.2	14.1	0.1	13.9	69.4	0.4	0.8
12	1.5	20.0	0.1	20.7	56.5	0.4	0.8
16	1.6	23.6	0.1	25.4	48.2	0.3	0.8
20	1.7	25.5	0.2	28.6	43.0	0.3	0.7

Peg, Closed

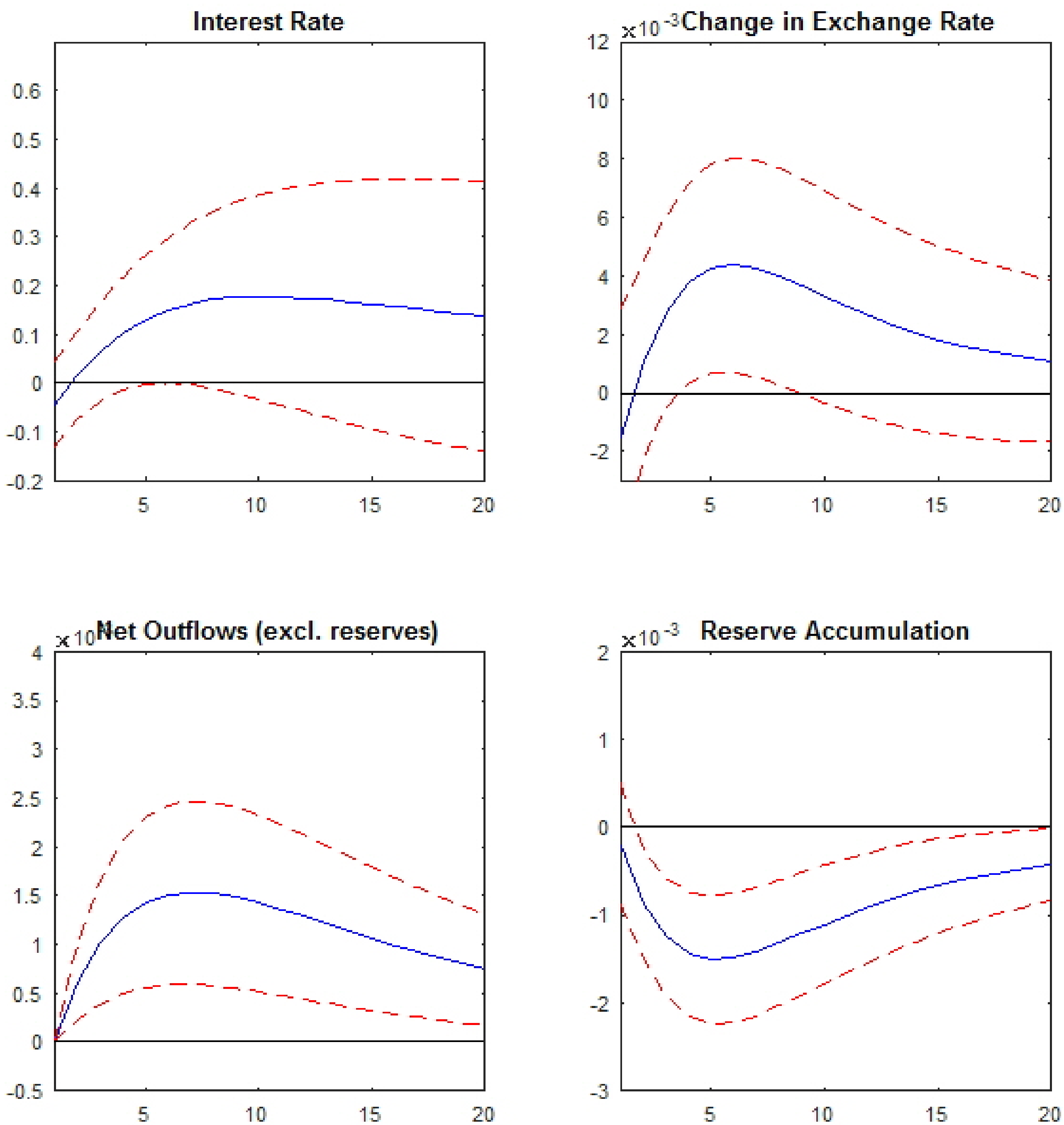
$Horizon$	π_t	y_t	o_t	r_t^f	r_t	fx_t	xr_t
4 quarters	0.6	0.1	0.3	0.9	97.8	0.3	0.0
8	1.4	0.4	0.3	3.3	94.1	0.5	0.0
12	1.8	0.8	0.3	6.5	90.1	0.5	0.0
16	2.0	1.0	0.2	10.0	86.2	0.5	0.1
20	2.0	1.1	0.2	13.3	82.7	0.5	0.1

Figure 1: Responses of home variables following a 1 p.p. increase in the foreign policy rate in a country with a floating currency and an open capital account.



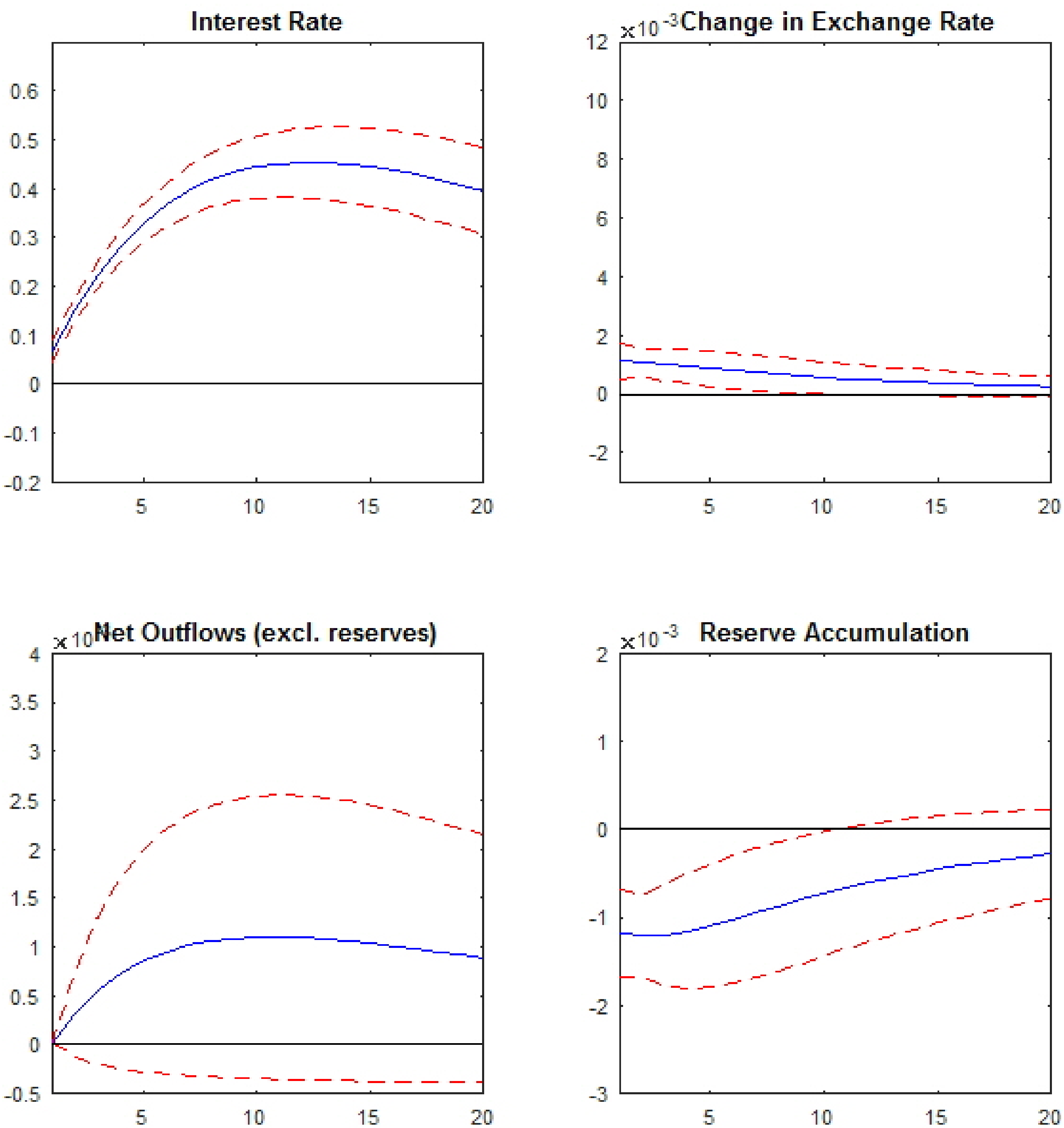
Notes: Red dashed lines are ±1 Standard error bands

Figure 2: Responses of home variables following a 1 p.p. increase in the foreign policy rate in a country with a floating currency and a closed capital account.



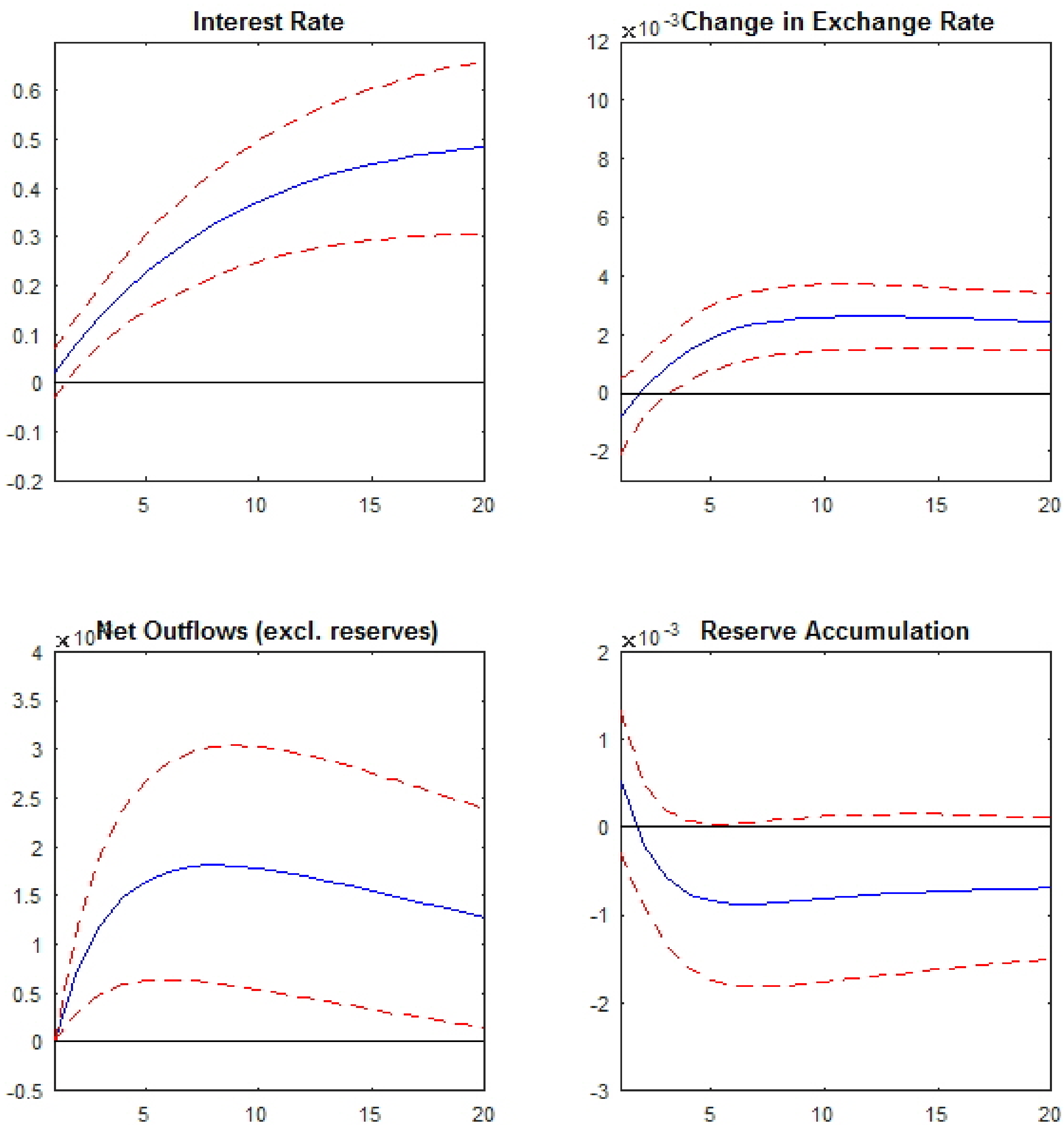
Notes: Red dashed lines are ±1 Standard error bands

Figure 3: Responses of home variables following a 1 p.p. increase in the foreign policy rate in a country with a fixed currency and an open capital account.



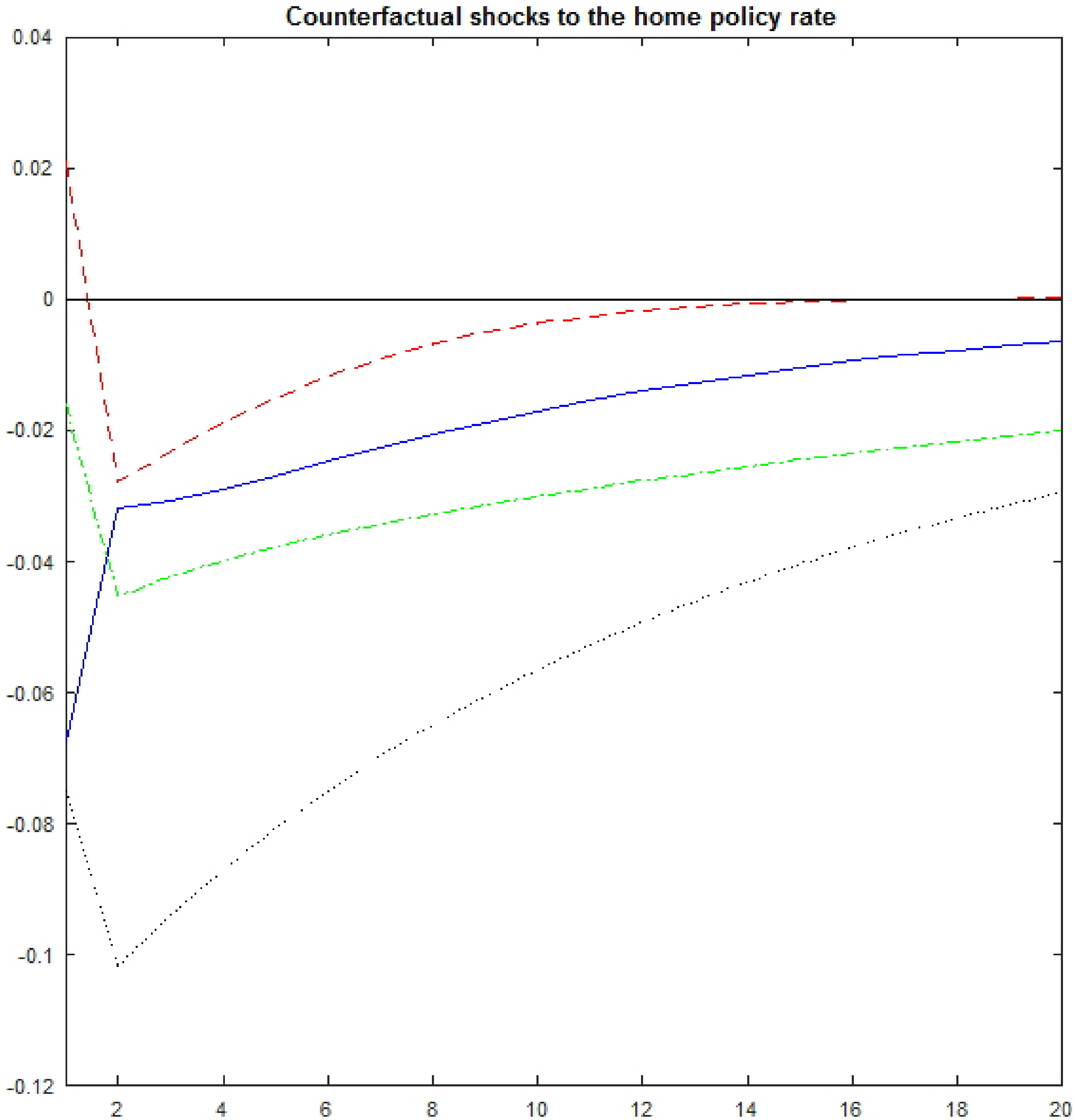
Notes: Red dashed lines are ±1 Standard error bands

Figure 4: Responses of home variables following a 1 p.p. increase in the foreign policy rate in a country with a fixed currency and a closed capital account.



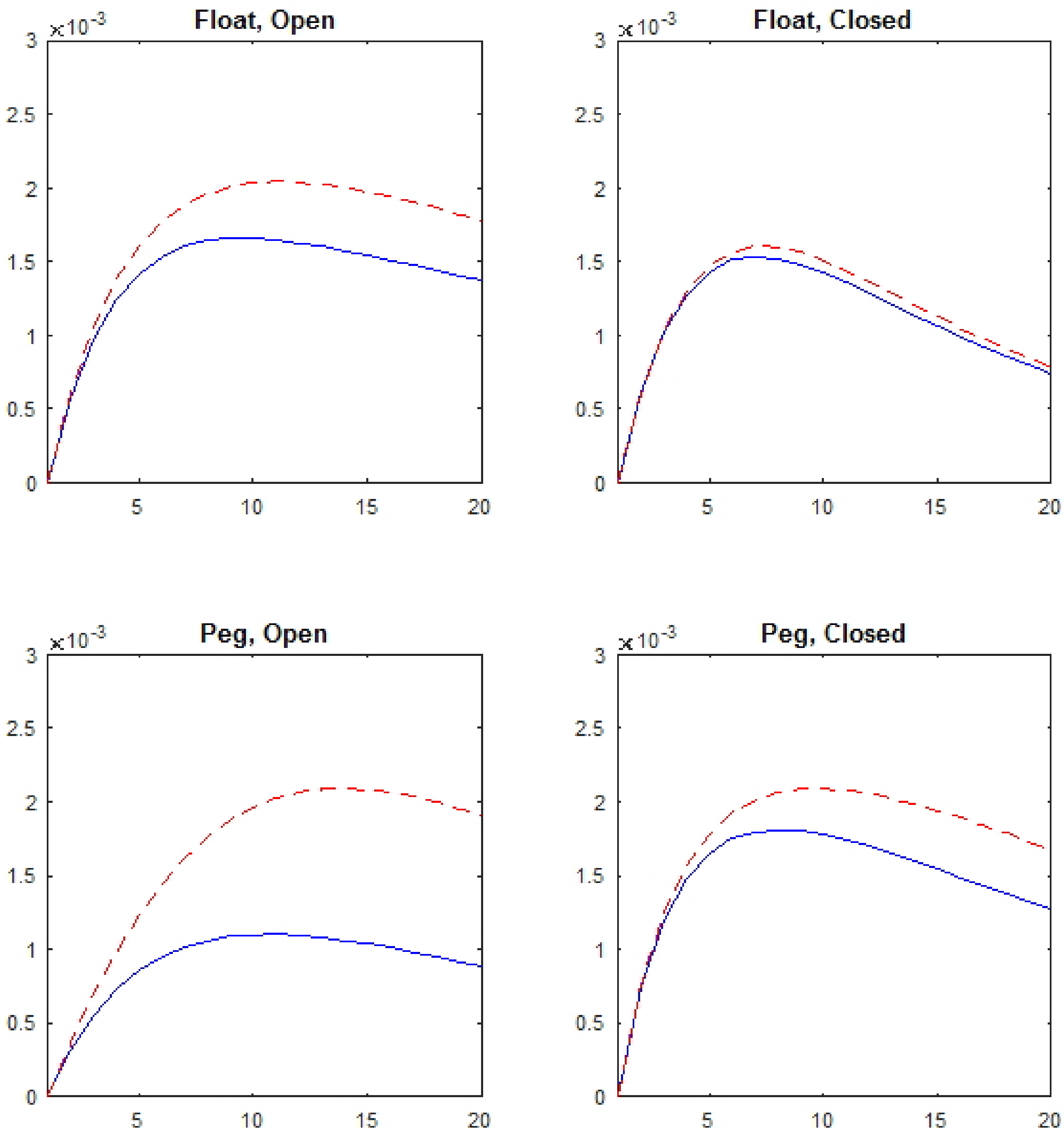
Notes: Red dashed lines are ±1 Standard error bands

Figure 5: Counterfactual shocks to the home policy rate that would be necessary to keep the home policy rate constant following a shock to the foreign policy rate.



Notes: Blue solid line is the series of counterfactual shocks in the subset of countries with a floating currency and an open capital account, the red dashed line is for the subset with the floating currency and the closed capital account, the black dotted line is for the subset with the fixed currency and the open capital account, the green dash-dot line is for the subset with a fixed currency and a closed capital account.

Figure 6: Responses of net capital outflows in the actual model and in the counterfactual model where the home policy rate is held constant.



Notes: Blue solid line is the acual response, the red dashed line is the counterfactual response where the home policy rate is held constant.