Capital Controls, Macroprudential Policy, and the Mundellian Trilemma *

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Abstract

Can exchange rate flexibility ensure the policy autonomy of open economies, as indicated by the trilemma? The rising spillovers from US monetary shocks through the global financial cycle have led researchers (such as Rey, 2015) to postulate a dilemma where the independence of monetary policy only exists under capital controls. Using an interacted panel vector autoregression (PVAR) model, this paper tests the validity of the trilemma, and potential remedial effects of capital control and macroprudential policies, for 45 key advanced and emerging economies during 1999-2016. We find exchange rate flexibility remain effective in lowering the domestic monetary response to US interest rate shocks, especially in emerging economies, and capital controls are not necessary. Macroprudential policies also provide policy autonomy in advanced economies by reducing the domestic monetary sensitivity to U.S. shocks. Our results support the validity of the trilemma even in the time of financial globalisation, and show that sensitivity to the global financial cycle can be handled with macroprudential policies.

Keywords: Mundellian trilemma, macroprudential policy, capital control, monetary policy, exchange rate regime

JEL Codes: E42, F33, F38

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1 Introduction

The trilemma advocates flexibility of exchange rate as the key policy for an open economy to preserve the independence of its monetary policy, as in Fleming (1962) and Mundell (1963). However, the rapid advancement of financial globalisation and the dominant role of the US dollar as an international currency have raised concerns about the ability of countries to limit the spillover effects of US monetary policy. Cross-border capital flows and the resulting synchronization of asset prices have casted doubt on the ability of a flexible exchange rate to provide a sufficient buffer. This leads to the dilemma hypothesis (Rey, 2015) which states that preserving monetary policy autonomy may now require restrictions on capital mobility, irrespective of exchange rate arrangements.

Against the backdrop of global financial integration, this paper assesses two questions on policy autonomy. First, is monetary policy more independent under a flexible exchange rate than under a fixed regime, even when faced with US policy shocks? A positive answer would imply that the policy trilemma remains valid in the era of global financial cycle. Second, can capital controls and macroprudential policies reinforce the independence of domestic policy under financial globalization in a flexible exchange rate regime? While capital controls target the capital flow channel of global shock transmission, macroprudential policy is concerned with a country's financial stability. Both policies can potentially deal with the spillovers from the global financial cycle that a flexible exchange rate is unable to fully absorb alone.

The paper assesses the validity of the trilemma over the recent decades (1999-2016), and tests if the benefit of exchange rate flexibility, relative to other arrangements, has remained valid under financial globalization. We conduct the analysis using an interacted panel vector autoregression (IPVAR). This methodology facilitates for a comparative study on the responses of domestic monetary policy to US interest shocks, measured by shadow federal funds rate, evaluated at different exchange rate regimes and capital account policies. In this empirical framework, we examine whether exchange rate flexibility, or the use of capital controls, can lower policy sensitivity of non-US economies to US monetary policy actions. The sample covers 45 key economies, consisting both of advanced countries and emerging markets, the results being contrasted between the two country groups. Our analysis also considers the effectiveness of complementary policies to support policy autonomy under exchange rate flexibility. We first evaluate whether capital flow restrictions are necessary, and then whether macroprudential policies can stabilize domestic credit and leverage in the presence of US monetary policy shocks.

Results of the paper lend support to exchange rate flexibility as an effective buffer of US monetary policy spillovers, even in the era of global financial integration. The responses of domestic policy rates to US shock are lower under more flexible exchange rates, in particular for emerging market economies. The Mundellian trilemma thus remains a relevant concept for policy choices of central banks. Our findings also indicate that capital

flow restrictions are of limited use for countries with flexible exchange rates. The sensitivity of domestic monetary policy to US shocks is not significantly reduced in countries with a greater intensity of capital restrictions, either for advanced or emerging economies. One of the core policy prescriptions advocated by the dilemma may therefore not be as immediate and potent as assumed.

On the other hand, a tighter stance in macroprudential regulation is found to be useful for advanced economies, as it reduces the domestic policy sensitivity to US shocks, especially under greater capital mobility. The limited effectiveness of macroprudential tools in emerging markets, could reflect a higher prevalence of non-bank lending and foreign bank operations. Given the successful evidence in advanced economies, emerging market economies cold potentially bolster their policy autonomy by expanding their macroprudential toolkit to cover non-bank sector and domestic lending by foreign banks.

The rest of the paper is organized as follows. Section 2.2 provides a review of the relevant literature. Section 2.3 presents the empirical methodology, including the specification of the Interacted Panel VAR model and the estimation procedures. Section 2.4 presents the results on the validity of the trilemma. Section 2.5 examines the effectiveness of macroprudential policies, followed by a brief policy discussion. Section 6 concludes the paper.

2 Literature Review

The Mundellian trilemma states that an economy can pursue only two out of the three objectives: capital mobility, stable exchange rate, and an independent monetary policy. A policy trade-off is thus highlighted by the trilemma hypothesis. If capital market is fully open, then flexible exchange rate is necessary for national monetary policy rates to autonomously focus on domestic inflation and output gaps (Fleming, 1962 and Mundell, 1963). Alternatively, if fixed exchange rate and capital openness are to be prioritized, domestic monetary policy has to co-move closer with interest rates abroad, predominantly with the policy rate of the Federal Reserve.

The past century has testified the soundness of trilemma across countries to a large extent (Obstfeld et al., 2005). Notwithstanding, the validity of impossible trinity is a phenomenon in the context of de facto exchange rate regimes, as de jure floating arrangements from emerging markets may lack credible adherence (Calvo & Reinhart, 2002). Moreover, the merit of float in bolstering monetary independence is more pronounced from a short-run viewpoint (Frankel et al. 2004).

Recent developments of financial globalisation have exhibited extreme episodes of cross-border capital flows (Forbes & Warnock, 2012), and global synchronization of booms

and busts in asset price and credit growth. In other words, the global financial cycle has channelized U.S. monetary policy shocks to transmit internationally. For countries with flexible exchange rates, globalization of core country shocks have thrown domestic monetary policy independence into the peril of a policy dilemma, instead of the trilemma: either to conserve monetary autonomy, or to keep capital flow free (Rey, 2014, 2015; and Miranda-Agrippino and Rey, 2015).

Our paper aims to investigate the proposed policy options that can mitigate the intensified sensitivity of periphery countries to policy shocks from the core country, in the context of a U.S. monetary tightening. The straightforward recourse, as suggested by the dilemma, are targeted capital controls. Klein & Shambaugh (2015) shows that partial capital controls against free capital mobility may have some effect in increasing policy independence if measures are sufficiently extensive. Capital controls in the form of tax on foreign bond holdings imposed by a small open economy can in principle alleviate volatility in net capital inflows (Davis & Presno, 2017) and redeem monetary policy independence, especially in combination with macroprudential regulation aimed at curbing risky credit (Korinek & Sandri, 2014). In our paper, we measure capital openness in terms of the intensity of capital flow restrictions, and we show that capital controls are unnecessary, and even counter-productive for emerging economies, towards policy autonomy when exchange rate flexibility has been allowed under capital mobility.

The other solution, then, is transferring some of the financial stablization objectives from monetary to macroprudential policies in order to reduce responses in policy rate. There is increasing theoretical support in favour of the usefulness of macroprudential policies, particularly in complementing monetary policy towards financial shocks. Aoki et al (2015) shows cyclical macroprudential limit on bank foreign currency borrowing enhance welfare when combined with inflation-targeting monetary policy. Similarly, with presence of nominal rigidity and binding zero-lower bound, macroprudential intervention can rectify financial market imperfections either for pegged or floating regimes (Farhi & Werning, 2016). Our paper assesses empirically the use of macroprudential policy as an effective tool to mitigate domestic monetary policy susceptibility to the global financial cycle driven by Fed policy actions. We found that macroprudential tightening can effectively minimize domestic policy responses to US tightening shock in particular for advanced economies. Moreover, the gain in policy autonomy is higher for those with more flexible exchange rates and freer capital flows.

The methodology applied in our paper is also related to the evolving literature of assessing the spillover impacts of U.S. monetary policy using variants of the vector autoregression (VAR) models. Many adopted the two-step procedure by regressing responses from VARs on country characteristics for sensitivity analysis. Miniane & Rogers (2003) showed that capital controls are not as potent in shielding domestic policy rate away from U.S. monetary shocks as exchange rate regime and degree of dollarization could. Georgiadis & Mehl (2015) found, under floating regimes, domestic monetary policy effectiveness is enlarged by the global financial cycle via valuation effects from net foreign currency exposure,

reinforcing the trilemma.

The results in this paper are generally in line with these empirical findings, yet we took the approach of incorporating interaction terms into panel VAR estimation that is largely built on the framework of Broda (2004), Broda & Tille (2003), and Towbin & Weber (2015), and we additionally considered the role of macroprudential regulations that have been widely applied by countries since the financial crisis. We obtained impulse responses conditional on levels of capital control, exchange rate regimes, and macroprudential stance in order to systematically illustrate the difference in sensitivity to U.S. shocks. The next section will outline our estimation strategy detailedly.

3 Empirical Strategy

To estimate the transmission effect of external monetary policy shocks on domestic interest rate, we estimate an Interacted Panel VAR with block exogeneity restriction with five explanatory variables and three interaction terms. The following three sections will address in detail the setup of the model, the selection of variables and interactions, as well as the estimation methodology applied in order to test the validity of trilemma and the effectiveness of macroprudential policies.

3.1 Model Specification

The Interacted Panel VAR model in our paper has the following structural form:

$$M_{i,t}Y_{i,t} = \tilde{A}_{i,0} + \sum_{l=1}^{L} \tilde{A}_{i,l}Y_{i,t-l} + \tilde{B}_{i,0}D_{i,t} + \sum_{l=1}^{L} \tilde{B}_{i,l}D_{i,t}Y_{i,t-l} + \tilde{u}_{i,t}, \tag{1}$$

$$t = 1, ..., T; i = 1, ..., N; \tilde{u}_{i,t} \sim N(0, \tilde{\Sigma})$$

In the above specification, $\mathrm{M}_{i,t}$ is a $k \times k$ matrix of contemporaneous effects among the k explanatory variables. $\tilde{u}_{i,t}$ is the vector of structural shocks, assumed uncorrelated across countries and normally distributed with a constant diagonal $k \times k$ covariance matrix. $\tilde{A}_{i,0}$ is a $k \times 1$ vector of country-specific effects, $\tilde{A}_{i,l}$ is a $k \times k$ matrix of autoregressive coefficients up to lag L. $\tilde{B}_{i,0}$ and $\tilde{B}_{i,l}$ are effects of the interaction, and on the interacted explanatory variables, respectively. For the variables, $\mathrm{Y}_{i,t}$ is a $k \times 1$ vector of explanatory variables, and $\mathrm{D}_{i,t}$ is the vector of interaction terms.

We can group and re-write equation (1) as:

$$M_{i,t}Y_{i,t} = \tilde{\gamma}_{i,0}X_{i,t} + \sum_{l=1}^{L} \tilde{\Gamma}_{i,l}Y_{i,t-l} + \tilde{u}_{i,t}, \tag{2}$$

such that,

$$\tilde{\gamma}_{i,0}X_{i,t} = \tilde{A}_{i,0} + \tilde{B}_{i,0}D_{i,t},$$

where all interaction terms also enter as exogenous individual controls, and,

$$\sum_{l=1}^{L} \tilde{\Gamma}_{i,l}Y_{i,t-l} = \sum_{l=1}^{L} (\tilde{A}_{i,l} + \tilde{B}_{i,l}D_{i,t})Y_{i,t-l},$$

is the composite effect of explanatory variables conditional on interaction variables.

3.2 Variables

Because we focus on domestic response of policy rate, a minimalistic set of classic endogenous variables are studied, that reflects output, inflation and exchange rate objectives of monetary policy rules across countries.

$\mathrm{Y}_{i,t}$ represents the vector of explanatory variables either expressed in percentage changes or log differences, and are listed as follows:

$$\begin{aligned} Y_{i,t} &= [USP_{i,t}, DOM_{i,t}]' \\ &= [USP_{i,t}, EXR_{i,t}, CPI_{i,t}, GDP_{i,t}, DPR_{i,t}]', \end{aligned} \tag{3}$$

where at time t $\mathrm{USP}_{i,t}$ is the U.S. monetary policy indicator as our proxy for external monetary policy shock. $\mathrm{DOM}_{i,t}$ is a vector of domestic variables for country i at time t, including $\mathrm{EXR}_{i,t}$, the country real effective exchange rate, and $\mathrm{CPI}_{i,t}$, the inflation rate as well as $\mathrm{GDP}_{i,t}$, the growth rate of real GDP. $\mathrm{DPR}_{i,t}$ is the domestic interest rate of each country at time t.

We follow small open economy assumptions for the 27 advanced economies and 18 emerging market countries, and focus on responses in the domestic interest rate to US policy shocks in the block-exogenous variable, $\mathrm{USP}_{i,t}$.

As mentioned above, $\mathrm{D}_{i,t}$ is a 3×1 vector of interaction terms, with $\tilde{B}_{i,0}$ reflecting its direct effect on $\mathrm{Y}_{i,t}$. In particular, $\tilde{B}_{i,l}$ shows the influences of $\mathrm{D}_{i,t}$ on the varying relationship

between the endogenous variables in $Y_{i,t}$. In our case, $D_{i,t}$ includes three components:

$$D_{i,t} = [CAP_{i,t}, ERA_{i,t}, MPPI_{i,t}]', ^{1} \tag{4}$$

where $CAP_{i,t}$ is the index of capital flow restrictions derived from Fernandez et al. (2016)'s dataset, that higher values means a higher level of capital control, i.e. less capitall openness. $ERA_{i,t}$ is the exchange rate arrangement for country i at time t, based on the coarse classification by Ilzetski et al.(2017). $MPPI_{i,t}$ is the country-time-specific indicator of macroprudential policy index from the quarterly cumulative aggregate of macroprudential measures in Alam et al. (2019).

The data sources of $USP_{i,t}$, $DOM_{i,t}$ and $D_{i,t}$ for the benchmark estimation, along with their construction methodologies, are explained in detail in Appendix 2A.

To put the model into the context of our topic, we estimated with recursive contemporaneous effects, with the first variable being exogenous. Since we are only interested in the response of domestic interest rate to the exogenous shock, the ordering of the variables in $DOM_{i,t}$ does not matter for our analysis:

$$\begin{bmatrix} 1 & 0 \\ M_{0,it} & 1 \end{bmatrix} \begin{bmatrix} USP_{i,t} \\ DOM_{i,t} \end{bmatrix} =$$

$$\eta X_{it} + \sum_{l=1}^{L} \begin{bmatrix} m_{l,it}^{11} & 0 \\ m_{l,it}^{USP} & m_{l,it}^{DOM} \end{bmatrix} \begin{bmatrix} USP_{i,t-l} \\ DOM_{i,t-l} \end{bmatrix} + \xi_{it}, \tag{5}$$

where $M_{0,it}$ is a 6×6 lower triangular matrix with ones on the main diagonal, $m_{l,it}^{USP}$ is a 6×1 vector of coefficients on lagged values of $USP_{i,t-l}$, and $m_{l,it}^{DOM}$ is a 6×6 matrix of coefficients on lagged values of variables in $DOM_{i,t-l}$.

Let $\beta_{l,it}^{rc}$ be the typical element of $\tilde{\Gamma}_{i,l}$ with r representing rows and c that of columns, calling it structural beta parameters. Then we can decompose $\beta_{l,it}^{rc}$ into:

$$\beta_{l,it}^{rc} = \beta_{l,0}^{rc} + \beta_{l,1}^{rc} MPPI_{i,t} + \beta_{l,2}^{rc} CAP_{i,t} + \beta_{l,3}^{rc} ERA_{i,t} \tag{6}$$

for variables other than $USP_{i,t}$. Therefore, their responses to shocks in $USP_{i,t}$ will depend on the values of the interaction terms.

We estimated the benchmark panel VAR using ordinary least squares (OLS) with country fixed effects. Since we are only interested in identifying shocks to the block exogenous variable, our identification strategy in (4) can adequately facilitate estimation equation-by-equation with ordering of variables in $DOM_{i,t}$ indifferent and error terms uncorrelated.

[1] To account for the possibility that the initial condition of the interactions matter, such as the effect of prudential capital flow management measures (CFMs) before the shock, we did backstage check by interacting with $D_{i,t-1}$ instead. The resulted impulse responses of domestic policy rate are closely similar to the benchmark specification, and the estimates are available upon request.

To set $\text{USP}_{i,t}$ as the block exogenous variable, we restrict the dynamics of $\text{USP}_{i,t}$ to be only determined by its own lagged values and are independent of the variables in $\text{DOM}_{i,t}$ or the interaction terms. We also allow responses in $\text{DOM}_{i,t}$ towards their own lagged values and exogenous shocks in USP to vary based on the value of the interaction terms.

For the benchmark, we chose **2 lags** based on the AIC criterion. The horizon for cumulative impulse responses is 24 quarters after one standard deviation contractionary U.S. policy shock, or equivalently, an approximately 0.38% increase in the change of U.S. shadow rate. We computed cumulative impulse response functions evaluated at the 25% and 75% percentiles of the corresponding interaction terms, and constructed 85% level confidence intervals from 500 simulations of the bootstrapped impulse responses.

3.3 Estimation

Our goal is to assess whether country i's responses to U.S. monetary policy shocks vary depending on its exchange rate regime and capital account policy. Then, in addition, we evaluate whether levels of macroprudential policy tightness generate varied response to external policy shock, under different combinations of the former two country-specific conditions.

Specifically, we began by testing the validity of Mundellian trilemma versus the dilemma hypothesis as in Rey (2014), by evaluating the following four cases among different capital account policies and exchange rate regimes:

Table 1: **Cases of $\text{CAP}_{i,t}$ and $\text{ERA}_{i,t}$ Combinations**

	OPEN	**CLOSED**
FIXED	case 1	case 3
FLEXIBLE	case 2	case 4

First, we compare responses of domestic policy rate between cases 1 and 2 that, under open capital account, whether flexible exchange rate remain an effective absorber against US monetary policy shocks. We illustrate the validity of the trilemma hypothesis by differencing the cumulative impulse responses evaluated at peg and flexible regimes. That is, for each of the 500 bootstrapped simulations, we computed ΔIRF_t=$IRF_t^{Peg,Open}$-$IRF_t^{Float,Open}$ and construct the empirical distribution of ΔIRF_t.

Then, a graph is derived for the average ΔIRF_t at its respective horizons from the empirical distribution, as well as the 85% confidence intervals. [2]

[2]Specifically, we looked into the empirical distribution of ΔIRF_t and see which fraction lies above zero, thereby determine the statistical significance of floating's effect on policy autonomy. The 85% confidence interval is therefore the fraction between the 15th and 85th quantiles of the empirical density

Therefore, a **positive** ΔIRF_t supports the trilemma implication, i.e. domestic policy rate response is less sensitive to US policy movements under flexible exchange rate than pegged regimes. Otherwise, the trilemma hypothesis is weakened, where exchange rate flexibility no longer ensures monetary policy independence when capital flows are highly mobile. In other words, they respond to U.S. policy movements with greater magnitude ($\Delta IRF_t \leqslant 0$). In this case, restricting country capital accounts became potentially necessary for floaters to retain policy autonomy.

To test the validity of the dilemma hypothesis, we compare domestic monetary policy responses between cases 2 and 4 by computing ΔIRF_t=$IRF_t^{Float,Open}$- $IRF_t^{Float,Closed}$. This is to evaluate whether countries under flexible exchange rate gain greater autonomy over domestic monetary policy from restricted capital mobility. Therefore, a **positive** value supports the use of capital control suggested by the dilemma, where monetary policies are more independent when the capital flows are managed.

Next, we consider whether the use of macroprudential policies acts as a complementary shock absorber against US monetary policies for countries with open capital account and flexible exchange rates. For each of the four cases in Table 1, we computed ΔIRF_t=$IRF_t^{LooseMPPI}$-$IRF_t^{TightMPPI}$ for the 500 bootstrapped simulations. Similarly, we derive graphs for the average ΔIRF_t at its respective horizons from the empirical distribution of size 500, and report their 85% confidence intervals.

If a greater intensity of macroprudential measures can effectively release monetary policy makers from tightly following U.S. policy movements, then a positive ΔIRF_t is expected. We also test if ΔIRF_t may vary across difference capital and exchange rate regimes, to determine whether macroprudential measures is most effective under the combination of open capital account and flexible exchange rates, as advocated by the trilemma hypothesis to achieve highest policy autonomy.

Note that we evaluated smaller values of the interaction terms at their 25th percentile, and larger values of which at their 75th percentile. The values for the 25th/75th percentiles at which the interaction terms are evaluated for the IRF are listed below for the advanced economies and emerging market economies, respectively.

In Table 2, we listed the values of each interaction variable that fall at their 25th and 75th percentiles. We refer values of ERA at their 25th percentile as "peg" in relative sense, and the 75th percentile as relatively "flexible", or equivalently, "float". Similarly, we evaluate CAP at their 25th percentile as "open", and the 75th percentile as "closed". Also, we treat MPPI stance to be "loose" at its 25th percentile, and to be "tight" at its 75th percentile.

Using the methodology presented above, we proceed to showcase the estimated results on

for each ΔIRF_t between the impulse responses from the same draw.

Table 2: **Values of Benchmark Interaction Variables at their 25/75th percentiles**

	ADEs	**EMEs**
CAP 25th, open	0.025	0.35
CAP 75th, closed	0.175	0.7875
ERA 25th, relatively "peg"	1	2
ERA 75th, relatively "flexible"	3	3
MPPI 25th, loose	-2	0
MPPI 75th, tight	1	6

the validity of trilemma in section 4, and on the effectiveness of macroprudential policies in section 2.5.

4 Trilemma or Dilemma: Exchange Rate Flexibility, Capital Controls, and Policy Autonomy

In this section, we aim to assess if responses of domestic policy rate to US policy shocks differ significantly under various conditions of capital openness and exchange rate regime. We start by describing our results from testing hypotheses of the trilemma and the dilemma for advanced economies and emerging market economies sequentially. Then, we offer a brief discussion on our contribution to the trilemma-or-dilemma discourse on how to achieve monetary policy independence in the era of global financial integration, as well as whether concerns from the global financial cycle can be effectively addressed by capital controls.

4.1 Structure of Analysis

To begin with, we examine the validities of trilemma and dilemma hypothese on achieving monetary policy autonomy (especially for floating countries), with only $\text{ERA}_{i,t}$ and $\text{CAP}_{i,t}$ included as interactions. The focus is whether monetary policy under flexible exchange rate and capital mobility are better shielded against exogenous shocks of U.S. policy, relative other arrangements. If this is true, then the cumulative response of domestic policy rate under flexible exchange rate regime should be smallest under capital openness, compared to either those with pegged exchange rates, or other floaters with restricted capital accounts. In this sub-section, we introduce how we construct and present the resulted figures from the interacted PVAR estimation that reflect these considerations.

Accounting for their divergent economic characteristics, we estimate samples of key ad-

vanced and emerging economies separately, and the results are presented in Figures 2B.1 and 2B.2, respectively. The two figures illustrate the cumulative impulse responses of domestic policy rate to US policy tightening shock. The size of the shock is an on-impact increase of the US shadow rate by 0.38%. We standardize the shock so that the cumulative size of the shock is 1%. The top four panels in Figures 2B.1 and 2B.2 present the cumulative impulse responses across different combinations of exchange rate arrangement and capital openness, as explained by the four cases in Table 1. The vertical axis shows the values of cumulative impulse response in the unit of percentages, and the horizontal axis denotes forecast horizon in quarters.

The bottom graphs present two ΔIRF_ts, aiming at examining the validity of the trilemma and the dilemma policy implications. The left shows the difference of domestic monetary policy responses between peg and flexible under open capital accounts, so that a positive difference supports the trilemma hypothesis, as the cumulative domestic policy responses is smaller with exchange rate flexibility. The right shows the difference of domestic monetary policy responses between open and closed capital accounts under flexible exchange rates, so that a positive difference supports the dilemma hypothesis, as the total domestic policy responses is lower with capital account restrictions. The red lines shows the mean of the corresponding impulse responses and the mean differences, while dashed lines report their 85% confidence intervals.

In the upcoming sub-sections, we first describe the results for key advanced economies and for major emerging market economies accordingly. Next, we examine policy implications of these empirical patterns, and discuss the role of flexible exchange rate and capital controls in the time of financial globalisation, with reference to whether the policy trilemma has been reshaped into a dilemma by the global financial cycle.

4.2 Advanced Economies

To examine empirical validity of the Mundellian trilemma, two aspects need to be addressed. First, does flexible exchange rate arrangement itself strengthen independent monetary policy than what peg could accomplish? That is, could the central bank cater more to domestic economic condition as long as it forgoes the objective of exchange rate stability? For advanced economies, our benchmark results suggest an affirmative answer.

In the bottom left graph of Figure B.1, we find the cumulative responses under pegged arrangement is significantly higher than under flexible regimes for open capital accounts both on impact and during the subsequent forecasting horizons. Attention is needed, though, that the impulse response evaluation for peg includes only the Euro Area countries. As classified by Ilzetzki et al(2017), they belong to currency unions with no separate legal tender, thus sharing the same degree of exchange rate inflexibility as pre-announced or de facto peg. However, the Eurozone as a whole practices exchange rate flexibility.Therefore,

while participation in a common currency area implies a lower level of monetary policy independence for the individual country to some extent, it does not reflect that monetary policies of the European Central Bank is less independent.

To address the above concerns, in Figure B.3, we also computed the difference of domestic policy responses between crawling peg and managed float. On average, the cumulative gain in policy autonomy from flexible exchange rate is 0.1%, with the bottom line at 85% lower confidence bound being slightly above 0.05%. This suggests that, policy rates in advanced economies are less responsive, i.e. more independent, to US monetary policy tightening, as long as exchange rates are more flexible. Quantitatively, the absorbed sensitivity of exchange rate flexibility against US shocks is quite substantial, accounting for an average of 10% in the cumulative size of the tightening in US monetary policy.

The second aspect concerning trilemma's validity is that, given exchange rate flexibility, it is possible that the global financial cycle can transmit shocks through capital flows, and affect the conduct of home monetary policy beyond what flexible exchange rate can accommodate. This leads to the dilemma hypothesis, that capital controls are necessary for policy autonomy even with flexible exchange rates. We test the effectiveness of this policy proposal, and we find the role of capital control in boosting policy autonomy is not only limited, but can also be counter-productive.

In the bottom right graph of Figure 2B.1, there is only evidence in the 2nd to 3rd quarter after the shock that floaters under open capital account is more sensitive than under restricted capital accounts, with the lower bound of the 85% confidence interval just above zero. However, since the 5th quarter ahead, the overwhelming majority of areas in the 85% confidence interval lies below zero, suggesting that in fact policy autonomy is stronger for floater with less restricted capital accounts, showing little support for the policy proposal of the dilemma.

It is necessary to note, however, that for the group of advanced economies, the notion of "open" and "closed" capital account is a relative concept. The 75th percentile of the capital restriction index for this group is 0.175, and the 90th percentile is 0.325, both of which are below the 25th percentile for emerging economies (0.35). This suggests capital openness in advanced economies are uniformly higher than most emerging economies. Given the comparatively greater capital mobility, our results in Figure B.1. imply that a moderate level of capital flow restriction cannot substantially improve monetary policy independence under exchange rate flexibility, and may even cause opposite consequences.

To summarize the above patterns for advanced economies, our empirical assessment strongly endorses the trilemma hypothesis, that exchange rate flexibility remains an effective tool over other arrangements in favour of monetary policy autonomy, even for the periods under increasing influences of the global financial cycle. On the other hand, our empirical evidence also shows that a modest amount of capital control, under which capital mobility remains at a high level relative to other developing economies, cannot

strengthen policy autonomy, and may even intensify vulnerability to US shocks. Therefore, restriction on capital flows cannot cut off the transmission of US monetary policy to domestic policy actions, therefore is unable to address the underlying concerns behind the dilemma hypothesis.

In the next sub-section, we will focus on the experiences for emerging economies and re-visit the role of flexible exchange rate and capital control for this country group.

4.3 Emerging Economies

Before presenting the results, consideration is needed where emerging market economies demonstrate many distinct features from the group of advanced economies. First, for exchange rate arrangements, the 25th percentile, i.e. evaluation of relatively "peg" regimes, for emerging markets is pre-announced or de facto crawling peg, which is one category more flexible than the same percentile for advanced economies. This is reasonable, given fewer emerging economies in our sample participate in currency unions such as the Euro Area.

Second, as noted before, the 25th percentile of capital flow restriction index for emerging economies, i.e. evaluation of relatively open capital account, is higher than the 75th percentile for advanced economies. This shows capital mobility among emerging market countries is predominantly more restricted than most advanced economies, and we will later examine the role of capital control for this country group with consistently more restricted capital flows.

We now begin presenting the benchmark results for emerging market countries from Figure B.2. First, regarding the validity of the trilemma, the bottom left graph of Figure B.2. failed to provide a sharp contrast in policy autonomy between crawling peg and managed float.

However, the indifferent policy autonomy between the above two forms of exchange rate arrangement does not necessarily imply failure of the trilemma for emerging economies. in Figure B.4, we further compared domestic policy rate responses under other exchange rate regimes. The left pair of impulse responses, as well as their difference in below, presents the contrast between peg and managed float, which is the same value of interactions chosen for benchmark evaluation on the advanced economies. We see an average of about 0.7% gain of autonomy in total for emerging economies to a cumulative 1% US tightening shock. While the average is substantially greater than that for advanced economies with the same condition, the 85% lower confidence bound is also closer to zero, implying greater divergence within the developing country group. Thus, when progression towards exchange rate flexibility is sufficiently substantial, i.e. from hard peg to managed float, our empirical methodology also supports the trilemma hypothesis.

In addition, the right pair of impulse responses evaluates the difference in domestic policy responses between peg and crawling peg. With a tighter confidence band, we observe on average 0.6% absorption against US policy tightening by crawling peg, compared to hard peg, with the bottom line being 0.2%. We also note that, though domestic policy actions demonstrate no significant difference between crawling peg and managed floating, emerging economies benefit essentially from forgoing a highly fixed regime and allowing for flexibility, which is also the focus of the trilemma hypothesis. Then, a crawling band either below or above 2%, as adopted by the classification of Ilzetzki et al(2017), may not matter as much.

Next, we assess whether capital controls is helpful for emerging markets under flexible exchange rate to strengthen independent conduct of their monetary policy. In fact, results from the benchmark estimation point to the contrary. The right bottom graph of Figure B.2. shows that flexible emerging economies with more open capital accounts are on average 0.5% less responsive to US tightening shocks, compared to those with intensive capital controls. This implies the implementation of stricter capital control, given that tighter restrictions comparative to developed economies are already in place, can be counter-productive in terms of monetary policy autonomy for emerging economies with flexible exchange rates.

This pattern is similar to that among advanced economies, but with greater magnitude and higher statistical significance.

As a brief conclusion, in this section flexible exchange rate is found to significantly limit co-movements of domestic policy rate with US monetary tightening shocks for the group of emerging market economies, which is consistent with the findings for key advanced economies. This offers support for the validity of the trilemma hypothesis in the recent decade, when key developing economies are increasingly exposed to global credit cycles driven by core country shocks. On the other hand, we also provide evidence that capital controls are unable provide extra absorption against US policy shocks as implied by the dilemma, and can be even counter-productive when the capital mobility of many emerging market countries is already highly restricted.

4.4 Discussion

Estimated results from the previous two sections convey two policy messages, that exchange rate flexibility, implied by the Mundellian trilemma, remains capable for countries under capital mobility to independently conduct monetary policy and absorb policy shocks from the US. However, the use of capital control, suggested by the dilemma notion, cannot improve monetary autonomy for countries under flexible regimes, and may even increase policy vulnerability to US policy movements when capital mobility is already limited.

4.4.1 Country Group Heterogeneity and Alternative Categorization

These general patterns hold both for the groups of advanced and emerging market economies, but with some differences given their divergent economic features. For the role of exchange rate arrangement, its positive effect on policy autonomy of advanced economies increases with the degree of exchange rate flexibility nearly consistently. Figure B.3 shows the mean decrease in domestic policy response for managed float against crawling peg, and that for crawling peg against peg, are both around 0.1%, which sums up to the 0.2% gain in Figure B.1.

However, for emerging markets (Figure B.4), the effectiveness of exchange rate flexibility is concentrated mainly on abandoning the fixed peg regime. Them, the choice of crawling peg or managed floating makes no consequential difference as long as exchange rate flexibility is allowed.

Our benchmark results relies on the latest country classification that treated Czech Republic, Latvia, and Slovenia as advanced economies. We similarly tested the robustness of our results with alternative classification that categorize these three countries as emerging market economies in Figure C.1. of Appendix C.

With considerable similarity to the baseline results, we find advanced economies are 0.05% less sensitive to 1% US tightening shocks as a managed floater, compared to crawling peg regimes. The gain for emerging market economies is considerably higher, with more than 0.5% monetary control by forgoing fixed exchange rate for crawling peg regimes. These results suggest that our benchmark estimation is robust to alternative grouping between advanced and emerging market economies.

4.4.2 Partial and Targeted Capital Controls

Regarding the role of capital control, we find the average level of capital openness matter. For advanced economies whose capital mobility is consistently high, empirical evidence in general points to no substantial benefit from better monetary policy autonomy. However, for emerging economies whose capital openness is on average worse, a higher level of capital flow restriction significantly intensify domestic monetary policy vulnerability to US tightening shocks, weakening the grounds of the dilemma hypothesis.

As a back-stage robustness check, we make use of the disaggregate indices from Fernandez et al. (2016) to examine whether partial or targeted capital controls can enhance policy autonomy beyond what the general capital restriction can capture.

First, we interacted the model instead with inflow and outflow restrictions to investigate the effectiveness of partial capital control, and the ΔIRF_ts are reported in Figure C.2

of Appendix C. However, the indifferent, or even negative, effect of one-sided capital controls on policy autonomy is largely similar to our baseline results. For emerging market economies in particular, we find restrictions targeted on capital inflow can aggravate the vulnerability of domestic interest rate to be affected by US policy shocks, while little difference is made by those on capital outflow.

Second, in Figure C.3 of Appendix C, we focus on targeted capital flow restrictions on equity and bond, two types of portfolio flows that are found most volatile and sensitive to global shocks among emerging market economies (Pagliari and Hannan, 2017). Monetary policy responses with greater intensity in both type of restrictions tend to be less autonomous facing US tightening shocks.

Cutting off portfolio flows, despite its volatility, may not necessarily imply an insulation from the global financial cycle. While capital mobility might enable global shocks to transmit into domestic financial market, where exchange rate movements may amplify the impacts, cross-border holding of assets and liabilities also promotes international risk sharing and better hedging strategies for portfolio investments. Thus, capital flow restrictions, whether general or targeted, may not address the underlying driver of domestic and global financial co-movement that propels domestic monetary policy to shadow that of the core country.

4.4.3 Why Capital Controls May Not Help

Our estimation results so far suggest that capital controls, by disconnecting flows driven by the global financial cycle, have failed to further shield countries under exchange rate flexibility from propagation of US policy shocks. One possible explanation is that capital controls may hinder the necessary external adjustment brought upon by exchange rate fluctuations.

For example, depreciation of the exchange rate *ceteris paribus* could improve the current account balance and increase national saving. Absent capital control, domestic investors could diversify part of the investment abroad, and international risk-sharing can limit portfolio exposure to country-specific risks that could be magnified by global financial shocks. Similarly, appreciation of the domestic currency and current account deficits necessitate capital inflows to finance domestic investment, so that from our estimation, inflow restrictions by emerging markets can further pressure domestic monetary policy into expansion following lower world interest rates.

Nonetheless, the ineffectiveness of capital account management towards monetary policy autonomy does not necessarily imply the underlying concerns behind the dilemma hypothesis, such as the intensification of US monetary policy spillover through global financial linages into domestic policy decisions, is unwarranted. It is possible that US

policy spillovers will invariably affect monetary policy of the other countries through capital flows, unless capital mobility is completely restricted without any leakage. Klein& Shambaugh(2013) have similarly shown that partial capital controls cannot enable greater monetary autonomy unless they are very extensive.

Yet even if capital flows is completely shut down, spillovers of US monetary tightening can also transmit along the global value chain to its trading partners through shrinking import demand. It is therefore likely that capital flow restrictions *per se* cannot fully address the fundamental vulnerabilities in the domestic financial market, such as unconstrained credit and leverage growth, as well as mismatched exposure to dollar funding, that intensify sensitivity to global financial conditions even with the absence of foreign investors. This calls for other policy remedies to deal with what the dilemma aims to solve. We will investigate one of the possible options, the use of macroprudential policy, in the next section.

4.5 Summary

Our results so far have highlighted several new aspects regarding policy implications for the trilemma. First, a greater level of exchange rate flexibility is still an effective buffer against contamination of US shocks on the domestic monetary policy, even with the presence of the global financial cycle, and the effectiveness is greater for emerging market economies.

Second, our empirical evidence also supports the use of crawling, or soft, peg, against fixed peg, for emerging market economies to mitigate the influence of US policy action on domestic interest rate decisions. It may also be a sufficient choice of regime for this country group, that more flexible regimes like managed floating and wider moving bands do not provide consequentially greater policy autonomy.

Third, restricting international capital flows is shown as unnecessary, if not counterproductive, for countries to maintain independent monetary policy against US policy spillovers, when exchange rate flexibility is already exercised.

5 Can Macroprudential Policies Defend Monetary Policy Autonomy?

Another tool to further enhance country monetary policy autonomy is the use of domestic macroprudential policy, which is also considered by Obstfeld(2015) and Rey (2014 and 2015), as an alternative measure to smooth domestic financial cycle amid large swings of

international capital flows. In this section, we proceed to assess if this notion is empirically supported. Specifically, we evaluate domestic policy responses between loose and tight macroprudential stance, and assess whether countries with capital mobility and flexible exchange rate can gain extra policy autonomy from macroprudential tightening.

5.1 Structure of Analysis

This sections examines whether a tighter macroprudential standing can further allow country monetary policy to focus on domestic economic conditions. If this is true, the cumulative policy rate responses under tighter macroprudential conditions should be less, and we expect a positive difference in policy responses between loose and tight macroprudential stances.

Again, we estimate samples of key advanced and emerging economies separately, and the results are presented in Figures B.5 and B.6, respectively. The top four paired panels present the cumulative impulse responses for loose and tight macroprudential policies across different combinations of exchange rate arrangement and capital openness, as explained by the four cases in Table 1. The vertical axis shows the values of cumulative impulse response in the unit of percentages, and the horizontal axis denotes forecast horizon in quarters. The bottom graphs present the ΔIRF_ts between loose and tight macroprudential policies. The red lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

For the upcoming sub-sections, we separate our analysis by advanced and emerging economies, with comparisons of their results alongside. In the end, we will conclude this section with a brief policy discussion.

5.2 Macroprudential Policy and Advanced Economies

From Figure B.5, we find strong evidence that policy autonomy among advanced economies is significantly enhanced across all combinations of exchange rate and capital account regimes. The reduction in domestic policy response under tighter macroprudential condition is on average 0.1%, accounting for 10% of the cumulative size of the shock.

Focusing on the case of capital openness and flexible exchange rate (case 2), we also find the mean decrease in domestic monetary sensitivity is more than 0.1%, with the lower 85% confidence bound being about 0.06%. On the other hand, with restricted capital account and exchange rate flexibility, the average decrease is slightly below 0.1%, with the lower bound being 0.05%. Therefore, not only can tighter macroprudential policy further strengthen monetary autonomy against US policy spillovers, its effect is more

potent under better capital mobility.

There are several channels through which macroprudential measures could absorb external policy shocks in favour of more independent monetary policy for advanced economies with developed domestic banking system and deeper integration into the global financial market.

First, tools like limits on bank leverage, loan restrictions and loan-to-deposit ratios target on the quantity, rather than the cost, of credit. Thus, they can directly intervene domestic credit cycle synchronization with global financial market dynamics, which enables monetary policy to focus more on price stability and output growth, rather than the disturbances from credit cycle dynamics.

Second, measures such as requirement on countercyclical capital buffer, liquidity and funding risk measures, as well as risk mitigation for systemically important financial institutions, tackle areas in the banking system where systematic risks are accumulated. In the time of a US interest rate hike, where country's external borrowing constraint is tightened, these prudential measures can achieve the goal of domestic financial stabilization by removing the most vulnerable threats, and ease the need for monetary policy accommodation.

Third, many prudential tools are applied specifically to the household or the corporate sector, such as bank capital requirement and loan loss provision requirement. Other measures aim at limiting excessive credit growth in certain foreign currency, such as limits on foreign currency lending and reserve requirements. These tools allow for flexibility in credit cycle smoothing, and can tailor to currency-and-sector-specific traits beyond what interest policies can address.

For robustness, we also replace the general index with selected single macroprudential tools and examine country's gain of policy autonomy from a tightening in the specific measure, for open advanced economies with flexible exchange rate. Figure C.4 of Appendix C shows that loan restrictions are most effective, reducing policy rate sensitivity as much as 0.3%. While the effectiveness of loan-to-value ratio and capital requirement are slightly above the general case in Figure B.5, limits on foreign-currency lending is shown to be only marginally effective, with the lower bound just above zero. A detailed look into the macroprudential tools testify that policies aimed at limiting leverage and risky credit can significantly enhance the resilience of domestic monetary policy with floating exchange rate against the transmission of US policy shocks.

5.3 Macroprudential Policy and Emerging Economies

While macroprudential policy is found strongly effective for the group of advanced economies, Figure B.6 shows no substantial difference between loose and tight macroprudential stances for the group of emerging market economies across all the four cases. This evidence points out that macroprudential tools cannot further bolster monetary policy autonomy for emerging market countries.

The contrast is quite striking, though, given the fact that the average macroprudential measures in place for emerging economies in our sample is 4, tighter than the number for advanced economies that is only 0.12. Moreover, the gap between the 25th and 75th percentiles of MPPI for emerging markets is 6 measures, while that for the advanced economies is only 3. The insignificant effect of macroprudential measures on emerging market policy autonomy is relatively convincing, given that a macroprudential tightening with more cumulative measures still demonstrates no significant effectiveness.

The ineffectiveness of macroprudential policy to enhance interest rate policy independence can be attributable to the financial market characteristics concerning emerging market economies.

First, non-bank lenders have been operating beyond the radar of macroprudential regulations, and have grown to be a major source of credit for many emerging market borrowers since the Great Financial Crisis (Hardy, 2019). The effectiveness of macroprudential tightening in the banking sector may be partially offset by the stronger expansion of non-bank lending. Balance sheet vulnerability of the non-bank institutions, mainly driven by leverage exposure risk and liquidity mismatch, is increasingly an elevated concern for financial stability among key emerging market economies (IMF GFSR, October 2019). In this situation, interest rate policy, by influencing the cost of financing, is more straightforward in curbing excessive credit growth in the non-bank sectors.

Second, the high share of lending by foreign banks[3] deepens the link between emerging market economies and the global financial cycle. A US rate hike tightens the external financing constraint for emerging economies, and reliance on foreign credit exacerbates exposure to contractionary balance sheet effects. However, in our sample of emerging market economies, only four countries have ever applied limits on foreign currency lending[4] according to Alam et al.(2019), and there is no record for specific regulations on domestic operation by foreign banks. The insufficiency of macroprudential measure targeted at foreign lending may have accounted for our finding that an on-average tighter macroprudential standing in emerging economies is still unable to ease domestic interest

[3]The share of reliance on foreign bank credit is on average 15%-20% in total credit, according to Hardy (2019) as of the second quarter of 2018.

[4]These 4 countries are: Hungary (between 2010 and 2011), Poland (since 2006), Romania (since 2005), and Turkey (since 2009).

rate policy from responding to US policy shocks.

Empirical patterns of advance economies have exemplified the effectiveness of macroprudential measures toward strengthening policy autonomy through flexible exchange rates as implied by the trilemma hypothesis. While we lack evidence for emerging economies, the distinct feature of their credit structure indicate spaces for further improvement, and we will return to this topic in the next sub-section.

5.4 Policy Discussion

The above presentation of our empirical analysis shows that a tighter macroprudential standing could further enhance monetary policy autonomy especially under capital mobility and exchange rate flexibility.

This evidence is most prominent among the group of the advanced economies, suggesting the independent conduct of monetary policy against external policy shocks can be fostered by a more stabilized financial market and banking system. This can be realized through the build-up of capital buffer, counter-cyclical adjustments on credit growth, limiting risks in loan provision, and targeted prudential measures on specific sectors and currencies, etc. Therefore, application of macroprudential regulations help to sharpen the trilemma policy implications faced by central banks in advanced economies, so that flexible exchange rate remain one of the optimal choices towards independent interest rate policy in an open economy.

On the other hand, the effectiveness of macroprudential tools is barely significant for emerging market economies. However, so long as exchange rate flexibility can effectively lower domestic interest rate sensitivity to spillovers of US policy shocks, our results point to possible areas of improvement for emerging economies to obtain better policy autonomy. For example, as discussed above, emerging market economies could expand their macroprudential tool-kit to encompass domestic and foreign non-bank financial institutions. Moreover, regulations targeted at lending by foreign bank, and in particular those aimed at foreign currency lending, should be further reinforced, in order to avoid transmissions of external policy spillovers through the valuation channel.

5.4.1 Fed Shock or Global Shock?

One caveat to the robustness of our empirical presentation so far is whether measuring US monetary policy shock as the change in shadow federal funds rate is sufficiently accurate. What if the co-movements in policy rate are induced by a common external shock that also drives the shadow rate to change?

The bottom line of the analysis so far is that the significantly differing impulse responses suggest that flexible exchange rate and macroprudential policy are capable of steering a non-US country's independent monetary conduct away from global disturbances towards domestic fundamentals. While the shadow rate measure might be "contamintated" by globally common factors, central banks under floating and stronger macroprudence are capable of responding less to this shock, which can nonetheless be viewed as policy autonomy regarding the global financial cycle.

On the other hand, it is also possible that the responses of non-US policy rate to global shocks in the shadow rate measure may have already internalized expectations on the action and impact of US monetary policy moves. This implies that expectations on potential Fed policy moves can also impair independent policy-making of other central banks. In order to examine all these possibilities, we replaced the shadow rate measure with a "cleaner" shock series of US monetary policy by Bu, Rogers & Wu (2019), in order to disentangle whether country monetary autonomy face any fundamentally different treatments of policy between Fed shocks and global shocks, and results are presented in Appendix D.

The left graph of Figure D.1 shows that flexibility of exchange rate still allows advanced economies to move their own policy rate less in response to a "pure" US monetary policy shock. However, the usefulness of macroprudential policy (right graph of Figure 2D.1) is significant only when a country also removes nearly all of its capital restrictions. Since most developed countries have maintained a high level of capital openness, this piece of evidence suggests that macroprudential regulation could be especially useful when there is little capital controls.

For emerging market economies, Figure D.2 highlights the importance of macroprudential tools towards monetary autonomy. On the one hand, tighter macroprudential stance alone can insulate emerging markets from closely co-moving with Fed actions when either the central bank operates under flexible exchange rate and capital openess, or under soft-peg with capital controls. On the other hand, when the nature of the US policy shock is purely driven by Fed's surprises, flexible exchange rate needs tighter macroprudential regulations in order to effectively lower the sensitivity of emerging market policy rates, which has not been discovered under the shadow rate measure.

Excluding endogeneous global factors from US policy moves, the roles of flexible exchange rate and macroprudential policy remain crucial to monetary autonommny of the non-US countries. What is special is when and how these tools can be useful. For advanced economies, flexible exchange rate is key, while macroprudential regulations are not as useful when dealing with Fed shocks that are of unexpected nature. For emerging market economies, however, macroprudential tools are very potent to address the exogeneous and unanticipated monetary shocks from the US, while flexible exchange rate is a general shock absorber to both global shocks and US policy influences. In terms of the dilemma, Figure D.3 also shows that capital controls are found to be counterproductive facing pure

Fed policy shocks, which is consistent with our benchmark results.

In short, empirical exercises of this paper substantiated the policy trilemma, where exchange rate flexibility remain key to monetary policy autonomy in an open economy with international capital flows and co-movement with global financial dynamics. While our findings suggest that capital controls, implied by the dilemma, are unnecessary for floaters to defend monetary independence from external policy spillovers, macroprudential policies are found to be a promising remedy instead, which is the case for advanced economies, to achieve better monetary policy independence through domestic financial stability. For emerging market economies, there is also potential for macroprudential tools, given that non-bank and foreign credit providers are also taken into consideration.

6 Conclusion

In this paper, we evaluated possible solutions to the global financial cycle underlying the trilemma-dilemma discussion on policy autonomy among key advanced and emerging economies. We assessed the role of flexible exchange rate, capital controls and macroprudential policies in a panel vector autoregression framework, in the post-1999 era of escalating financial globalization and the international spillovers from the aftermath of U.S. monetary policy shocks. As a result, we show that flexible exchange rate, accompanied by application macroprudential regulations, is key to domestic monetary policy autonomy amid the global financial cycle.

Specifically, our empirical evidence endorses the coherence of the trilemma policy proposals even in the time of financial globalization, that under exchange rate flexibility, domestic monetary policy remains less sensitive to U.S. monetary shocks, especially for emerging market economies. However, capital controls, as advocated by the dilemma, is not found necessary for countries with flexible exchange rate to conduct more independent monetary policy, and can even be counter-productive among emerging markets. For advanced economies, macroprudential policies are effective boosters to monetary sovereignty. While the effect has not been significant for emerging market economies so far, the prevalence of non-bank credit and foreign bank operations point to potential areas of improvement for these countries to achieve better financial resilience and monetary policy independence.

Nevertheless, there could be more reasons behind the under-performance of macroprudential regulation in reducing emerging market policy sensitivity to US shocks. This opens an avenue for prospective future studies. One could further examine if any specific macroprudential tools, or those not covered by aggregate index adopted by this paper, may be particularly effective among emerging markets to strengthen domestic policy autonomy. One could also focus on country-specific vulnerabilities to US policy spillovers that are not captured by their macroprudential regulation in place, such as credits from the non-bank

institutions, such as shadow banking.

Moreover, while prudential policies are effective for advanced economies, they could be beggar-thy-neighbour. Macroprudential tightening in one country may transfer risks abroad, thereby weakening the global financial stability. Mitigation of potential spillovers from the policy reaction of affected countries thus awaits a deeper look. In order to minimize the observed international transmission of core country policy action, it would be optimal for central banks to cooperate *ex ante*, and the potential areas compatible for policy cooperation is another arena for future studies to investigate.

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Appendix A. Country Coverage and Data Source

In this data appendix, we will explain the data applied for our empirical analysis in the following three steps. First, we introduce the quarterly periods and the list of countries to be studied. Second, we present in detail data sources for each country and every explanatory variable (those in $Y_{i,t}$). Lastly, we describe the dataset used for each interaction terms (those in $D_{i,t}$), and the respective values corresponding to the 25th and 75th percentiles of each variable.

Appendix A.1. Sample Period and List of Countries

We have covered a total of 45 key advanced and emerging economies between 1999:Q1 and 2016: Q4. The countries are categorized as follows and estimation is separated for these two country groups.

Advanced Economies (27 in total): Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, South Korea, Latvia, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovenia, Spain, Sweden, Switzerland, United Kingdom.

Emerging Markets (18 in total): Brazil, Bulgaria, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Romania, Saudi Arabia, South Africa, Thailand, Turkey.

Appendix A.2. Data for Explanatory Variables

The data sources to construct the explanatory variables are briefly described as follows.

$\mathbf{USP}_{i,t}$: Change in end-of quarter value from the monthly Wu-Xia shadow rate for U.S. that accounts for the zero-lower-bound episode with negative values of Federal Funds Rate.

$\mathbf{EXR}_{i,t}$: Quarterly change in the measure of real effective exchange rate by Darvas(2012a,b).

$\mathbf{CPI}_{i,t}$: Percentage change of quarterly consumer price index is from IMF's IFS database.

$\mathbf{GDP}_{i,t}$: Quaterly real GDP growth from IMF's IFS. We mainly used the not seasonally-adjusted series, except for Canada, South Africa, and Mexico, where only seasonally adjusted data is available.

DPR$_{i,t}$: Quaterly changes of country monetary policy rate. Most data series are in monthly frequency, and we use end-of-quarter values (March, June, September, December) to construct quarterly series. We mainly use policy rate as percent per annum from IMF's IFS quarterly series. For countries with missing this data, we replace them with other monetary-policy-related interest rates. For Bulgaria we used 3-month rate from Eurostat. For Poland we used central bank refinancing rate. For Spain we used money market rate. For France and the Netherlands we used the deposit rate. We also used Eurostat's *irt h mr3 m* series for Austria, Belgium, Finland, Greece, Ireland, Italy, Latvia, Cyprus, Estonia, Lithuania, Portugal, Slovak, and Slovenia, which is their historical 3-month rates. For Euro Area countries and the U.K. during the binding zero lower bound period, we similarly used the Wu-Xia shadow rate.

Appendix A.3. Data for Interaction Terms

Our dataset choice and construction method for the benchmark interaction variables included in the PVAR are illustrated below.

CAP$_{i,t}$: Fernandez et al. (2016)'s novel measure (the "FKRSU" Measure) of capital control restrictions.[5] We use the variable "ka" for benchmark estimation, which is a continuous variable with range [0,1] as the overall restrictions index encompassing all asset categories and both capital flow directions. The higher the value, the more restricted the capital account, and thus lower capital openness. The original series is in annual frequency, so for each we extend it into a quarterly series.

ERA$_{i,t}$: Ilzetski et al. (2017)'s coarse classification of exchange rate regimes. The original series is in monthly frequency, and we use end-of-quarter values (March, June, September, December) to construct the quarterly series. Exchange rate arrangements and their classified values are listed from fixed to flexible as follows; 1 - no separate legal tender, pre-announced / de facto peg; 2 - pre-announced / de facto crawling peg, or crawling band narrower than or equal to +/-2%; 3 - crawling / moving band, managed floating; 4 - freely floating; and 5 - freely falling.

MPPI$_{i,t}$: IMF 's iMaPP database by Alam et al (2019). We consider all of the 17 instruments[6] by computing cumulative values of the variable "SUM 17". As MPPI$_{i,t} \rightarrow$

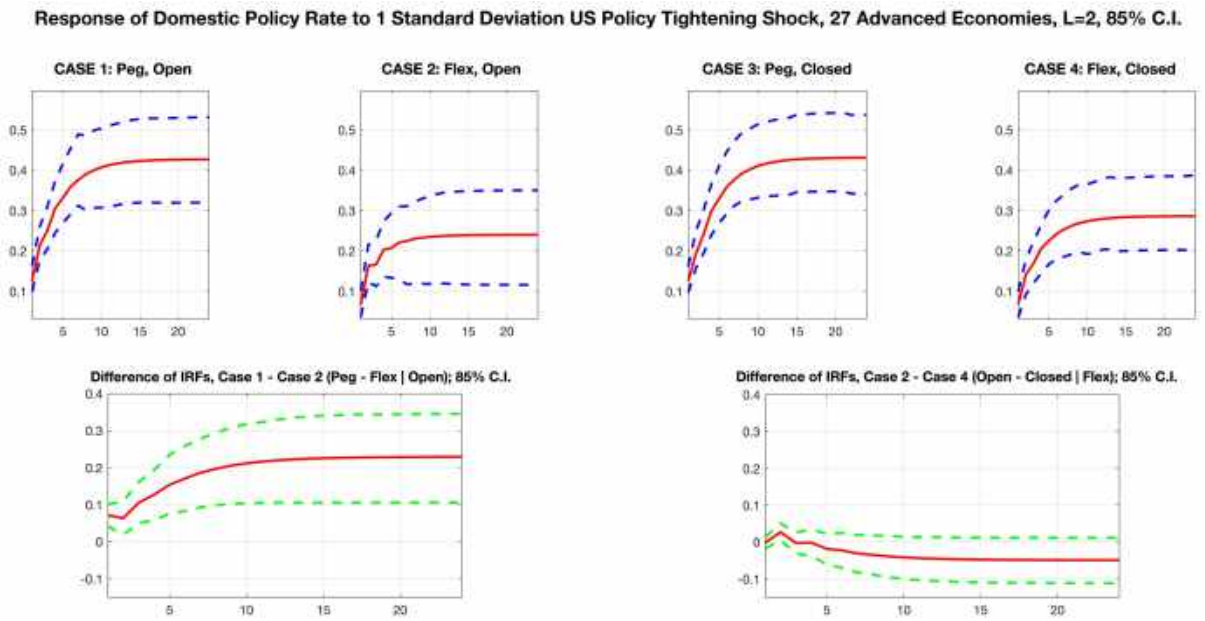
[5]The asset categories considered for both cross-border inflow and outflow restrictions are: equity, bond, money market instruments, collective investments, derivatives, commercial credits, financial credits, direct investments, real estate flows, guarantees, sureties and financial backup facilities.

[6]The 17 macroprudential instruments are: counter-cyclical capital buffer; capital conservation buffer; capital requirements; limit on bank leverage; loan loss provision requirements; limit on aggregate credit; loan restrictions; limits on foreign currency lending; limits on loan-to-value ratios; limits to the debt-service-to-income ratio and the loan-to-income ratio; tax on specified transactions; liquidity risk measures; limits on loan-to-deposit ratios; limits on net or gross open foreign exchange positions; reserve requirements; measures taken to mitigate risks from global and domestic systemically important financial

max, the macroprudential stance becomes tighter. The original series is in monthly frequency, and we use end-of-quarter values (March, June, September, December) to construct the quarterly series.

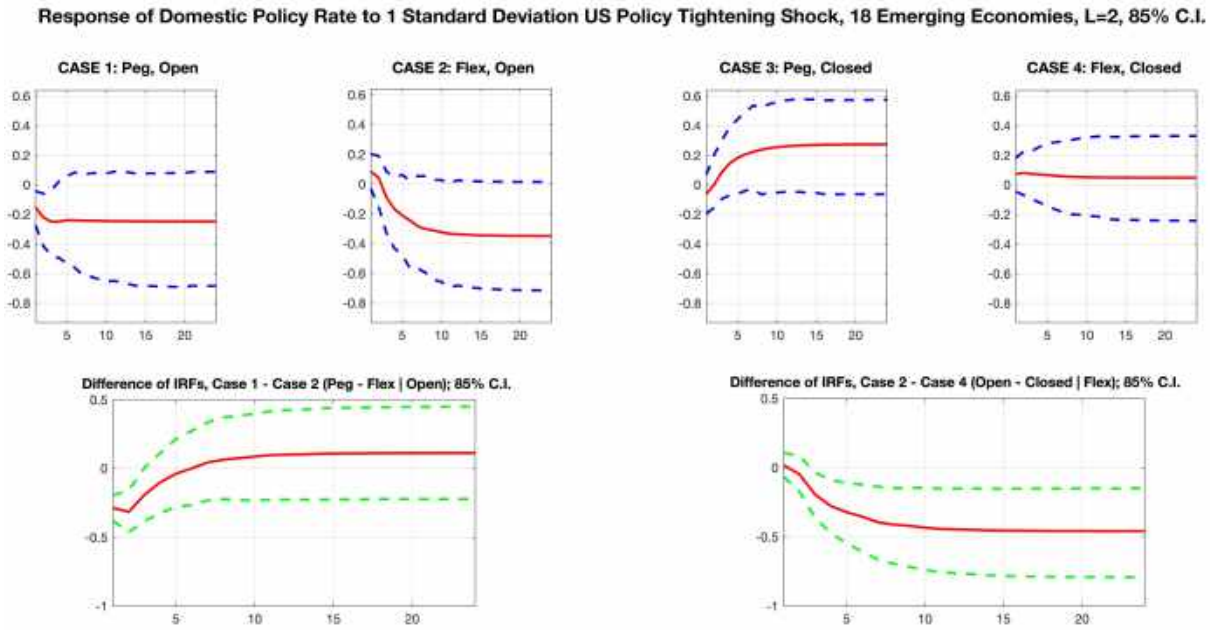
institutions (SIFIs); and other measures.

Appendix 2B. Figures of Key Results



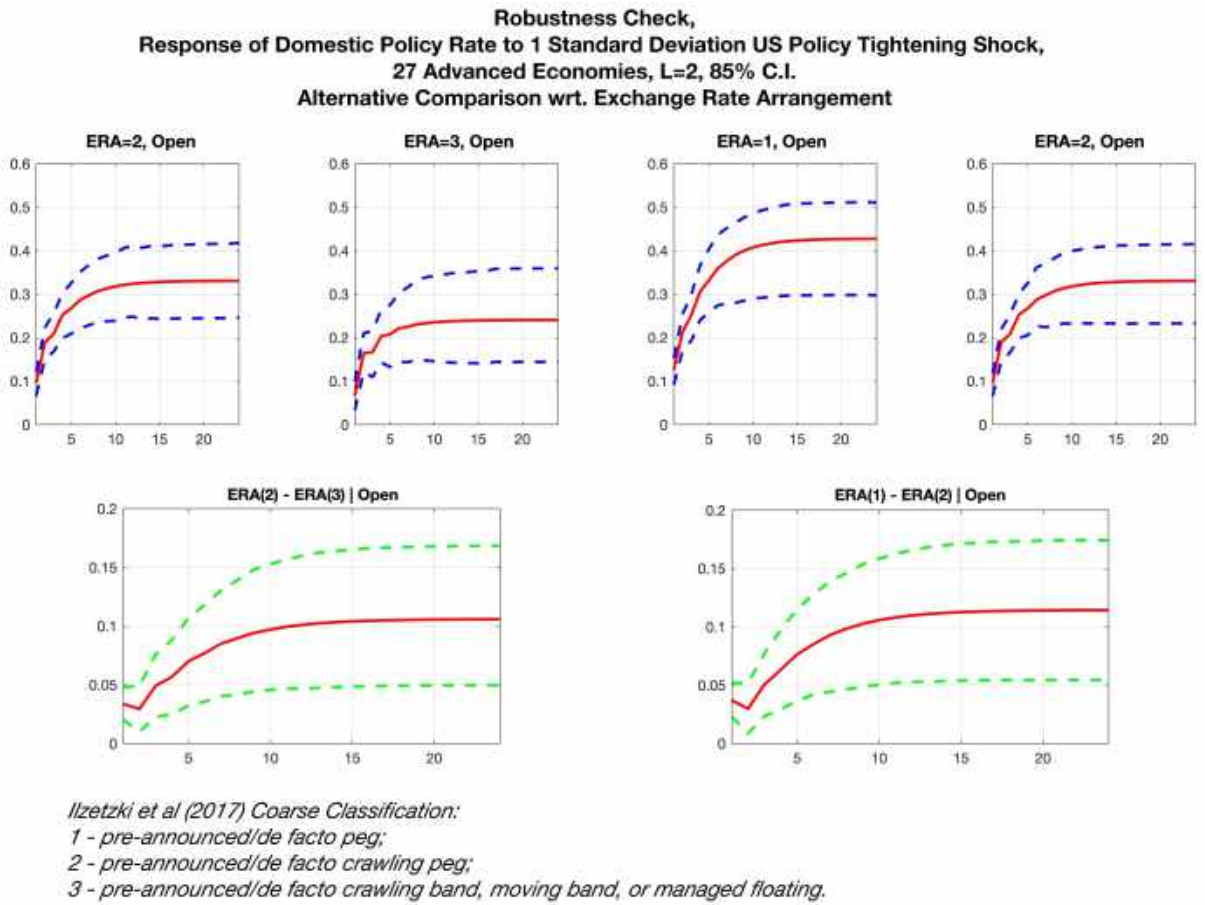
The above graph shows the impulse responses of domestic policy rate to one standard deviation increase in U.S. shadow rate, as well as their differences. The top four panels present the cumulative impulse responses across different combinations of exchange rate arrangement and capital openness, as explained by the four cases in Table 1. The vertical axis shows the values of cumulative impulse response in the unit of percentages, and the horizontal axis denotes forecast horizon in quarters. The bottom graphs present two ΔIRF_ts. The left shows the difference of domestic monetary policy responses between peg and flexible under open capital accounts, so that a positive difference supports the trilemma hypothesis. The right shows the difference of domestic monetary policy responses between open and closed capital accounts under flexible exchange rates, so that a positive difference supports the dilemma hypothesis. The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

Figure B.1. Trilemma vs. Dilemma: Advanced Economies



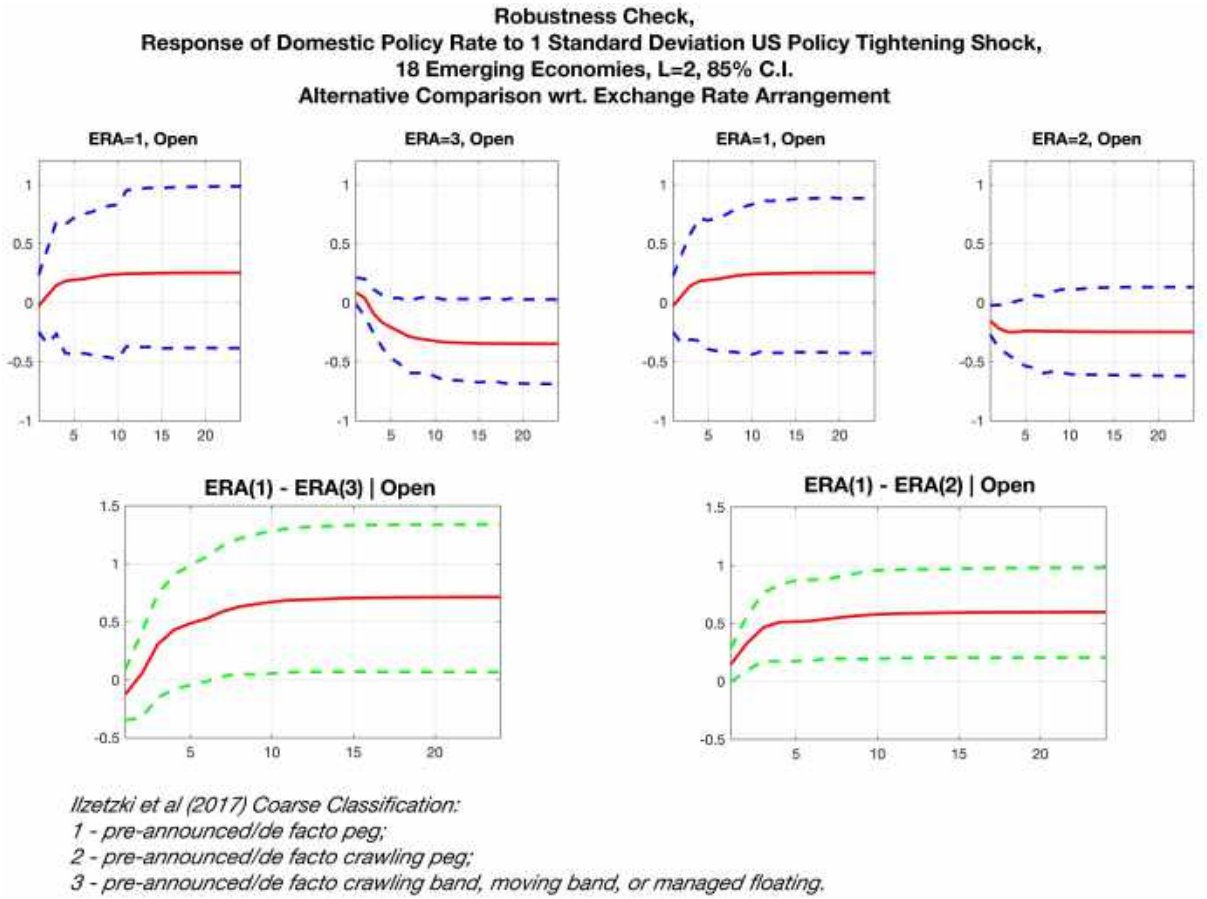
The above graph shows the impulse responses of domestic policy rate to one standard deviation increase in U.S. shadow rate, as well as their differences. The top four panels present the cumulative impulse responses across different combinations of exchange rate arrangement and capital openness, as explained by the four cases in Table 1. The vertical axis shows the values of cumulative impulse response in the unit of percentages, and the horizontal axis denotes forecast horizon in quarters. The bottom graphs present two ΔIRF_ts. The left shows the difference of domestic monetary policy responses between peg and flexible under open capital accounts, so that a positive difference supports the trilemma hypothesis. The right shows the difference of domestic monetary policy responses between open and closed capital accounts under flexible exchange rates, so that a positive difference supports the dilemma hypothesis. The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

Figure B.2. Trilemma vs. Dilemma: Emerging Economies



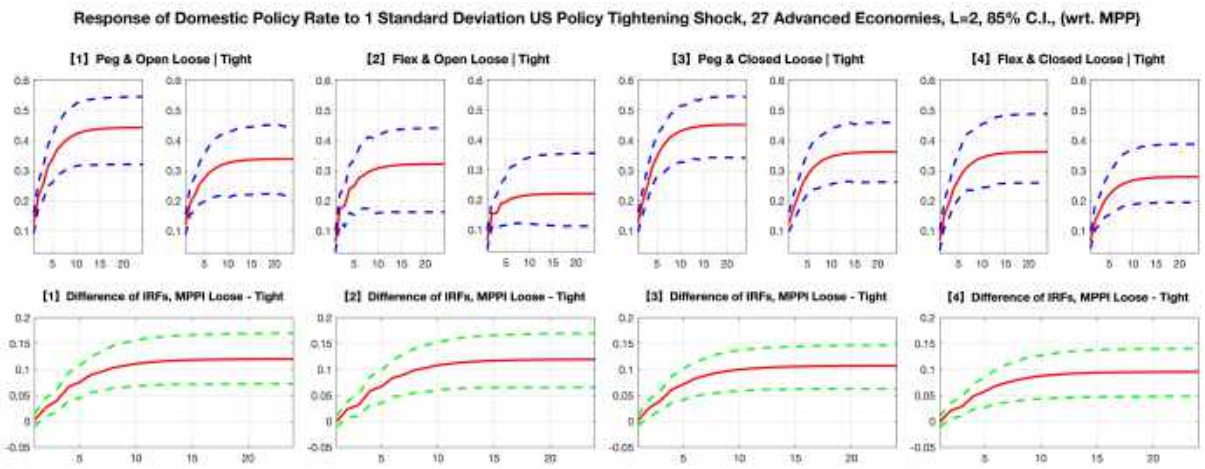
The above graph shows the impulse responses of domestic policy rate to one standard deviation increase in U.S. shadow rate, as well as their differences. The top two pairs of panels present the cumulative impulse responses between crawling peg and moving band / managed float, as well as between peg and crawling peg, respectively. The vertical axis shows the values of cumulative impulse response in the unit of percentages, and the horizontal axis denotes forecast horizon in quarters. The bottom graphs present their respective differences (ΔIRF_ts). The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

Figure B.3. Trilemma vs. Dilemma: Alternative Comparison of Exchange Rate Regimes for Advanced Economies



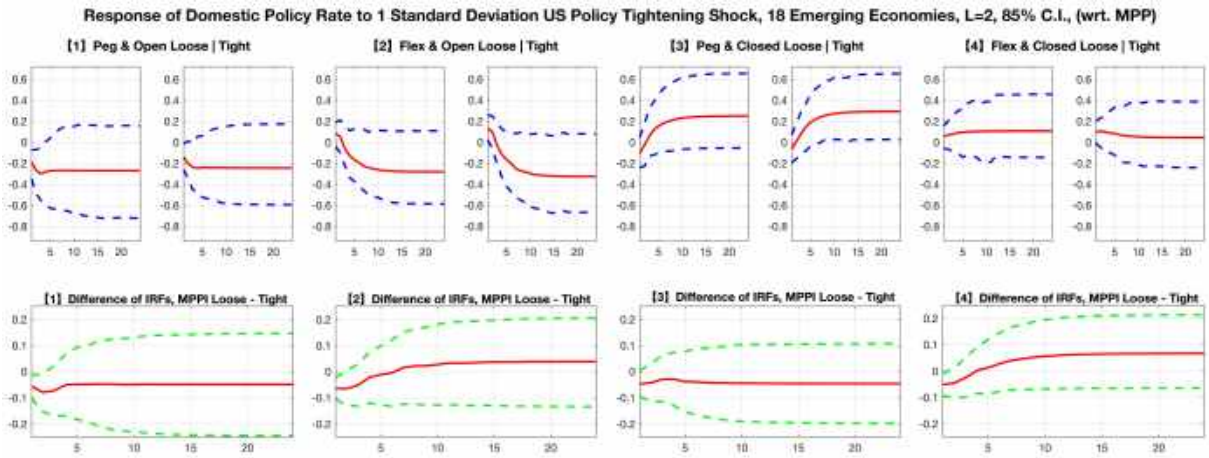
The above graph shows the impulse responses of domestic policy rate to one standard deviation increase in U.S. shadow rate, as well as their differences. The top two pairs of panels present the cumulative impulse responses between peg and moving band / managed float, as well as between peg and crawling peg, respectively. The vertical axis shows the values of cumulative impulse response in the unit of percentages, and the horizontal axis denotes forecast horizon in quarters. The bottom graphs present their respective differences (ΔIRF_ts). The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

Figure B.4. Trilemma vs. Dilemma: Alternative Comparison of Exchange Rate Regimes for Emerging Economies



The above graph shows the impulse responses of domestic policy rate to one standard deviation increase in U.S. shadow rate, as well as their differences. The top four paired panels present the cumulative impulse responses for loose and tight macroprudential policies across different combinations of exchange rate arrangement and capital openness, as explained by the four cases in Table 1. The vertical axis shows the values of cumulative impulse response in the unit of percentages, and the horizontal axis denotes forecast horizon in quarters. The bottom graphs present the ΔIRF_ts between loose and tight macroprudential policies, so that a positive difference implies that macroprudential tightening can partially absorb the US tightening shock for monetary policies. The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

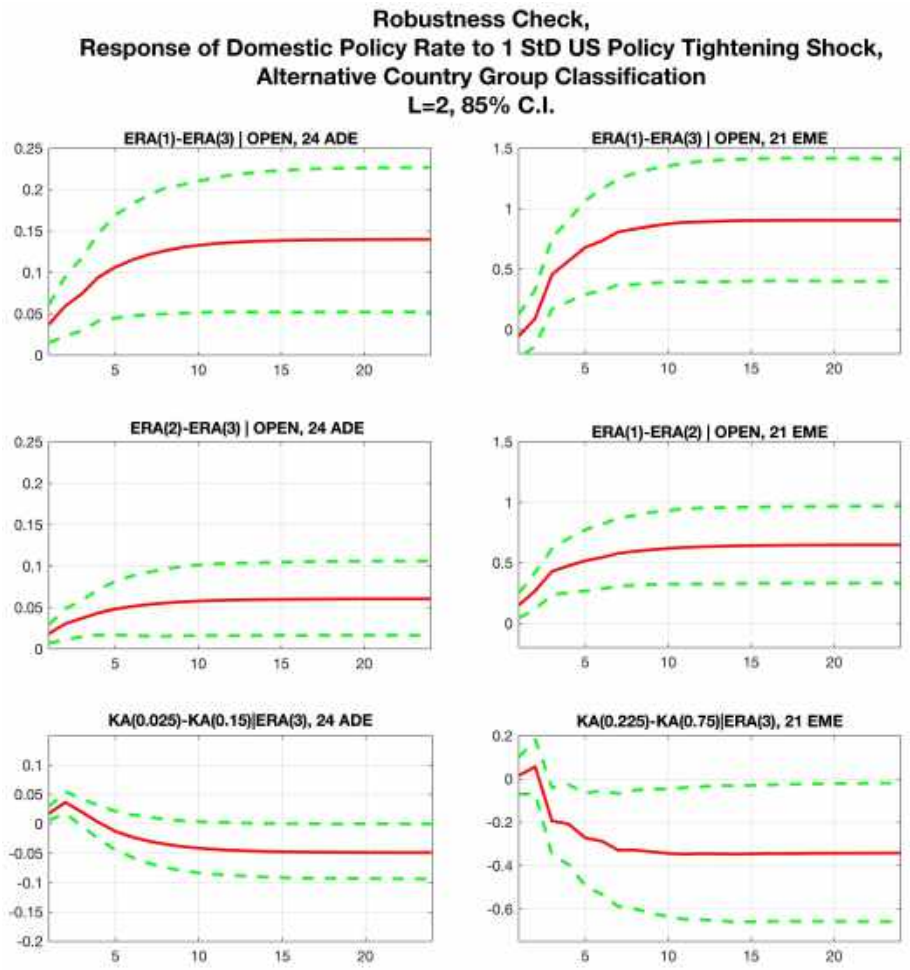
Figure B.5. The Use of Macroprudential Policy: Advanced Economies



The above graph shows the impulse responses of domestic policy rate to one standard deviation increase in U.S. shadow rate, as well as their differences. The top four paired panels present the cumulative impulse responses for loose and tight macroprudential policies across different combinations of exchange rate arrangement and capital openness, as explained by the four cases in Table 1. The vertical axis shows the values of cumulative impulse response in the unit of percentages, and the horizontal axis denotes forecast horizon in quarters. The bottom graphs present the ΔIRF_ts between loose and tight macroprudential policies, so that a positive difference implies that macroprudential tightening can partially absorb the US tightening shock for monetary policies. The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

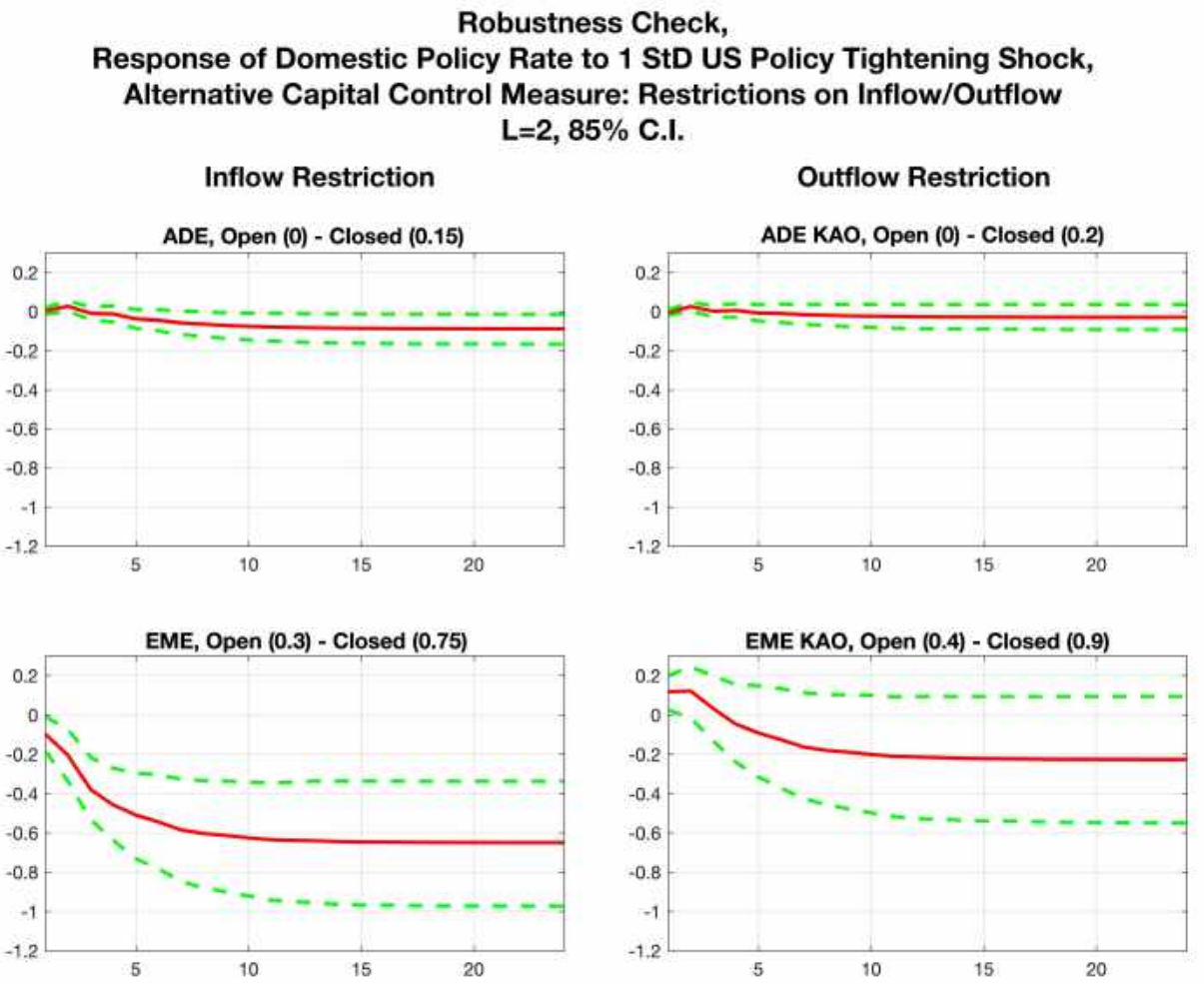
Figure B.6. The Use of Macroprudential Policy: Emerging Economies

Appendix C. Additional Robustness Checks



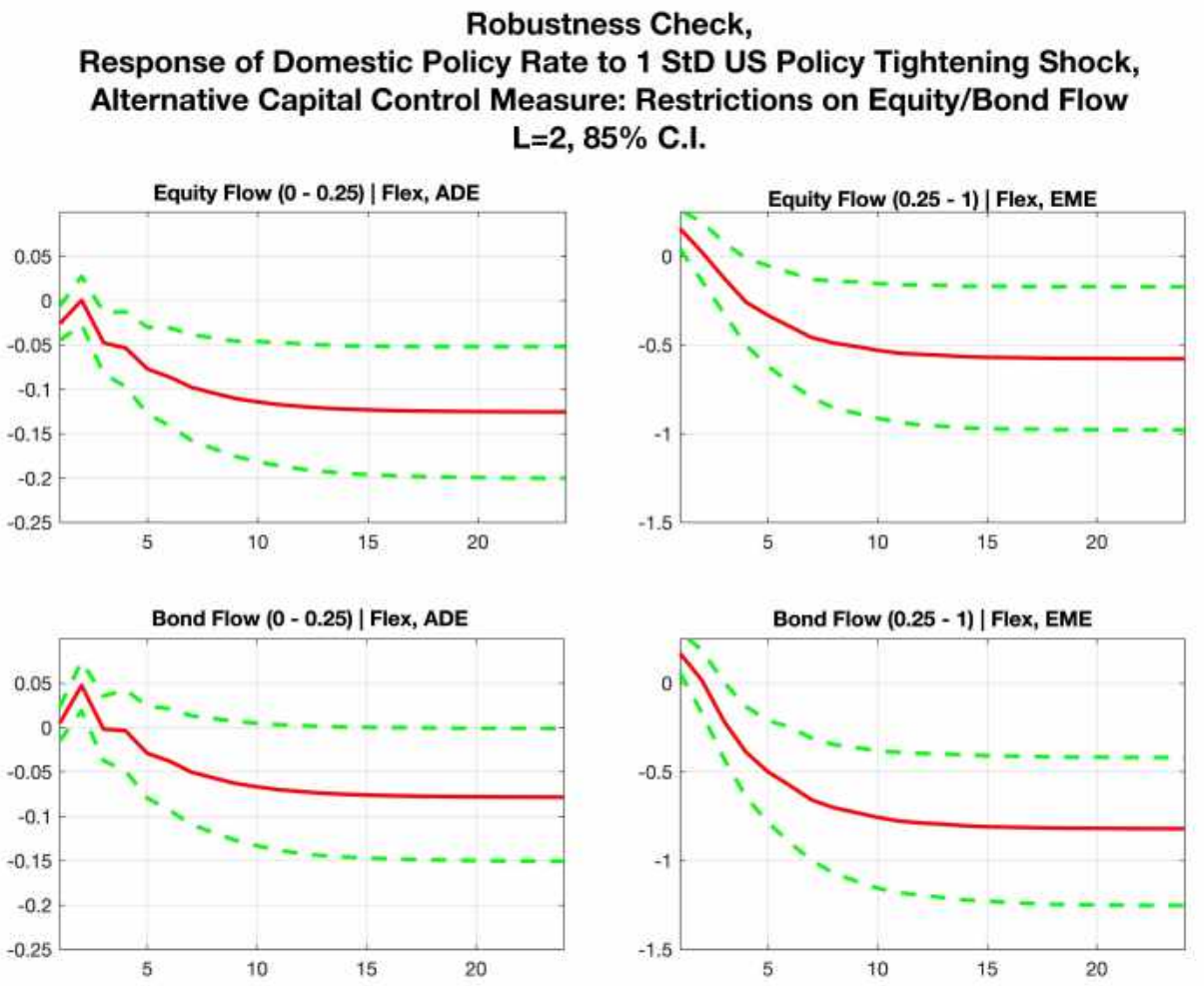
The above graph shows the ΔIRF_ts of domestic policy rate responses to one standard deviation increase in U.S. shadow rate, for alternative country group classification that treats Czech, Latvia and Slovenia as emerging economies. Results for the 24 newly classified advanced economies are reported on the left, while those for the 21 emerging economies are on the right. The upper four panels present the impulse responses between relatively fixed and flexible exchange rate arrangements, while the bottom two graphs are those between high and low capital openness.The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

Figure C.1. Trilemma vs. Dilemma: Alternative Country Group Classification



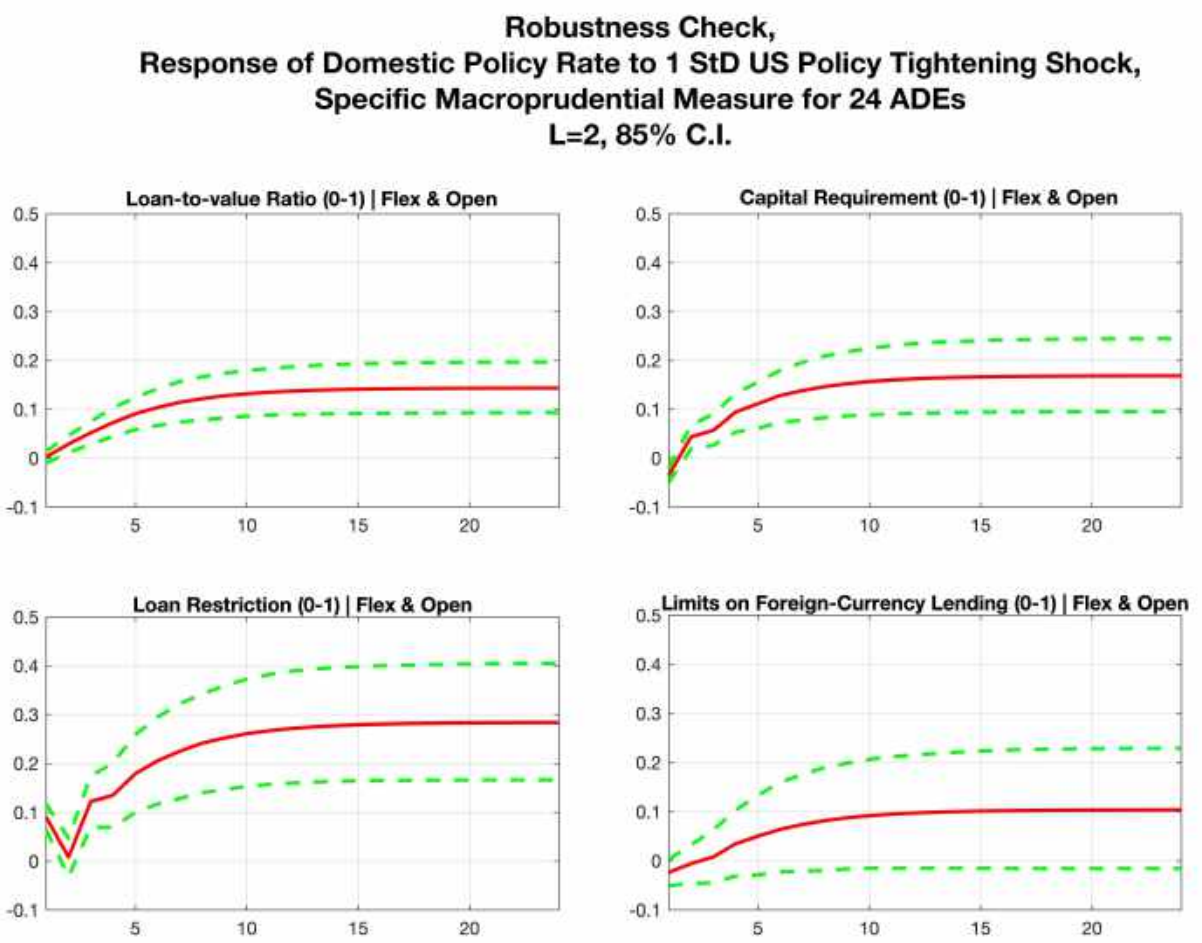
The above graph shows the ΔIRF_ts of domestic policy rate responses to one standard deviation increase in U.S. shadow rate. The top two panels present the impulse responses between high and low capital inflow/outflow openness for the 27 advanced economies, respectively. The bottom two panels present the respective differences (ΔIRF_ts) for the 18 emerging market economies. The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

Figure C.2. Trilemma vs. Dilemma: Alternative Comparison of Partial Restrictions on Capital Inflow/Outflow



The above graph shows the ΔIRF_ts of domestic policy rate responses to one standard deviation increase in U.S. shadow rate. The left two panels present the impulse responses between high and low equity/bond flow openness for the 27 advanced economies. The right two panels present the respective differences (ΔIRF_ts) for the 18 emerging market economies. The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

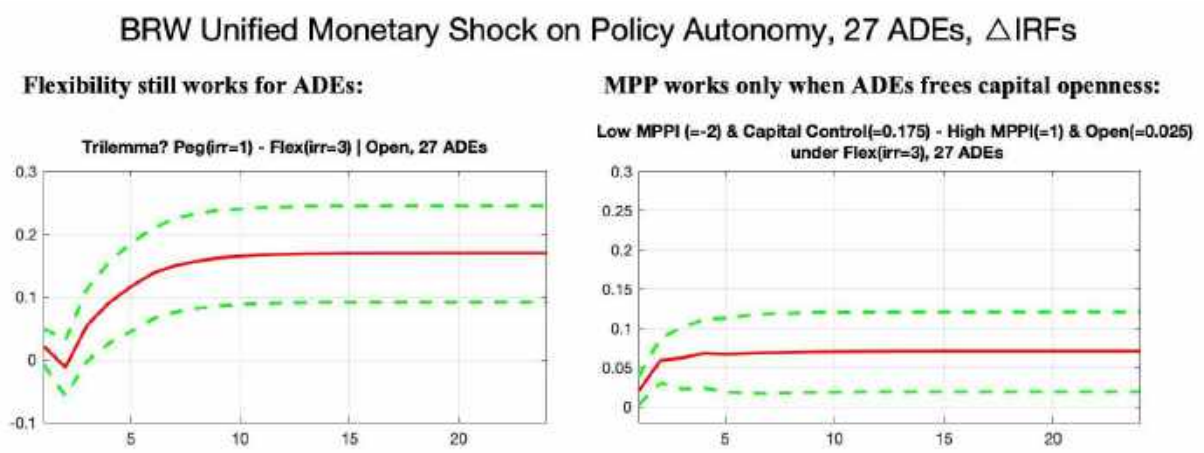
Figure C.3. Trilemma vs. Dilemma: Alternative Comparison of Targeted Restrictions on Equity/Bond Flow



The above graph shows the ΔIRF_ts of domestic policy rate responses to one standard deviation increase in U.S. shadow rate for the 27 advanced economies for four specific macroprudential measures. The solid lines shows the mean of the corresponding impulse responses, while the dashed lines reports the 85% confidence intervals.

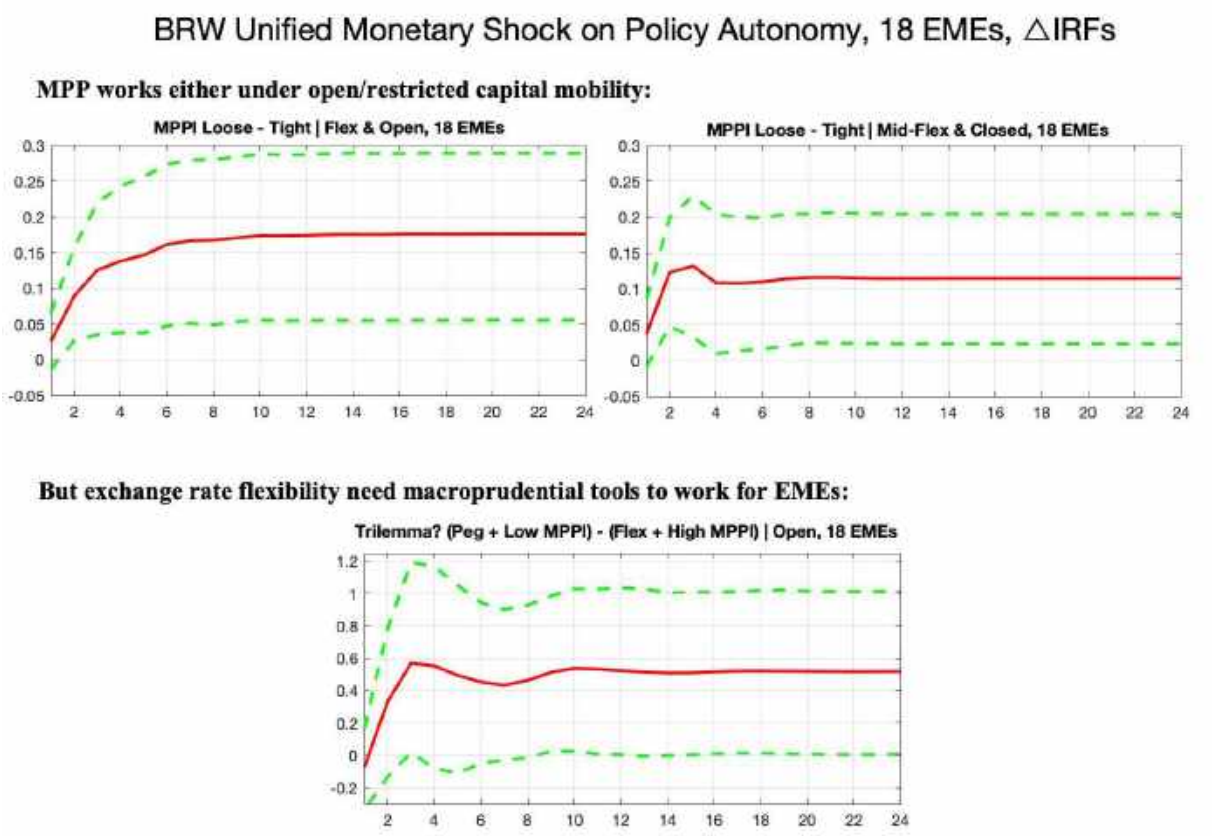
Figure C.4. The Use of Macroprudential Policy: Specific Tools for Advanced Economies

Appendix D. Fed shock using BRW(2019) measure



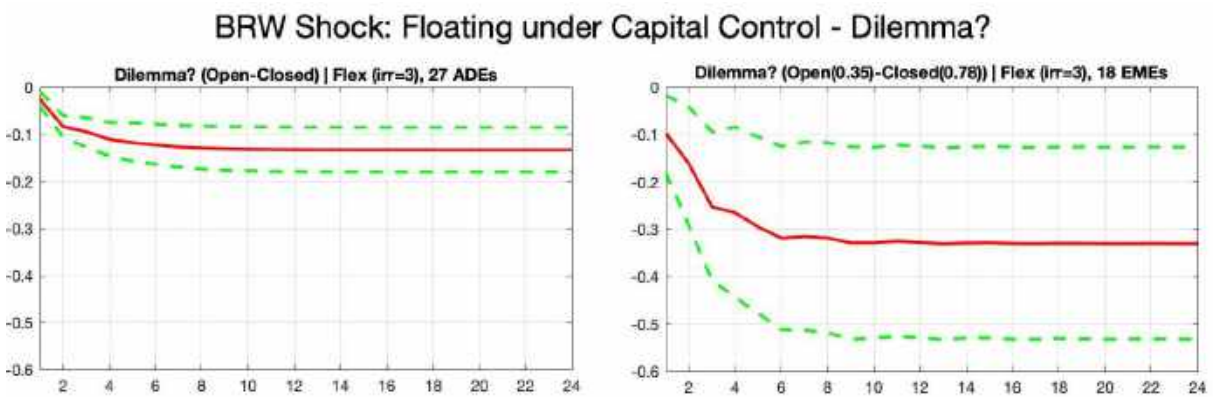
The above graph shows the ΔIRF_ts of domestic policy rate responses to one standard deviation increase in U.S. monetary policy shock (Bu, Rogers & Wu, 2019) for the 27 advanced economies. The left graph is ΔIRF_t on the trilemma, i.e. effectiveness of flexible exchange rate under open capital account. The right graph is ΔIRF_t on macroprudential policy conditional on further reduction of capital mobility restrictions.

Figure D.1. ΔIRF_ts for Advanced Economies



The above graph shows the ΔIRF_ts of domestic policy rate responses to one standard deviation increase in U.S. monetary policy shock (Bu, Rogers & Wu, 2019) for the 18 economies. The upper graphs are ΔIRF_t on the use of macroprudential policy, i.e. effectiveness of tighter macroprudential measures under open(left)/restricted(right) capital account. The bottom graph is ΔIRF_t on the trilemma, conditional on further tightening of macroprudential regulations.

Figure D.2. ΔIRF_ts for Emerging Economies



The above graph shows the ΔIRF_ts of domestic policy rate responses to one standard deviation increase in U.S. monetary policy shock (Bu, Rogers & Wu, 2019) for the 27 advanced econnomies (left) and 18 economies (right). The upper graphs are ΔIRF_t on the use of macroprudential policy, i.e. effectiveness of tighter macroprudential measures under open(left)/restricted(right) capital account. The bottom graph is ΔIRF_t on the trilemma, conditional on further tightening of macroprudential regulations.

Figure D.3. ΔIRF_ts on the Use of Capital Controls