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Jingting LIU

Joseph Dennis ALBA

Wai Mun CHIA

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International Monetary Policy Transmission, Risk Spillovers and the UIP Deviation of Emerging Economies

Jingting Liu[1], Joseph Dennis Alba[2], Wai Mun Chia[3]

Abstract

This paper studies the transmission mechanism of US monetary and global financial risk spillover into emerging countries using panel VAR. It finds that one standard deviation increase in the US interest rate reduces output and investment in emerging countries by 0.1% and 1%. These variables drop by 0.5% and 1.8% following a global financial risk (proxied by CBOE Volatility Index, or VIX) shock. The paper provides evidence that global financial risk spillover and US monetary shock transmission into emerging countries is at least partly through movement in UIP deviation. In fact, global financial risk (VIX) and UIP deviation are highly correlated: High global financial risk (VIX) is often accompanied by high UIP deviation. In a counterfactual analysis, by muting the response of UIP deviation to VIX, negative impact on emerging countries' GDP due to global financial risk shock is slashed by half. In terms of US monetary spillover, an increase in the US interest rate reduces the UIP deviation of emerging countries on impact because emerging countries' domestic interest rate responds by less than the US rate. This initial more muted increase in emerging countries' interest rate is due to an initial drop in the VIX response. In other words, global financial risk proxied by VIX does not increase immediately following contractionary US monetary shocks. Over time, however, the VIX picks up and emerging countries enter a risk-off phase in which credit inflows drop and UIP deviation increases in emerging economies. As part of the paper's contribution, this mechanism can also explain Engel's predictability reversal puzzle as it creates a positive correlation between UIP deviation and the initial period interest rate differential between the emerging country and the US in the short term while in the longer term, this correlation reverses sign.

[1] Asia Competitiveness Institute, Lee Kuan Yew School of Public Policy, National University of Singapore. Email: jtliu@nus.edu.sg
[2] Nanyang Technological University. Email: ajoalba@ntu.edu.sg
[3] Nanyang Technological University. Email: aswmchia@ntu.edu.sg

1. Introduction

Global financial risk, often proxied by CBOE Volatility Index (VIX), strongly co-moves with US monetary stance[4]. Extending the argument further, Rey (2013) proposes the existence of a global financial cycle in capital flows, asset prices and credit growth that co-moves with the VIX. US monetary policy is one of the determinants of the global financial cycle. Specifically, an increase in the US effective federal funds rate (FFR) leads to a delayed but persistent increase in the VIX and a delayed contraction in gross credit flows. The striking implication is that regardless of whether a peripheral economy adopts a fixed or flexible exchange rate regime, its domestic monetary condition may be influenced by global financial cycles driven by the global financial risk condition (VIX) and monetary policy stance of the center economy. The Mundell-Fleming Trilemma may thus have morphed into a dilemma, and an economy has to either impose capital control to ensure monetary autonomy, or to give up monetary autonomy for free capital mobility. Many have since studied whether the Trilemma indeed no longer holds, typically in a panel regression framework. Interest rate changes of a panel of small periphery economies are regressed on the interest rate changes of the base country (usually the US), controlling for other factors[5]. Positive, large and significant estimated coefficients are often taken as evidence that periphery countries follow US in setting interest rates, therefore indeed monetary autonomy is lost. While research testing validity of trilemma is abundant, few have studied the *mechanism* of how US monetary and global financial risk shocks are transmitted to emerging countries. This paper aims to fill this gap.

In this paper, we study how US monetary and global financial risk shocks are propagated to emerging countries through their impact on the uncovered interest parity (UIP) deviation of emerging countries in a panel vector autoregression (VAR) framework. We postulate that UIP deviation is a reasonable measure of the financing cost of the emerging country relative to that of the US, for it directly captures the dispersion between domestic (emerging country) interest rate and US interest rate unaccounted for by changes in the exchange rate which could reflect global risk factors. We use a panel VAR framework because it can capture the dynamic responses of emerging country variables that allow us to examine how both US monetary shocks and global financial risk shocks transmit to emerging markets.

Our main contributions are threefold. First, we show that UIP deviation, strongly correlated with global financial risk proxied by the VIX, is a key link in propagating global financial risk shocks into emerging countries' real economy. Second, we show that following a contractionary US monetary shock, there is a delayed increase in the VIX which gives rise to a similarly delayed increase in emerging countries' UIP deviation. In other words, both the VIX and UIP deviation first decrease before they increase. Through the delayed increase in UIP deviation, the contractionary US monetary shock further affects emerging countries' real economy. Third, we provide a possible explanation for the

[4] See Bekaert, Hoerova, and Lo Duca (2013).

[5] See, among others, Klein and Shambaugh (2015) and Obstfeld (2015).

predictability reversal puzzle. The interest rate differential and one-period UIP deviation are known to be positively correlated, and this is the well-known predictability puzzle. The predictability reversal puzzle states that this correlation reverses sign as horizon extends (Engel 2016). We show that the predictability reversal puzzle is particularly related to the dependence of UIP deviation on global financial risk proxied by the VIX.

We show that UIP deviation is a key device in transmitting global financial risk shocks to emerging-market real economy. We begin by observing that global financial cycle tends to be negatively correlated with the business cycles at emerging countries. Figure 1 panel (a) plots the first principal component of output of 26 emerging countries commonly studied in global financial cycle literature against the VIX. Indeed, episodes of high global financial risk are associated with low output, and vice versa[6]. Formally, using a panel VAR framework, we find that following a one standard deviation increase in the VIX, real output and investment of emerging countries contract by about 0.5% and 1.8%[7]. Variance decomposition shows that global financial risk shock explains more than 13% of variations in output and more than 16% of variations in investment. We next note that global financial risk proxied by the VIX is strongly and positively correlated with the first principal component of UIP deviation, as shown in panel (b) of Figure 1. Given the high correlation between the VIX and UIP deviation of emerging countries, we ask to what extent UIP deviation affects the transmission of global financial risk shocks to the domestic real economy. By muting the response of UIP deviation to global financial risk in a counterfactual analysis, we find that the variance of output explained by the VIX dropped from 13% to 6.5% — slashed by half.

[6] We obtain similar observations by plotting the real output and investment of individual sample countries against the VIX. Plots are not reported due to space constraint.

[7] Our estimates are consistent with existing literature. Using a group of six emerging countries, Akinci (2013) finds that a one standard deviation shock to global financial risk leads to about 0.6% decrease in output and more than 1.5% decrease in investment.

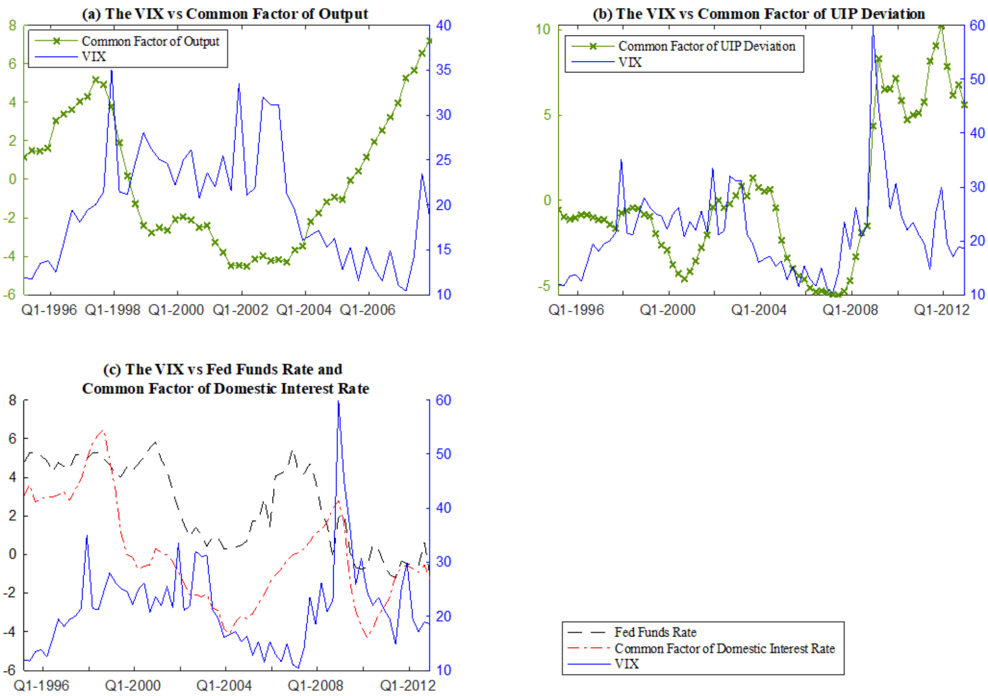

Figure 1: Stylized facts—output, UIP deviation, domestic interest rate and global financial variables. Notes: the common factor of output is the first principal component of output of the sample countries (excluding Colombia, India and Egypt for incomplete data) for 1995 Q1 to 2007 Q4. It explains about 50% of variation in the output. Common factor of UIP deviation is the first principal component of UIP deviation of the sample countries (Chile, Egypt, Hong Kong, India and Slovakia are excluded for incomplete data) for 1995 Q1 to 2012 Q4. It explains more than 80% of variation in UIP deviation. Common factor of domestic interest rate is the first principal component of de-trended log money market rate of the sample countries (excluding Chile, Egypt, Hong Kong, India and Slovakia). It explains more than 30% of variation in domestic interest rate.

In terms of the role of UIP deviation in US monetary spillover, we find that an increase in the US interest rate reduces the UIP deviation of emerging countries on impact because of the decrease in the differential between emerging country interest rate and US interest rate. More specifically, emerging countries' domestic interest rate increases by less following the increase in US interest due to an initial drop in the VIX response. This initial drop in the VIX following contractionary US monetary shocks is a common feature documented in several influential studies including Bruno and Shin (2015) and Rey (2013). Over time, however, the VIX picks up and emerging countries enter a risk-off phase. UIP deviation, which is highly dependent on the global financial risk condition proxied by the VIX, also increases and contracts the real economy of emerging countries. In other words, there is a delayed effect of a contractionary US monetary shock on the VIX which feeds into the UIP deviation and real economy of the emerging countries. More precisely, we find that following a one standard deviation contractionary US monetary policy shock, real output and investment of emerging countries contract by 0.1% and 1% respectively[8], and variance decomposition suggests 8% of the variation in GDP is explained by US monetary shocks. In the same counterfactual analysis where we mute the response of UIP deviation to the VIX, however, the variance of GDP explained by US monetary shocks decrease from 8% to 5%, and both the GDP and investment of emerging countries contract by less.

We would like to highlight that our findings provide a possible explanation for reconciling two puzzles put forth in Engel (2016). The first is the well-known predictability puzzle that the initial interest rate differential and one-period UIP deviation are positively correlated. The second is the predictability reversal puzzle that the correlation between the initial period interest rate differential and UIP deviation at some future horizon turns negative. We provide empirical evidence that the effect of global financial risk on UIP deviation can account for the predictability reversal puzzle. Specifically, following an increase in US interest rate, the emerging country interest rate increases but by less and the VIX decreases. The differential between emerging country interest rate and US interest rate thus decreases and is negative. As the interest rate differential is a key component of UIP deviation, UIP deviation also decreases and is negative. Five quarters after the contractionary US monetary shock, the VIX increases and rises above zero and reaches its peak after 10 quarters[9]. Highly dependent on the VIX, UIP deviation also increases and rises above zero. The correlation between the *initial* interest rate differential and the UIP deviation thus flips sign and turns negative. When we mute the response of UIP deviation to the VIX in the counterfactual analysis, this sign reversal disappears. We further show that the sign reversal is due to US interest rate decreases as the VIX increases while emerging country interest rate decreases by much less and remains higher than US interest rate. Therefore, the differential between emerging country interest rate and US interest rate turns positive as the horizon extends, causing UIP deviation to also turn positive when the VIX is high.

This paper is closest in spirit to Kalemli-Ozcan (2019) which similarly studies how US monetary shocks transmit to emerging countries through UIP deviation using a local projection framework. We differ, however, in what drives the dynamics of UIP deviation. To account for the positive correlation among UIP deviation, interest rate differential and the VIX, Kalemli-Ozcan (2019) argues that when the US raises interest rate, global financial risk proxied by the VIX increases, and emerging countries therefore raise interest rates by even more to stabilize their exchange rates. In this paper we present empirical evidence that contradicts the argument. We show that the impulse response of emerging country interest rate increases by less than the increase in US interest rate. It is not a result of the specific methodology we use but reflects a salient feature of the data that changes in emerging country interest rate have been smaller than US interest rate (see Fig. A5 in the Appendix), and this is especially so during crisis periods. In other words, when global financial risk (VIX) is high, US interest rate decreases

[8] These estimates are in line with existing studies. Using a panel data set of seven emerging countries, Uribe and Yue (2006) finds that in response to a one percentage point increase in US interest rate, domestic output declines by 0.2% and investment declines by more than 0.6%. Using a group of six emerging countries, Akinci (2013) finds that a one standard deviation contractionary US interest rate shock leads to about 0.3% decline in output and 1% decline in investment.

[9] Rey (2013) similarly finds an increase in the US interest rate causes VIX to increase after 5 quarters and until 11 quarters.

by more than the decrease in emerging countries' interest rates, therefore the differential between emerging country interest rate and US interest rate will be high. This accounts for why UIP deviation is positively correlated with both global financial risks proxied by the VIX and interest rate differential. We highlight that our findings entail non-trivial differences in policy implications from that of Kalemli-Ozcan (2019). Kalemli-Ozcan (2019)'s policy recommendation was that emerging country central banks should not overreact to US monetary policy changes to stabilize exchange rate, but as we show later in the paper, central banks of emerging countries change their interest rates by less than the US, possibly due to the lack of policy room. EME central banks ease interest rates by less than the US when global financial risk is high, likely to avoid negative balance sheet effects when they are net borrowers in dollar and capital flows out of the country. In such a scenario, the policy implication would be that EMEs need to build up reserves and buffer to create more policy room during risk-off periods. Further, the VIX does not increase on impact but rather is found to exhibit a delayed increase following a contractionary US monetary policy shock in several studies including ours. Other related literature includes Froot and Thaler (1990) which proposes delayed portfolio adjustment that investors do not necessarily adjust portfolio immediately after a change in interest rate differential to explain for predictability puzzle. More recently, Bacchetta and van Wincoop (2021) take the hypothesis to model and show delayed portfolio adjustment may account for several puzzles related to exchange rate and interest rate differential dynamics.

Following the results that US monetary shock can affect emerging country real economy through its impact on the VIX and UIP deviation, and that shocks to the VIX have large impacts on output and investment at emerging countries, the implications of our results echo Rey (2013) in that policy needs to tackle with changing global financial risk conditions and global financial cycles. Implementing capital control or macroprudential policies may be a useful option to curb capital flows as has been proposed in existing literature. More fundamentally, improving institutional quality, macroeconomic fundamentals and investors' confidence in the economy may be a long-term goal.

The rest of the paper is organized as follows. Section 2 describes the empirical model and the data. Section 3 presents the baseline estimation and simulation results (Section 3.1 and 3.2). We discuss the role of UIP deviation in transmitting global financial shocks (Section 3.3), driving factors of UIP deviation and predictability reversal puzzle (Section 3.4) and the effectiveness of domestic monetary policy transmission (Section 3.5). Section 4 examines the transmission of global financial shocks to domestic private sector financing cost. Section 5 investigates the credit flows into emerging countries. Section 6 presents robustness checks. Section 7 concludes.

2 Empirical Model and Data

The goal of the empirical strategy is to understand the international monetary policy transmission mechanism and the interaction between global financial cycle and business cycles at emerging economies. The empirical model closely follows Uribe and Yue (2006) and Akinci (2013):

$$Ay_{i,t} = \sum_{k=1}^{p} B_k y_{i,t-k} + \lambda_i + \varepsilon_{i,t} \tag{1}$$

where λ_i is a fixed effect, subscript i denotes countries, t indicates time period and

$$y_{i,t} = [\widehat{gdp_{i,t}}, \widehat{inv_{i,t}}, tby_{i,t}, R_t^{us}, VIX_t, \rho_t]$$
$$\varepsilon_{i,t} = [\varepsilon_{i,t}^{gdp}, \varepsilon_{i,t}^{inv}, \varepsilon_{i,t}^{tby}, \varepsilon_{i,t}^{R^{us}}, \varepsilon_{i,t}^{VIX}, \varepsilon_{i,t}^{\rho}]$$

$\widehat{gdp_{i,t}}$ and $\widehat{inv_{i,t}}$ are the de-trended log real gross domestic product and log real investment of emerging countries. $tby_{i,t}$ denotes the emerging countries' trade balance-to-GDP ratio. R_t^{us} is real effective US Fed Funds rate and VIX is the CBOE Volatility Index which captures global financial risk conditions. ρ_t denotes UIP deviation. The choice of domestic variables follows Uribe and Yue (2006) and is believed to capture business cycle dynamics in emerging countries reasonably well. We choose US Fed Funds rate and VIX as the global financial variables following the global financial cycle literature (see, among others, Bruno and Shin, 2015; Rey, 2013).

Unlike in Uribe and Yue (2006) and in Akinci (2013), we choose UIP deviation instead of country spread as our focus is on international monetary policy transmission and we postulate that UIP deviation is a reasonable measure of the financing cost of the emerging country relative to that of the US, for it directly captures the dispersion between domestic (emerging country) interest rate and US interest rate unaccounted for by changes in the exchange rate which could reflect global risk factors. Indeed, we observe that the first principal component of the UIP deviation of our sample countries strongly and positively correlate with the VIX. Another benefit of using UIP deviation is that it can be constructed for a large number of countries. We will discuss about the construction of UIP deviation and examination of international monetary policy transmission in detail in the next section.

2.1 Identification

We identify structural shocks by restricting the matrix A to be lower triangular with unit diagonal elements. Our identification strategy implies that fast-moving financial variables respond to real domestic shocks contemporaneously. At the same time, US monetary policy shocks, global financial risk shocks and UIP deviation shocks feed into the domestic real economy with a one-period lag.

Additionally, we impose US Fed Funds rate and the VIX to be exogenous variables that follow a bivariate VAR process. In particular, we impose $A_{4,j} = A_{5,j} = B_{k,4,j} = B_{k,5,j} = 0$ for all $j \neq 4, 5$ and $k = 1, 2, \cdots, p$. The restriction rests upon the assumption that shocks in small emerging economies do not affect global financial conditions. Within this exogenous block, US Fed Funds rate is ordered before the VIX, which is a common practice in the global financial cycle literature. We also note that the ordering of domestic real variables does not affect the identification of global financial shocks.

Our identification scheme closely follows Uribe and Yue (2006). For example, Uribe and Yue (2006) estimates a 5-variable VAR with the following ordering: real GDP, real gross domestic investment, trade balance-to-GDP ratio, gross real US interest rate and gross real emerging country interest rate. They calculate emerging country interest rate as the sum of J.P. Morgan's EMBI+ stripped spread and US interest rate. Compared to their VAR system, we have one more variable VIX, which captures global financial risk. While they compute emerging country interest rate as the sum of US interest rate and a spread, we compute a UIP premium which is the difference between emerging country interest rate and US interest rate net of exchange rate changes. In Uribe and Yue (2006), US interest rate is assumed to be exogenous and follow a univariate autoregressive process while we assume both US interest rate and the VIX are exogenous and follow a bivariate VAR process.

Nevertheless, as a robustness check, we replace real effective US Fed Funds rate R_t^{us} and UIP deviation ρ_t with log nominal US interest rate and log nominal emerging country interest rate respectively, and we include log bilateral nominal exchange rate vis-à-vis US dollar. We then construct the impulse response of UIP deviation from the impulse responses of US interest rate, emerging country interest rate and exchange rate change. We show that our key results are robust to this alternative specification. Further, in Section 2. we show that our baseline results hold when we use narrative identification of shocks.

2.2 Estimation Method and Data

We estimate the structural panel VAR model (1) equation by equation using fixed effect estimator, also known as least square dummy variable estimator (LSDV). We pool quarterly data from 1995 Q4 to 2007 Q4 of twenty-six developing and emerging market economies listed in Table 1. These sample countries are commonly covered in previous studies of global financial cycle and monetary policy trilemma[10] and account for the bulk of total US dollar debt owed by EMEs. According to McCauley et al. (2015), total dollar credit adds up to more than $3.8 trillion across all EMEs in Q2 2015, out of which $2.8 trillion were accounted for by 12 countries, which include Brazil, Chile, China, India, Indonesia, Korea, Malaysia, Mexico, Philippines, Russia, South Africa and Turkey. All of these countries are included in our sample except for China and India due to lack of data. To estimate the bivariate VAR process of the exogenous block, we use the same time span from 1995 Q4 to 2007 Q4 following Bruno and Shin (2015). Two lags are included in the VAR[11]. We purposely choose the end of the sample period to be 2007 Q4 so as to avoid the impact of the Global Financial Crisis (GFC) period on the

[10] See for example Georgiadis and Mehl (2016) and Han and Wei (2018).

[11] We choose two lags based on Bayesian information criterion (BIC). We also checked that the impulse responses and the variance decomposition are robust to using one lag and three lags.

estimation results. We also check whether our results are sensitive to using post-GFC period for estimation.

Table 1: Sample Countries

Region	Countries
South America	Bolivia, Brazil, Chile, Colombia, Mexico, Peru, Paraguay.
Asia	Hong Kong, Indonesia, South Korea, Malaysia, Philippines, Singapore, Thailand.
Europe & Elsewhere	Czech Republic, Croatia, Egypt, Hungary, Poland, Romania, Russia, Slovakia, Slovenia, Israel, Turkey, South Africa

Note: The table provides details of the countries included.

Fixed effect estimator assumes country-specific intercepts and homogeneous slopes. There are two potential issues associated with the estimator. First, as pointed out in Pesaran and Smith (1995), fixed effect estimator could be inconsistent in dynamic panels if the true slopes are also heterogenous. Second, fixed effect estimator could be inconsistent due to unobserved country effects and the presence of lagged dependent variables on the right-hand side. However, our panel features a relatively large time dimension and a smaller cross section dimension thus fixed effect estimator is a suitable choice. Nevertheless, we re-estimate the baseline model first with mean group estimator proposed by Pesaran and Smith (1995) and then by Arellano-Bond estimator in the robustness check and show that our estimation results are not sensitive to the choice of estimators. We note that mean group estimator takes country heterogeneity into account. Specifically, to obtain the mean group estimator, we estimate the VAR system country-by-country and then take the mean of the estimates[12].

Data on gross domestic product, gross domestic investment, net exports, money market rate and bilateral exchange rate vis-à-vis US dollar are from IMF's International Financial Statistics retrieved via CEIC database. GDP, investment and net exports are deflated using the GDP deflator and seasonally adjusted.

3 Analysis

In this section we first discuss the construction of UIP deviation and then present the impulse responses and variance decomposition results. We discuss the role of UIP deviation in transmitting US monetary policy shocks and global financial risk shocks.

[12] Country-by-country estimates and their mean are shown in Figure 2.27 and Figure 2.28. We understand that responses of countries with different characteristics (e.g., commodity exporters versus non-exporters, or countries with different policy room) may differ, but country-by-country estimates are generally consistent with our baseline results.

The standard UIP condition states that the difference between domestic interest rate and foreign (US) interest rate will be offset by the change of forward exchange rate relative to spot exchange rate:

$$i_t = i_t^{us} + E_t\{e_{t+1}\} - e_t + \rho_t \tag{2}$$

where i_t is domestic (emerging country) interest rate, i_t^{us} is US interest rate and e_t is the domestic currency price of US dollar. In the case when US raises its interest rate, if the emerging country holds its interest rate constant by resorting to a flexible exchange rate regime, its currency will depreciate (i.e., e_t increases) immediately and then appreciate in the future period. The equation is further augmented with a residual term ρ_t which is commonly referred to as UIP deviation or currency risk premium. We note that if the standard UIP condition holds, ρ_t should be close to zero and not forecastable.

We follow Brunnermeier et al. (2008) to construct UIP deviation for each of the sample countries from 1995 Q1 to 2007 Q4 using ex-post exchange rates. In particular, we use log quarterly money market rates from IMF IFS for i_t and i_t^{us} (both are nominal rates), and log end of period national currency per US dollar at quarterly frequency for e_t and e_{t+1}. Money market rates are average deposit rates between financial corporations within 3-month maturity. The choice is similar to Brunnermeier et al. (2008) which uses 3-month interbank interest rates. For almost all of the twenty-six sample countries, there is highly positive correlation between interest rate differential $i_t - i_t^{us}$ and excess return ρ_t, indicating violations of UIP in the data.

3.1 Impulse Responses

The impulse responses following a one standard deviation increase in real effective Fed Funds rate are shown in Fig. 2. Similar to the previous studies in global financial cycle literature, a contractionary shock to Fed Funds rate leads to a decline in the VIX first then followed by a persistent increase. UIP deviation exhibits a similar pattern by first decreasing then increasing in response to the contractionary US monetary policy shock. We note that point estimates of UIP deviation changes sign and rises above zero roughly 9 quarters after shock. This is similar to estimates in existing literature (see, for example, Figure I of Eichenbaum and Evans (1995) and Figure 3 and 4 in Engel (2016)). Both output and investment first briefly increase—due to the initial fall in the VIX and UIP deviation—and then decreases persistently. It is, however, puzzling that trade balance declines before reverting back, and the response is quite persistent. The decline is likely due to the existence of an upward trend in trade balance-to-GDP ratio for many countries over the sample period. We show in Fig. A1 in the Appendix that after trade balance-to-GDP ratio is de-trended, it increases following a contractionary US monetary shock while responses of other variables remain similar. Nevertheless, in the baseline case we do not de-trend the trade balance data following Uribe and Yue (2006).

Fig. 3 shows the impulse responses to a one standard deviation shock to the global financial risk proxied by the VIX. We interpret the decline in Fed Funds rate as the Fed easing its monetary policy stance in response to heightened global financial risk. UIP deviation increases on impact due to a widened differential between domestic interest rate and US interest rate[13]. Global financial risk shock has large negative impacts on domestic real economy. Output and investment both declines. The decline in investment is larger than GDP, indicating domestic absorption reduces by more than output and there is an improvement in trade balance as a result. Fig. A2 shows that impulse responses to VIX shock remains similar using de-trended trade balance-to-GDP ratio.

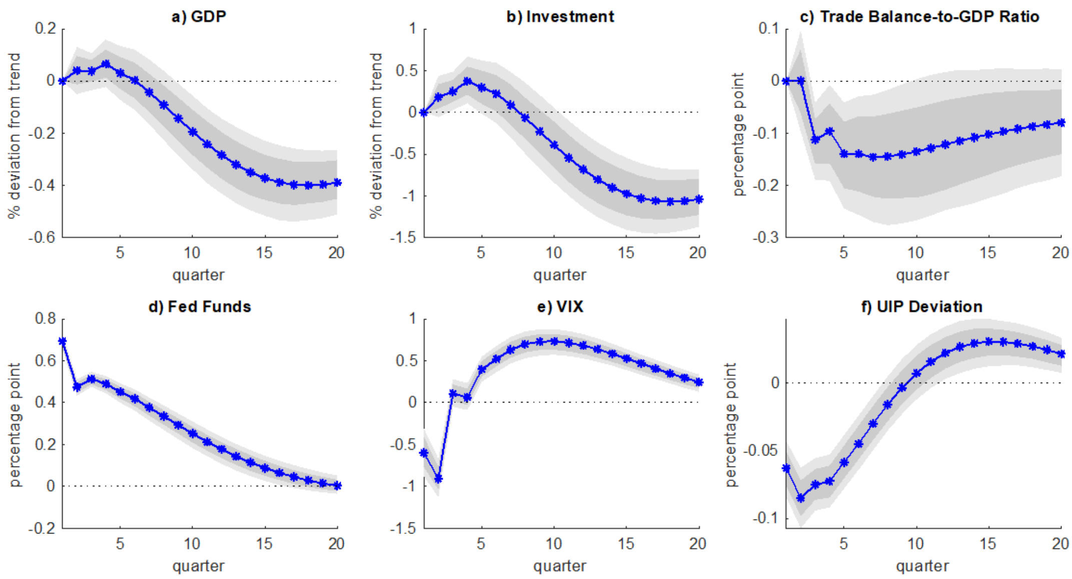

Figure 2: Impulse responses to a one standard deviation contractionary shock to Fed Funds. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

So far, the results suggest that first, shocks to both US monetary policy and global financial risk affect emerging countries' real economy. Second, global financial cycle may be an important factor driving both the domestic business cycle of emerging countries and changes in UIP deviation. When the VIX is low, the booming phase of the global financial cycle coincides with the booming phase of domestic economy. Both output and investment increases while UIP deviation decreases. These results reflect robust features of stylized facts in the data. Fig. 1 panel (a) shows the first principal component of output of the sample emerging economies and the evolution of the VIX. Periods of high global

[13] Using carry trade data of five currencies against US dollar—AUD, CAD, JPY, CHF, GBP and EUR—Brunnermeier et al. (2008) finds that higher VIX is associated with higher carry returns going forward, consistent with our finding that UIP deviation (or excess return of carry trades) exhibits humped shape in response to VIX shock.

financial risk are often associated with low output at emerging countries, and vice versa[14]. Panel (b) shows that the first principal component of UIP deviation and the VIX move largely in tandem[15].

We note that Hong Kong is the only sample country that has fixed exchange rate regime throughout the sample period. Most of the other countries are classified as flexible exchange rate regimes over most of the sample periods. We use coarse classification codes of Ilzetzki et al. (2019). Code 1 is classified as fixed exchange rate regime. Codes 2-6 are classified as flexible exchange rate regime. Countries with non-US dollar base currencies are classified as flexible exchange regimes vis-à-vis US dollar (See Table A1). Our impulse response results are robust to excluding Hong Kong from the sample. The figures are not reported to save space.

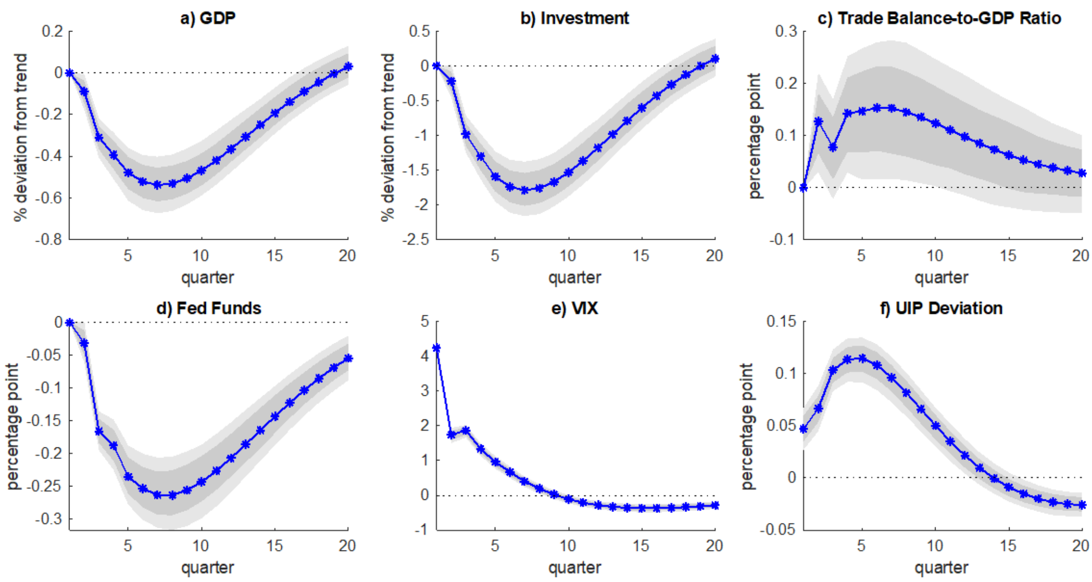

Figure 3: Impulse responses to a one standard deviation shock to the VIX. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

[14] We obtain similar observations by plotting the real output and investment of individual sample countries against the VIX. Plots are not reported due to save space.

[15] We obtain similar observations by plotting the UIP deviation of individual sample countries against the VIX, with Hong Kong the only exception. Over the entire sample period, UIP deviation of Hong Kong largely coincides the zero line with slight fluctuations, except for the brief dip around 2004. This is because Hong Kong pegs its currency to the US dollar.

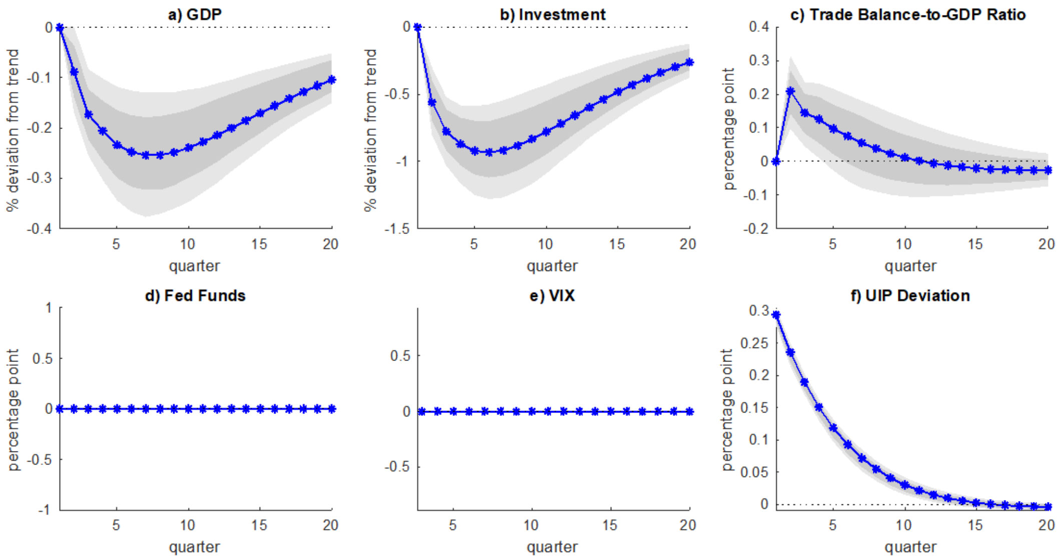

Figure 4: Impulse responses to a one standard deviation shock to UIP deviation. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

Finally, Fig. 4 shows the impulse responses to a one standard deviation shock to UIP deviation. By the way how UIP deviation is constructed, UIP deviation shocks may partly reflect domestic monetary policy shocks and partly reflect country risk shocks. In response to a one standard deviation increase in UIP deviation, both output and investment declines while trade balance improves. Note, however, our focus is on the partial identification of US monetary and VIX shocks.

3.2 Variance Decomposition

Fig. 5 shows the variance decomposition of the variables contained in panel VAR equation (1) over a horizon of five years. Based on the estimation, global financial risk shocks explain more than 13% of variations in output and more than 16% of variations in investment while US real Fed Funds rate shocks account for about 8% and 6% of the movements in output and investment respectively. US monetary shocks and global financial risk shocks explain around 9% and 20% of the fluctuation in UIP deviation, respectively. Shocks to domestic variables, including GDP, investment and trade balance combined explain around 10% of the fluctuation in UIP deviation. These results suggest that US monetary shocks and global financial risk shocks are key drivers of fluctuations in domestic business cycles and UIP premium, with the impact of global financial risk shocks especially prominent.

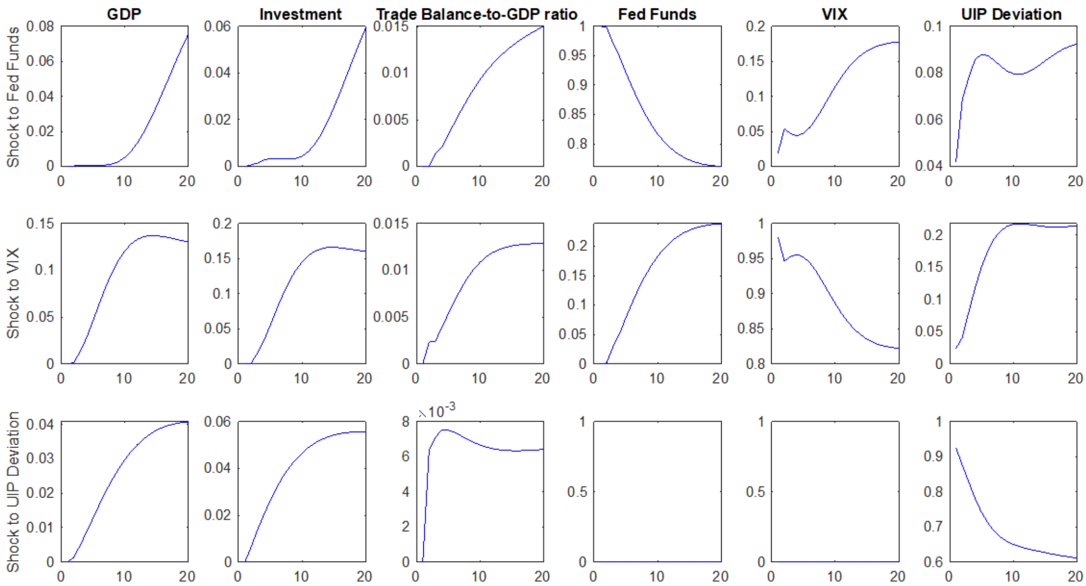

Figure 5: Forecast error variance decomposition. Notes: Solid lines show the fraction of the h-period ahead forecast error variance explained by the Fed Funds shocks (first row), by global financial risk shocks (second row) and by UIP deviation shocks (third row).

The variance decomposition is robust to exclusion of Hong Kong from the sample. In particular, the percentages of variations in GDP and investment accounted for by Fed Funds shocks and VIX shocks barely change. However, when Hong Kong is excluded from the sample, around 11.3% of variations in UIP deviation is accounted for by shocks to Fed Funds, 24% explained by shocks to the VIX, 57.2% explained by shocks to itself, leaving an even smaller 7.5% explained by shocks to domestic real variables. The figure is not reported for saving space.

3.3 Effect of UIP Deviation in Propagating Global Financial Risk Shocks and US Monetary Shocks into Domestic Real Economy

The variance decomposition plot shows that global financial risk shocks are an important source of fluctuations in UIP deviation. We thus ask whether the resulting variations in UIP deviation—reflecting changing financing costs of emerging countries relative to the US—pass on US monetary shocks and global financial risk shocks to the domestic real economy. To this end, we conduct a counterfactual analysis by muting the response of UIP deviation to the VIX without re-estimating the model. Specifically, in the equation of ρ_t in the panel VAR system (1), coefficients on the VIX are set to zero for all lags. We then simulate the impulse responses again and compute variance decomposition. We recognize, however, as noted in Uribe and Yue (2006) and Akinci (2013), such a method is subject to Lucas' critique and a theoretic modelling would be a more desirable approach.

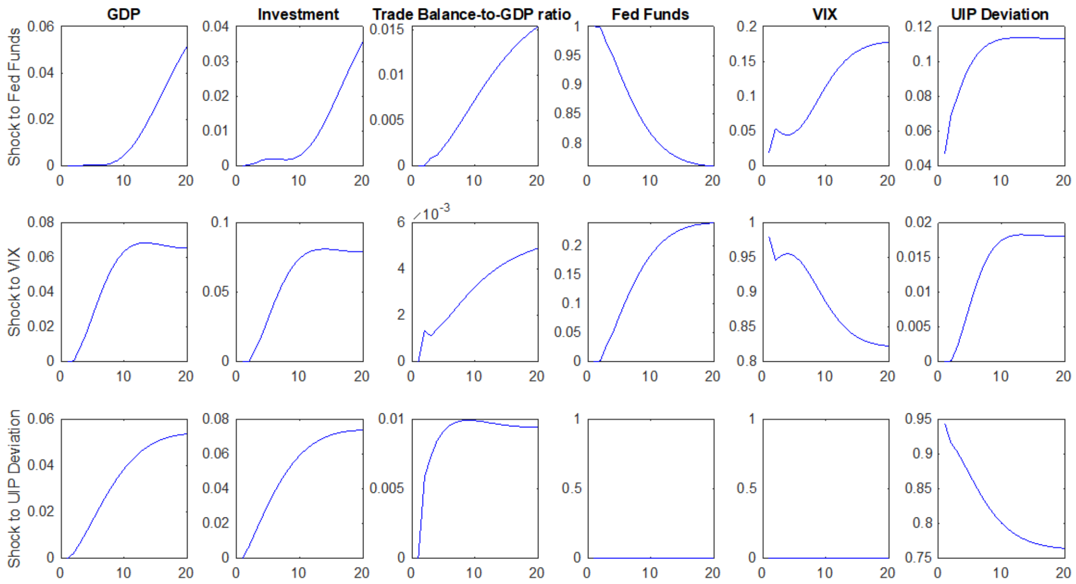

Figure 6: Forecast error variance decomposition—counterfactual case. Notes: Solid lines show the fraction of the h-period ahead forecast error variance explained by the Fed Funds shocks (first row), by global financial risk shocks (second row) and by UIP deviation shocks (third row). Hong Kong is excluded. In the eqution of UIP deviation, the coefficients of VIX at all lags are set to 0.

Fig. 6 displays the variance decomposition plot of the counterfactual exercise. By shutting down the response of UIP deviation to the VIX, the variance of GDP explained by the VIX dropped from 13% to 6.5% — slashed by half[16]. Notably, the variance of GDP explained by shocks to Fed Funds also decreased from around 8% to 5%, which is due to the variations in the VIX caused by shocks to Fed Funds now do not directly feed into UIP deviation and domestic real economy. The amount of variations in investment and trade balance explained by the VIX have also declined. These results highlight the role of UIP deviation in transmitting global financial risk shocks and US monetary shocks to the domestic real economy. This again reflects the stylized fact that UIP deviation co-moves with the VIX as shown in Fig. 1.

To further shed light on how UIP deviation channels US monetary shocks and VIX shocks into EME's real economy over different horizons, we shut down the response of UIP deviation to VIX four horizons at a time and recalculate the variance decomposition. Figure 7 shows that the reduction in the fraction of variance in GDP and investment explained by Fed Funds shock is the largest when we mute the response of UIP deviation to VIX between lag 5 and lag 8 (green solid lines). This is because within this interval, VIX rises above zero and reaches its peak following a contractionary US monetary shock. This exercise confirms that there is a transmission channel from the contraction in US monetary policy, to the increase in VIX, to UIP premium, which in the end feeds into emerging countries' real economy.

[16] By muting the response of UIP deviation to real Fed Funds and the VIX altogether, the variations in GDP attributable to the VIX further declines while the variations attributable to Fed Funds increase slightly from 7% to 9% (Hong Kong excluded).

The lower panel of Figure 7 shows that the reduction in the variations in GDP and investment explained by the VIX shock is the largest when the response of UIP premium to VIX is muted in the beginning periods (red solid lines). This is because the pain of a heightened global financial risk is most keenly felt in the early periods when VIX is hiked up.

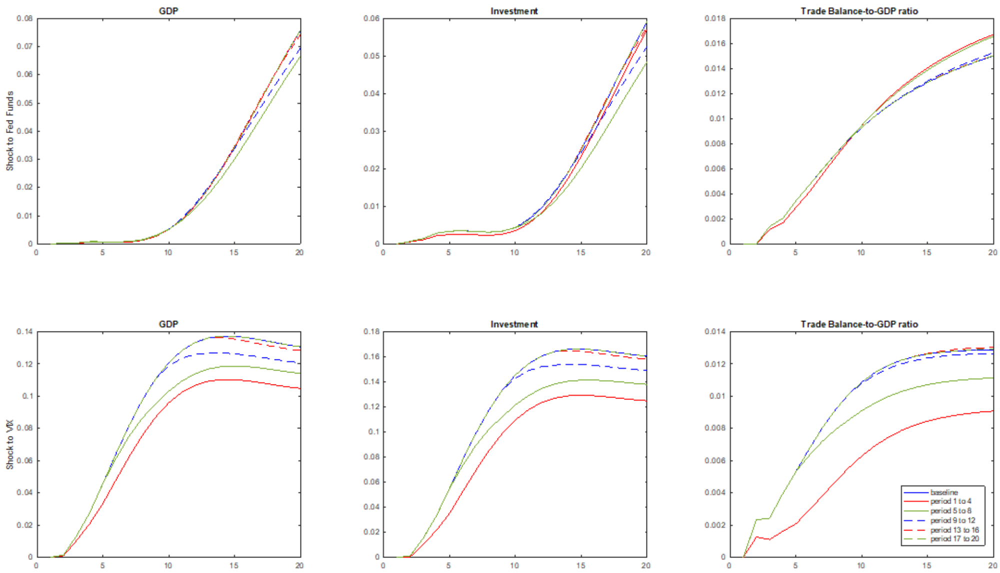

Figure 7: Forecast error variance decomposition—counterfactual case with response of UIP deviation to VIX muted four horizons at a time. Notes: Fraction of the h-period ahead forecast error variance explained by the Fed Funds shocks plotted in the first row, and by global financial risk shocks plotted in the second row. Hong Kong is excluded. In the eqution of UIP deviation, the coefficients of VIX are set to 0 for lag 1 to 4 (red solid line), lag 5 to 8 (green solid line), lag 9 to 12 (blue dashed line), lag 13 to 16 (red dashed line) and lag 17 to 20 (green dashed line).

UIP deviation is calculated as the difference between domestic interest rate and that of the US, net of ex-post exchange rate changes. The movement in UIP deviation thus may be driven by changes in domestic interest rate or changes in US interest rate. A natural question to ask is how domestic interest rate would respond to US interest rate shocks and global financial risk shocks and what drives the changes in UIP deviation that we have seen in impulse responses. We explore these questions next.

3.4 Driving Factors of UIP Deviation and Predictability Reversal Puzzle

We first make two observations in order based on data: First, movements in domestic interest rate track the movements in US interest rate which calls policy trilemma into question. Panel (c) of Fig. 1 shows the co-movement between the first principal component of de-trended log money market rates of emerging countries (Hong Kong excluded, together with some other countries) and the real effective Fed Funds rate. Second, US interest rate seems to be more volatile and driving the movements in interest rate differentials especially after 2000, as indicated in the country-by-country plot of de-trended log domestic money market rate, log US money market rate and their differential against the VIX in Fig.

A5. We thus postulate that emerging country interest rate changes when US interest rate changes, but by less.

More formally, we re-estimate a modified 7-variable VAR and construct interest rate differential and UIP deviation from the impulse responses. Specifically, the variables included in this modified VAR model are ordered as follows:

$$y_{i,t} = [\widehat{gdp_{i,t}}, \widehat{inv_{i,t}}, tby_{i,t}, i_t^{us}, VIX_t, i_{i,t}\ e_{i,t}], \tag{3}$$

where i_t^{us} is log nominal money market rate of the US and $i_{i,t}$ is log nominal money market rate of country i with a slight abuse of notation. Both i_t^{us} and $i_{i,t}$ are not de-trended in this exercise. $e_{i,t}$ is log nominal bilateral exchange rate vis-à-vis US dollar of country i. The ordering among US interest rate, domestic interest rate and exchange rate follows from Eichenbaum and Evans (1995). Interest rate differential and UIP deviation are constructed from the impulse responses of i_t^{us}, i_t and e_t. In particular, interest rate differential is computed as $i_t - i_t^{us}$ and UIP deviation is calculated as $i_t - i_t^{us} - (e_{t+1} - e_t)$. Fig. 8 and Fig. 9 show the impulse responses to a one standard deviation increase in US log nominal money market rate and VIX respectively. The responses of domestic real variables are qualitatively similar to the baseline case. Interestingly, Fig. 8 shows that domestic interest rate also increases following a contractionary US monetary policy shock, but the increase is smaller in magnitude compared to the increase in US interest rate. The lower bound of 90% bootstrap confidence bands of domestic interest rate lies above the zero line for most of the horizons. In addition, domestic currency initially remains stable in value and then exhibits a persistent depreciation as global financial risk proxied by the VIX also increases. The shape of exchange rate response is consistent with the delayed overshooting puzzle coined by Eichenbaum and Evans (1995) that a contractionary US monetary policy shock leads to a persistent appreciation of US dollar that does not necessarily occur contemporaneously. Fig. 9 shows that following an increase in the VIX, US interest rate immediately eases while emerging country interest rate first briefly increases before it starts to ease. Further, as the VIX decreases to zero at around 10th quarter, US interest rate response soon increases and reverts to zero while emerging country interest rate continues to decrease until the 15th quarter as the VIX reaches its minimum. UIP deviation responses constructed from impulse responses of US interest rate, domestic interest rate and exchange rate are qualitatively similar to those obtained previously in Fig. 2 and Fig. 3.

Combined, the impulse response results of this exercise suggest that changes in UIP deviation are driven by changes in US interest rate, which are generally larger in magnitude compared to the changes in emerging country interest rate. Hence when US interest rate increases, the differential between emerging country interest rate and US interest rate, as well as UIP deviation decrease on impact, as shown in Fig. 8. Further, global financial risk proxied by the VIX is an important factor influencing the dynamics of interest rate differential and UIP deviation. We note that first, both US and emerging country interest rates would respond to counterbalance the impacts of VIX changes. Second, the US interest rate responds by more as the VIX suppresses changes in emerging country interest rate. For example, Fig. 9 shows that following an increase in the VIX, the emerging country interest rate initially increases along with the VIX, causing it to ease more slowly and by less than US interest rate. Thus, when the VIX increases, interest rate differential also increases. As horizon extends, the VIX reduces and US interest rate reverts back to pre-shock level while emerging country interest rate continues to remain at a low level and reverts back more slowly. Thus, when the VIX is low, interest rate differential is also low.

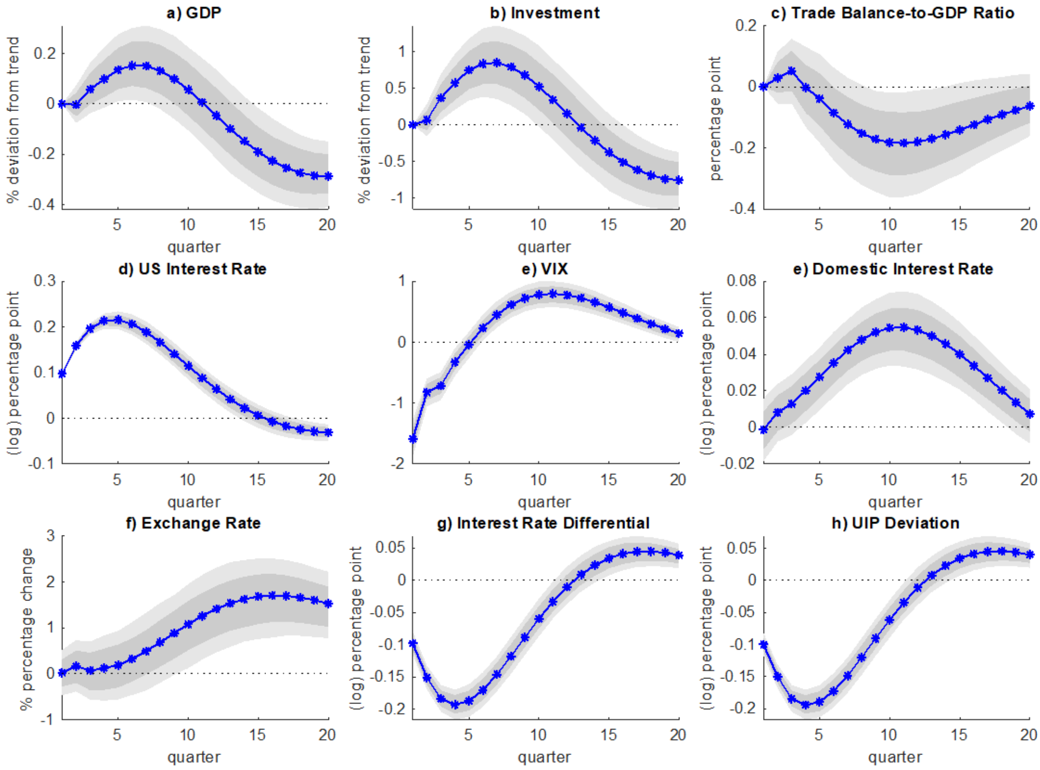

Figure 8: Impulse responses to a one standard deviation shock to US Interest Rate. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

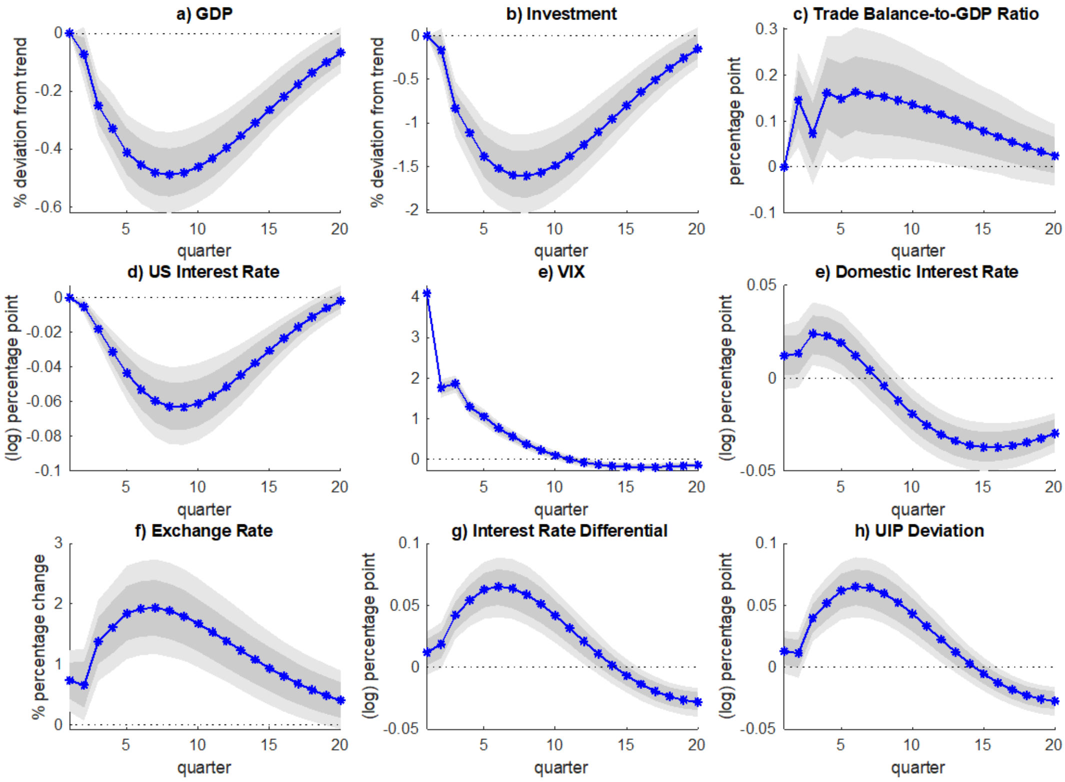

Figure 9: Impulse responses to a one standard deviation shock to VIX. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

To examine the effect of global financial risk proxied by the VIX on UIP deviation dynamics, we present the impulse responses to US real effective fed funds rate shock when the response of UIP deviation to the VIX is muted by setting coefficients on VIX in the equation of ρ_t in VAR system (1) to zero. Fig. 10 shows that in response to a one standard deviation contractionary US Fed Funds shock, in this *counterfactual* scenario the initial drop in UIP deviation is smaller compared to the baseline case. As the global financial risk proxied by the VIX increases above zero after the initial delay, UIP deviation increases and changes sign in the *baseline* case (dashed line). This sign change is dubbed as the "predictability reversal puzzle". The sign reversal, however, disappears once we shut down the response of UIP deviation to the VIX in the *counterfactual* case (starred line). The findings obtained in this exercise potentially provides an explanation for the predictability reversal puzzle put forth in Engel (2016) that while the correlation between one period ahead UIP deviation ρ_t and the initial interest rate differential $i_t - i_t^{us}$ is positive, or $cov(\rho_t, i_t - i_t^{us}) > 0$, the correlation between future horizon UIP deviation and the initial interest rate differential reverses sign, or $cov\left(E_t\rho_{t+j}, i_t - i_t^{us}\right) < 0$ for some $j > 0$. We have shown that this sign reversal is particularly related to the dependence of UIP deviation on global financial risk proxied by the VIX.

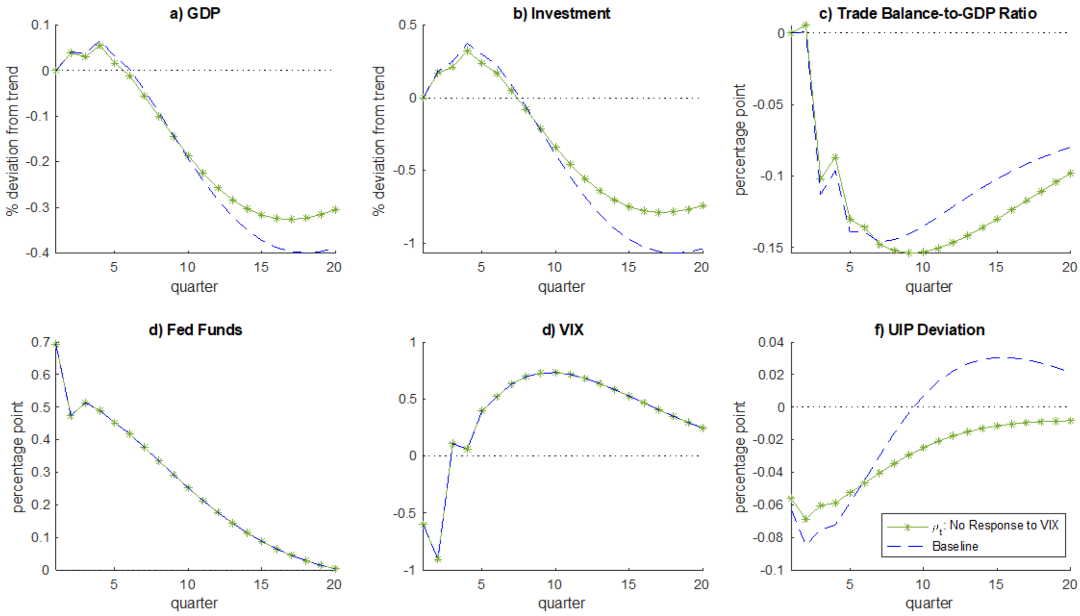

Figure 10: Impulse responses to a one standard deviation contractionary shock to Fed Funds—counterfactual case. Notes: Dashed lines are point estimates of impulse responses under the baseline case. Starred lines are the point estimates of impulse responses in the counterfactual case in which the response of UIP deviation to the VIX is muted.

We would like to highlight the difference between our findings and existing literature studying US monetary spillover through UIP deviation. Using a local projection framework, Kalemli-Ozcan (2019) similarly finds strong positive correlation among the VIX, UIP deviation and interest rate differential. She argues that the co-movement between interest rate differential and UIP deviation is due to EMEs raising their interest rates more than one for one in response to a US interest rate hike in order to limit exchange rate fluctuation with the presence of UIP deviation which is assumed to be also increasing. Our findings suggest, however, that interest rates at EMEs change *less than* one for one in response to US interest rate changes which is a robust feature of the underlying data (See Fig. A5). The gap between the change in domestic interest rate and the US interest rate, as we have shown in impulse responses, is due to the VIX would first decline after a contractionary US monetary shock which suppresses the increase in domestic interest rate. As a result, there is a co-movement among interest rate differential, UIP deviation and the VIX[17].

3.5 Effectiveness of Domestic Monetary Policy Transmission

We have shown that the changes in emerging country interest rates relative to US interest rate changes are limited by the global financial risk. Two factors may have contributed to this: First, it may be due

[17] If indeed a hike in US interest rate causes an immediate increase in risk perception and UIP deviation which prompts central banks at EMEs to raise their interest rates more than one for one in order to limit exchange rate fluctuations, then domestic interest rate and the VIX should be strongly positively correlated. However, this is rejected both by features of the underlying data (see Fig. A5) and by the impulse responses shown in Fig. 9 which indicate the movement in domestic interest rate counters the global financial cycle proxied by the VIX.

to emerging countries being more conservative in changing their monetary policy stance. For instance, when global financial risk heightens, an emerging country hoping to stimulate the economy by resorting to an expansionary monetary policy may be more constrained to do so out of the concern that a lower interest rate could further encourage capital outflows. Second, it could be that emerging country central banks are as aggressive as the Federal Reserve in setting their policy rates, but imperfect monetary policy transmission causes the market rate at which domestic banks borrow to be affected by global financial risk conditions. Thus, during the booming phase of global financial cycle, the money market rate (or deposit rate) ends up being lower as deemed desirable and during the risk-off phase, it ends up being higher. To test these two alternative scenarios, we examine the transmission of monetary policy rates at emerging countries to their money market rates (or deposit rates).

Table 2 summarizes the monetary transmission effectiveness of 25 of the sample countries[18]. We calculate the correlation between domestic log central bank policy rate and log money market rate or log deposit rate for the period from 1995 Q1 to 2019 Q4[19] as two simple measures of monetary policy transmission effectiveness. Central bank policy rate is the major policy rate on weekly repos. Both central bank policy rate and deposit rate are taken at quarterly frequency obtained from IMF IFS via CEIC database. The median effectiveness using either measure lies above 0.9 while the average effectiveness is substantially lower at a level between 0.7 and 0.8. The high correlation between policy rate and money market or deposit rate suggests that the first scenario discussed above is more plausible: emerging countries are more conservative in changing their monetary policy stance[20].

[18] Paraguay is excluded from this exercise as its central bank policy rate data only begins in 2011.

[19] We take the longest available data from 1995 Q1 to 2019 Q4 for each sample country. Treasury bill rate is used when money market rate is not available.

[20] One possible explanation is that emerging countries do not wish to further encourage capital outflows — for example when global financial risk (the VIX) is high — thus are more conservative in lowering its interest rate. In a separate exercise, we re-estimated the VAR model country-by-country with mean group estimator. We then extract and do a scatter plot of the peak response of UIP deviation of each country (usually after quarter 10 when the response of the VIX is also near its peak) following a one standard deviation contractionary US monetary policy shock against each country's average net exposure to US dollar denominated debt over the period of 1995-2007. The average exposure to US dollar debt is calculated based on Benetrix et al. (2015). There is a clear negative correlation between the two, suggesting that the more a country borrows in US dollar debt, the higher is its UIP deviation when the VIX is high and the less it lowers its interest rate. Additionally, we replace UIP deviation with de-trended domestic interest rate and simulate impulse responses to a one standard deviation increase in the VIX. We then extract and regress the mean response in domestic interest rate over a 9-quarter horizon (the VIX remains positive over this horizon) on individual countries' average net dollar debt exposure. The regression coefficient is negative and significant at 5% level, indicating that indeed the more a country borrows in US dollar the less it lowers its interest rate when global financial risk is high.

Table 2: Monetary Policy Transmission Effectiveness

	$Corr(i^p, i^{mm})$	$Corr(i^p - i^{mm}, VIX)$	$Corr(i^p, i^d)$	$Corr(i^p - i^d, VIX)$
RUS	-0.0653	0.0600	-0.0989	0.0610
HRV	0.1613	0.0337	0.4235	0.0526
MYS	0.4431	0.1423	0.7339	0.1789
EGY	0.7350	0.1736	0.8852	0.3071
SVN	0.7919	0.4818	0.9295	-0.0131
SGP	0.8040	-0.1917	0.4443	-0.4200
HUN	0.8952	-0.2294	0.9475	-0.2856
HKG	0.9104	-0.2724	0.8923	-0.1996
PHL	0.9114	-0.2779	0.7908	-0.1846
CHL	0.9274	-0.2881	0.9305	-0.2345
ROU	0.9418	-0.3769	0.9376	-0.3702
BOL	0.9422	-0.0808	0.9248	0.1454
IDN	0.9594	-0.4016	0.9467	-0.0416
THA	0.9641	-0.0629	-0.0528	-0.1095
CZE	0.9690	0.2379	0.7534	0.1998
PER	0.9750	-0.1294	0.8032	-0.1176
MEX	0.9787	-0.1929	0.9195	-0.0427
COL	0.9820	-0.2638	0.9750	-0.3392
ZAF	0.9879	-0.1354	NaN	NaN
BRA	0.9886	-0.0337	0.9847	-0.1742
TUR	0.9894	-0.0375	0.9439	0.1335
KOR	0.9940	-0.3977	0.9336	-0.5720
SVK	0.9903	-0.5201	0.6202	-0.0422
ISR	0.9932	-0.1174	NaN	NaN
POL	0.9943	0.0082	0.9921	-0.7562
Average	0.8466	-0.1149	0.7635	-0.1228
Median	0.9594	-0.1294	0.9195	-0.1095

Notes: i^p is the central bank policy rate, i^{mm} is the money market rate and i^d is the deposit rate, all at quarterly frequency. Data is sorted by monetary policy transmission effectiveness (i.e. the correlation between policy rate and money market rate $Corr(i^p, i^{mm})$) in ascending order.

We further note that the correlation between monetary policy transmission gap — calculated as the difference between central bank policy rate and money market or deposit rate (i.e. $i^p - i^{mm}$ or $i^p - i^d$) — is negatively correlated with global financial risk for an average emerging country. This suggests that during the booming phase of global financial cycle (i.e. VIX is low), money market or deposit rate is lower than the policy rate and during the risk-off period (i.e. VIX is high), money market or deposit rate is higher than the intended policy rate. Fig. 11 confirms that this indeed is the case. Both Panel (a) and (b) feature a prominent dip in the difference between policy rate and money market or deposit rate during the onset of Global Financial Crisis. Especially, the difference turns negative for money market rate, suggesting higher than desired money market rate likely driven by global financial risk surge and credit crunch. The difference between policy rate and money market rate peaked around 2017 3rd quarter within the period. Correspondingly, the VIX also posted the lowest level ever in October 2017.

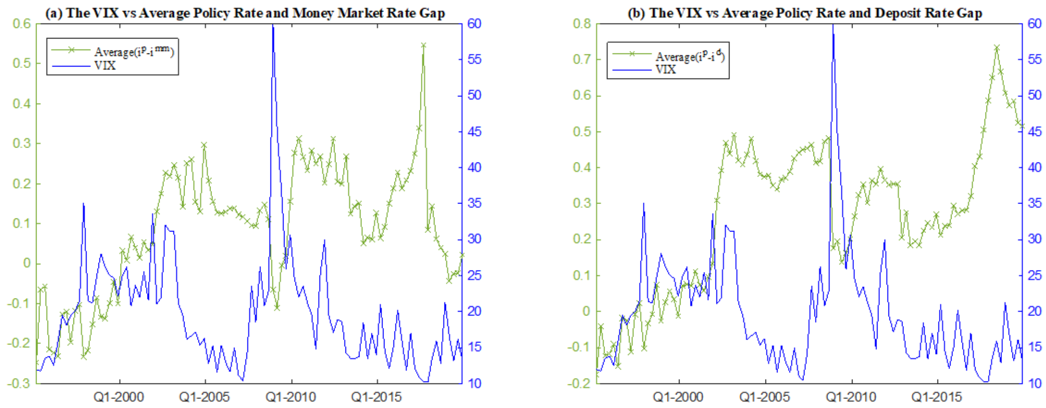

Figure 11: The VIX and monetary policy transmission gap. Notes: In Panel (a) policy transmission gap is measured as the average difference between central bank policy rate and money market rate. In Panel (b) policy transmission gap is measured as the average difference between central bank policy rate and deposit rate.

Fig. 12 (f) below plots the impulse response of interest rate spread over policy rate following a one standard deviation contractionary US monetary shock. The impulse responses are obtained by re-estimating the VAR system (1) with UIP deviation replaced by the difference between (log) money market rate and (log) central bank policy rate. An increase in the interest rate spread thus means market rate is higher than policy rate, and signals tightened monetary condition due to factors other than domestic monetary policy stance. On impact, US monetary tightening does not have much effect on domestic monetary transmission effectiveness, but as horizon extends and VIX rises above zero, interest rate spread over policy rate also increases. Overall, however, the impact is significant at 68% but not at 90% confidence level.

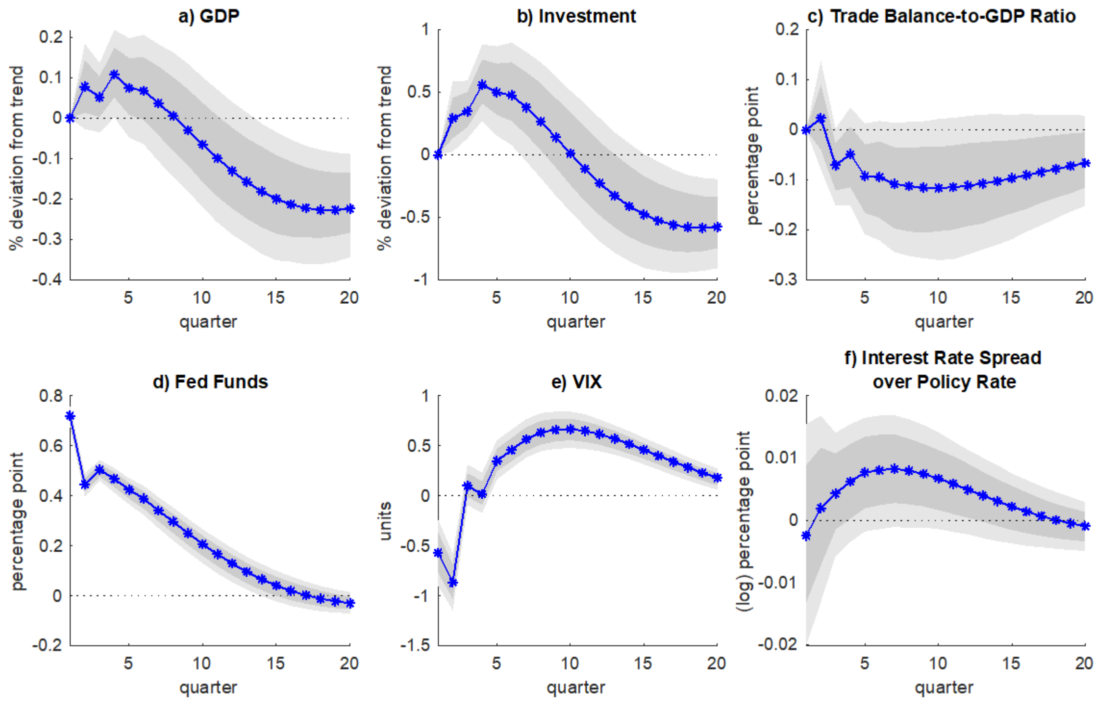

Figure 12: Impulse responses to a one standard deviation contractionary shock to Fed Funds. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses. Interest rate spread over policy rate is the difference between (log) money market rate and (log) central bank policy rate.

4 Transmission to Private Sector Financing Cost

In this section, we study the transmission of financial shocks to financing costs faced by the private sector at EMEs. To measure private sector financing cost, we use the level of domestic lending rate obtained from IMF IFS which is the rate commercial banks charge to nonbank borrowers on new loans with a maturity ranging from 3 – 6 months[21] . We re-estimate the panel VAR system (1) by replacing the last variable UIP deviation (ρ_t) with de-trended domestic log lending rate lr_t:

$$y_{i,t} = [\widehat{gdp_{i,t}}, \widehat{inv_{i,t}}, tby_{i,t}, R_t^{us}, VIX,\ lr_t], \tag{4}$$

and

[21] Another candidate measure for private sector financing cost is the lending spread defined as either the difference between banks' (log) lending rate and (log) deposit rate or the difference between (log) lending rate and (log) money market rate. One caveat for using lending spread, however, is that when lending spread increases it's unclear whether the increase is truly due to surge in banks' lending rate or decrease in banks' borrowing rate. Indeed, by augmenting the baseline VAR system (1) with lending spread ordered before UIP deviation ρ_t (ordering following Akinci (2013) in which lending spread measured as the difference between the domestic lending rate and the deposit rate is ordered before a measure of country spread), impulse responses show that while VIX shock unambiguously raises UIP deviation and lending spread thus depressing domestic GDP and investment, shock to lending spread leads to a decrease in UIP deviation and an increase in GDP and investment — a result that contradicts intuition. This is likely due to banks' lending rate to private sector moves more slowly than money market rate, and within the same period they often negatively correlate with each other. Lending rate and deposit rate are retrieved from IMF IFS via CEIC database.

$$\varepsilon_{i,t} = [\varepsilon_{i,t}^{gdp}, \varepsilon_{i,t}^{inv}, \varepsilon_{i,t}^{tby}, \varepsilon_{i,t}^{R^{us}}, \varepsilon_{i,t}^{VIX}, \varepsilon_{i,t}^{lr}].$$

Fig. 13 to Fig. 15 display the impulse responses to a one standard deviation shock to US Fed Funds rate, global financial risk and domestic lending rate respectively. The responses of domestic real variables are qualitatively similar to the baseline case. In response to a one standard deviation contractionary shock to real effective Fed Funds rate, domestic output and investment decreases while domestic lending rate increases — albeit the increase is much smaller in magnitude compared to the increase in domestic interest rate shown in Fig. 8. This again provides evidence for policy trilemma *invalidity* and that changes in US interest rate does transmit to domestic financing costs. We highlight that the co-movement between domestic lending rate and US interest rate reflects features of the underlying data. Lending rate is a slower-moving and less volatile rate compared to domestic (or US) money market rate—nevertheless, for most of the countries domestic lending rate tracks the money market rate which in turn tracks US money market rate.

Fig. 14 shows that in response to a one standard deviation increase in the VIX, domestic lending rate decreases. This is likely due to the easing of domestic interest rate. As noted previously, both US interest rate and domestic interest rate moves in a way that counters the global financial cycle. Fig. 15 shows that in response to a one standard increase in domestic lending rate, domestic output and investment contracts while trade balance improves.

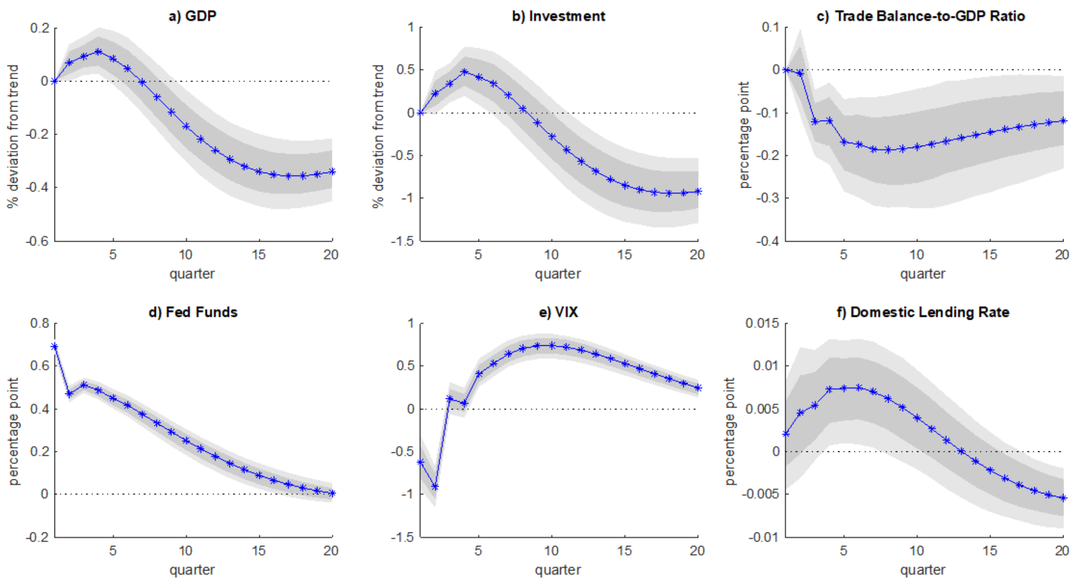

Figure 13: Impulse responses to a one standard deviation contractionary shock to Fed Funds—with lending rate. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

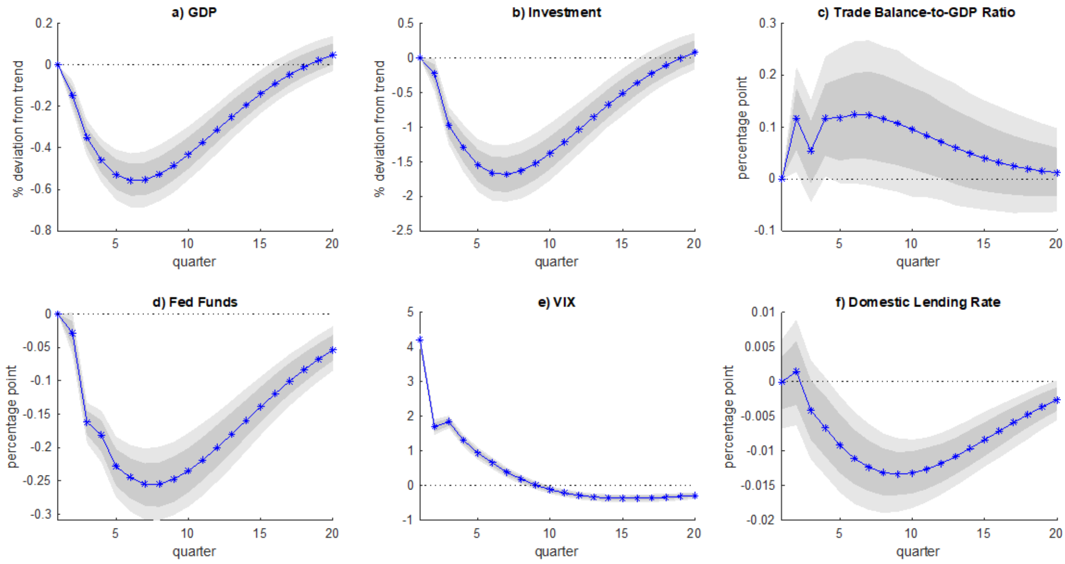

Figure 14: Impulse responses to a one standard deviation contractionary shock to the VIX—with lending rate. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

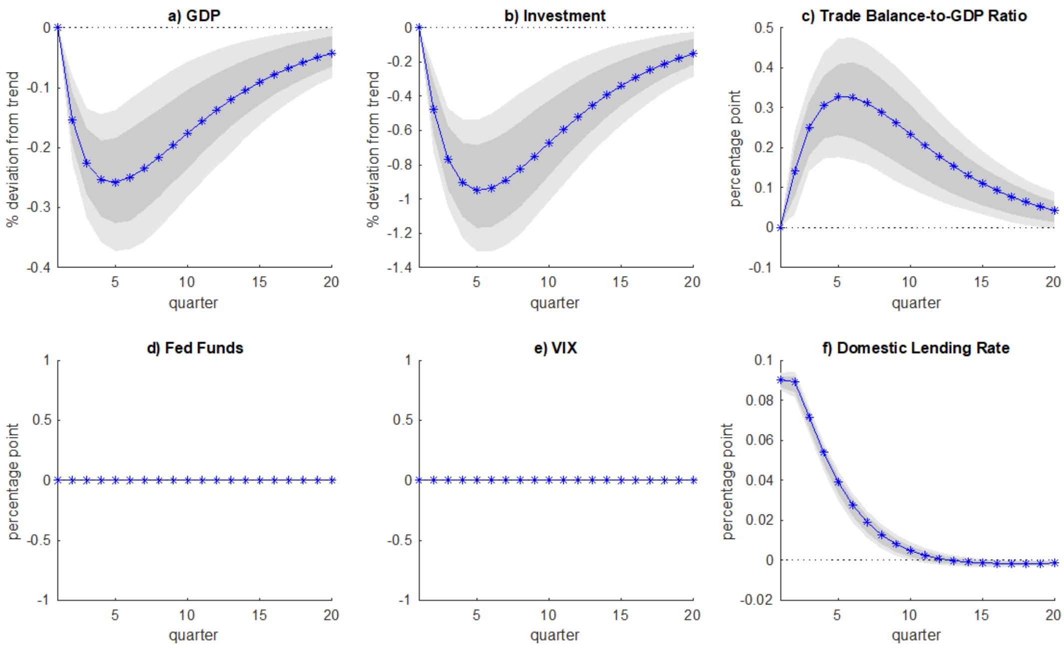

Figure 15: Impulse responses to a one standard deviation contractionary shock to lending rate. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

5 Credit Flows into Emerging Countries

In this section, we study how credit inflows to EMEs are affected by US monetary shocks and global financial risk shocks. To do so, we augment the VAR system (1) with credit inflow ordered between trade balance-to-GDP ratio and real Fed Funds. Again, we focus on the partial identification of US monetary shock and VIX shock only, and the ordering of credit inflow before Fed Funds rate rests upon the idea that credit flow may take time to adjust. We use de-trended total cross-border claims denominated in US dollar on the country retrieved from BIS locational banking statistics (LBS) as credit inflows.

Fig. 16 shows that following a contractionary US monetary shock, as VIX increases, credit inflow decreases. Unsurprisingly, Fig. 17 shows that following an increase in VIX, credit flow decreases significantly. Impulse responses of other variables remain similar to the previous specifications. Variance decomposition in Fig. 18 shows that VIX shock is a major factor driving credit inflow changes and explains around 10% of the variations in dollar denominated credit inflow. In the Appendix, we show that the impulse responses we obtained are robust to re-ordering credit inflow after UIP deviation (see Fig. A3 and A4).

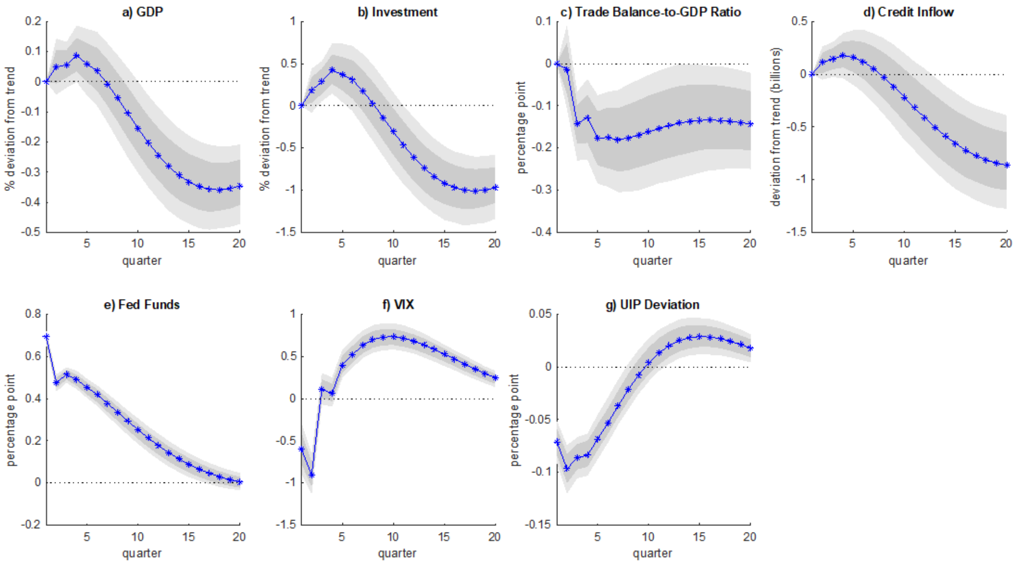

Figure 16: Impulse responses to a one standard deviation contractionary shock to Fed Funds—with credit inflow. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

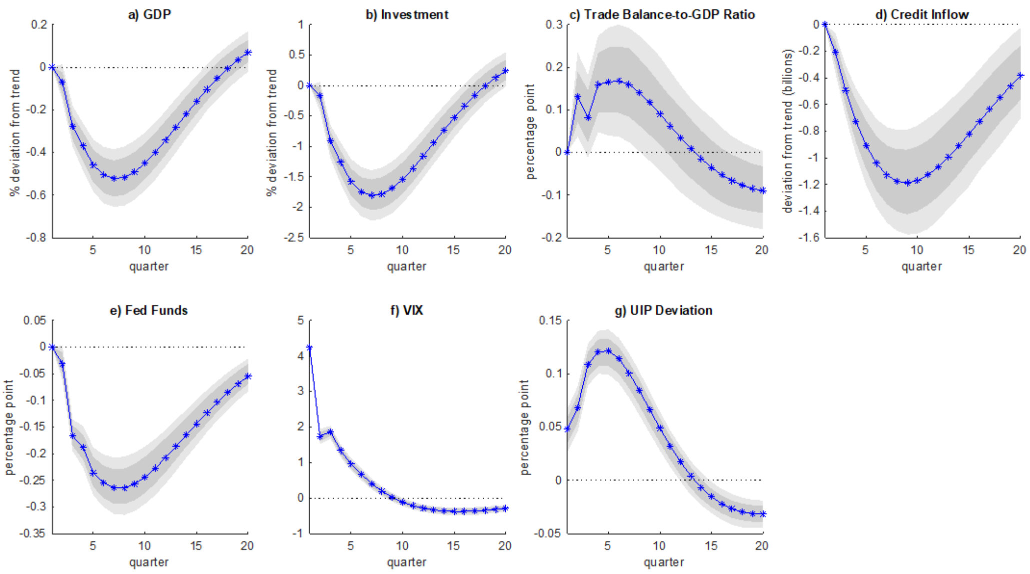

Figure 17: Impulse responses to a one standard deviation contractionary shock to VIX—with credit inflow. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

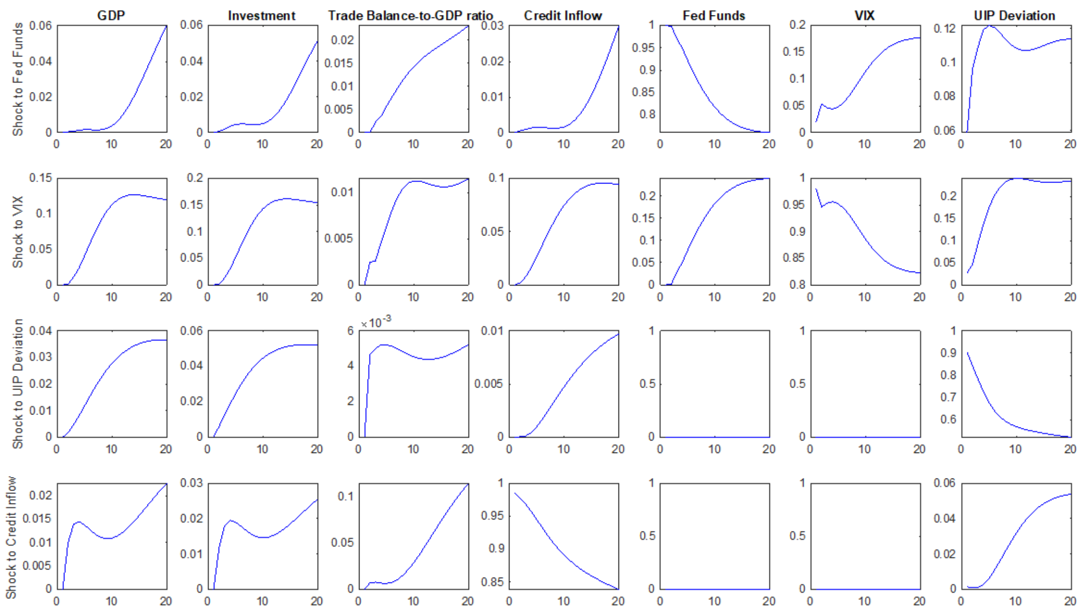

Figure 18: Forecast error variance decomposition. Notes: Solid lines show the fraction of the h-period ahead forecast error variance explained by the Fed Funds shocks (first row), by global financial risk shocks (second row), by UIP deviation shocks (third row), and by credit inflow shocks (fourth row). Hong Kong is excluded.

6 Robustness and Additional Checks

The results we have obtained so far depends on (1) a particular sample period (pre-Global Financial Crisis period); (2) the choice of fixed effect estimator and (3) a particular measure of global financial risk, the VIX; and (4) the Cholesky identification method. We now test the robustness of our main results to alternative sample periods, estimation methods, alternative global financial risk measures, and alternative identification methods.

6.1 Alternative Sample Period

We extend the sample length to 2019 Q4 and check whether the baseline results still hold when post-Global Financial Crisis (GFC) period is also included. Fig. 19 to Fig. 21 show that while impulse responses to the VIX shock and UIP deviation shock remains similar, impulse responses to a contractionary US monetary policy shock slightly differ from the ones using pre-GFC sample only. UIP deviation decreases and does not revert to zero by the twentieth quarter. Finally, Fig. 22 shows that VIX is still the dominating global financial variable that affects domestic real economy and UIP deviation over this longer sample.

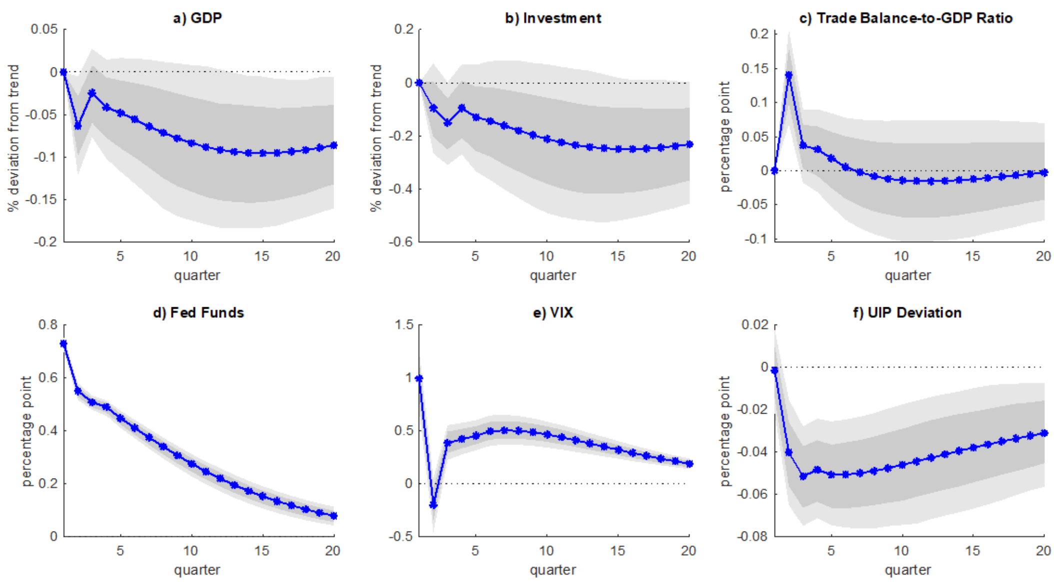

Figure 19: Impulse responses to a one standard deviation contractionary shock to Fed Funds — longer sample period. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Sample period: 1995 Q4 – 2019 Q4.

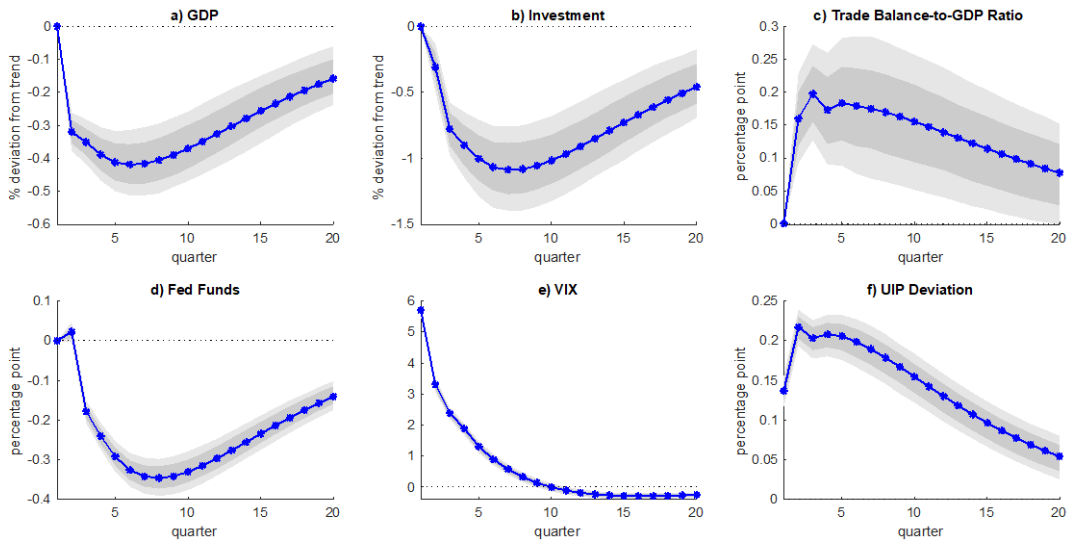

Figure 20: Impulse responses to a one standard deviation shock to VIX — longer sample period. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Sample period: 1995 Q4 – 2019 Q4.

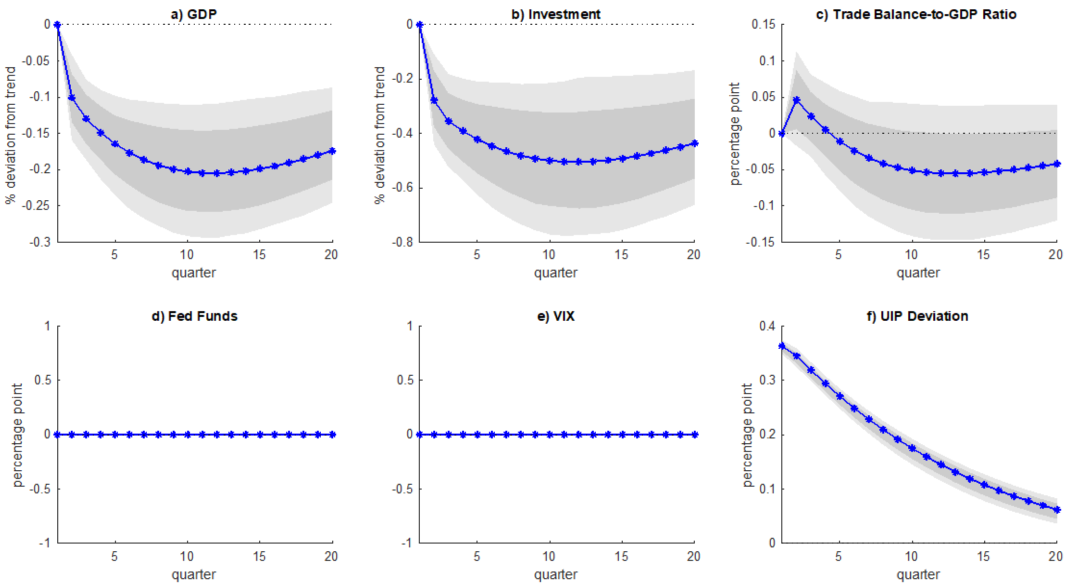

Figure 21: Impulse responses to a one standard deviation shock to UIP deviation — longer sample period. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Sample period: 1995 Q4 – 2019 Q4.

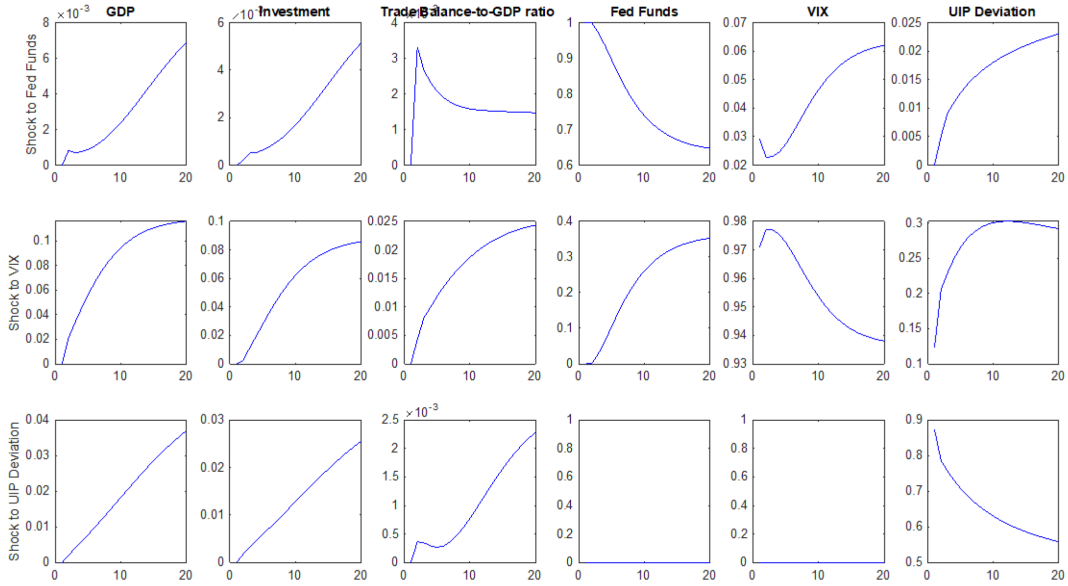

Figure 22: Forecast error variance decomposition — longer sample period. Notes: Solid lines show the fraction of the h-period ahead forecast error variance explained by the Fed Funds shocks (first row), by global financial risk shocks (second row) and by UIP deviation shocks (third row).

As post-crisis US monetary policy is at the zero lower bound and there are changes in policy communications, we also estimate the panel VAR using a sub-sample from 2010 Q1 to 2019 Q4 to take care of possible structural breaks. We use the shadow rate from Wu and Xia (2016) as a proxy for US monetary policy for this smaller sample. A key result shown in Fig. 23 is that the impulse response of the VIX to a one standard deviation contractionary US monetary policy shock is more muted, has its sign reversed and exhibits a persistent decrease — and this is why the impulse response of UIP deviation no longer overshoots above zero (see Fig.23)[22]. Fig. 24 shows that the responses of real variables to VIX shock also have their signs reversed. We also note that over the post-crisis period, the VIX accounts for a smaller fraction of variations in domestic GDP, investment and UIP deviation while US monetary policy accounts for a larger fraction[23] compared to the pre-crisis period as shown in Fig. 26.

[22] The finding that domestic interest rate increases following a contractionary US monetary policy shock still carries over to the subsample when we estimate the VAR again by replacing UIP deviation with domestic interest rate.

[23] Relatedly, Avdjiev et al. (2020) identifies 2009 Q1 as a structural break and that during the post-break period, the sensitivity of global liquidity to US interest rate increased and reached its peak around 2013 Fed "taper tantrum" period while the sensitivity to the VIX steadily declined.

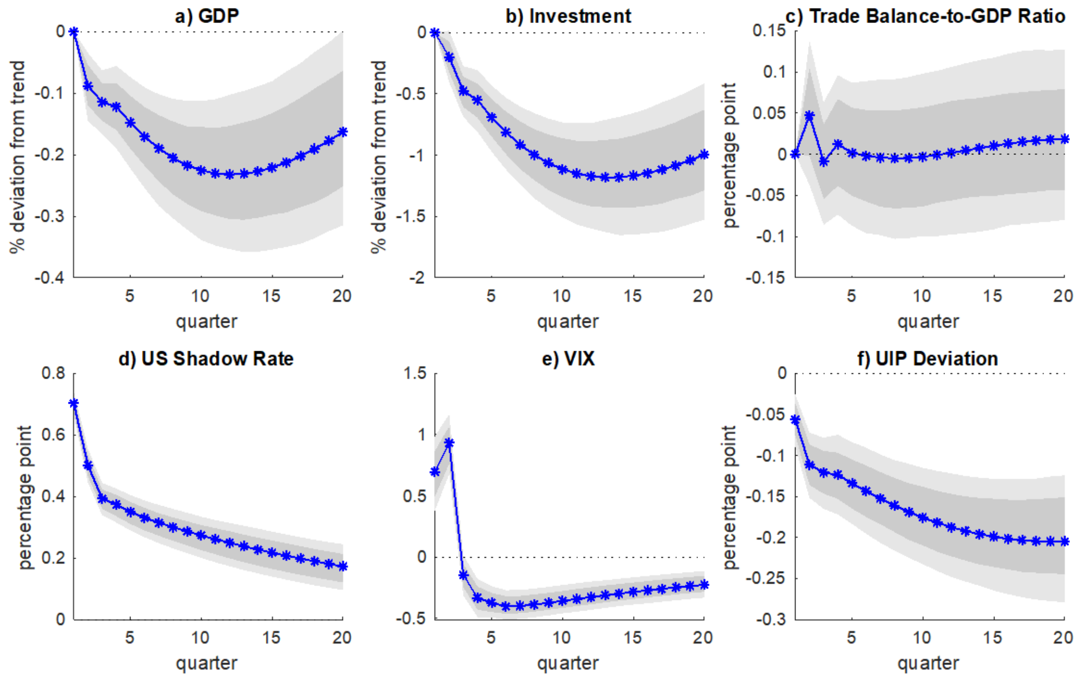

Figure 23: Impulse responses to a one standard deviation increase in Wu-Xia shadow rate. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Sample period: 2010 Q1 – 2019 Q4.

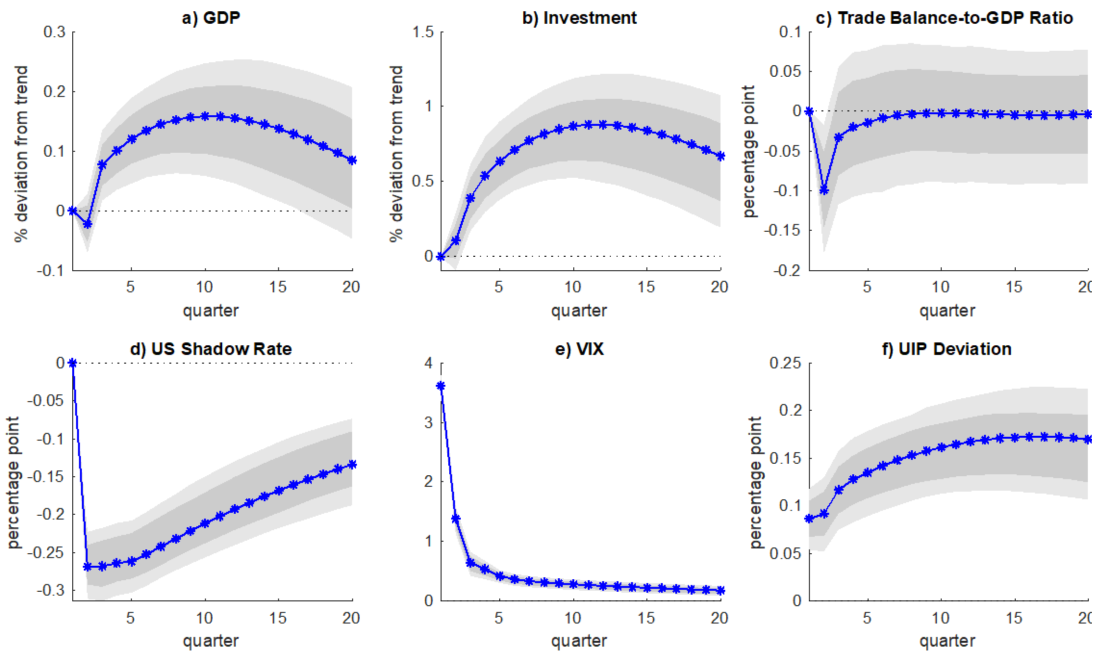

Figure 24: Impulse responses to a one standard deviation shock to VIX. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Sample period: 2010 Q1 – 2019 Q4.

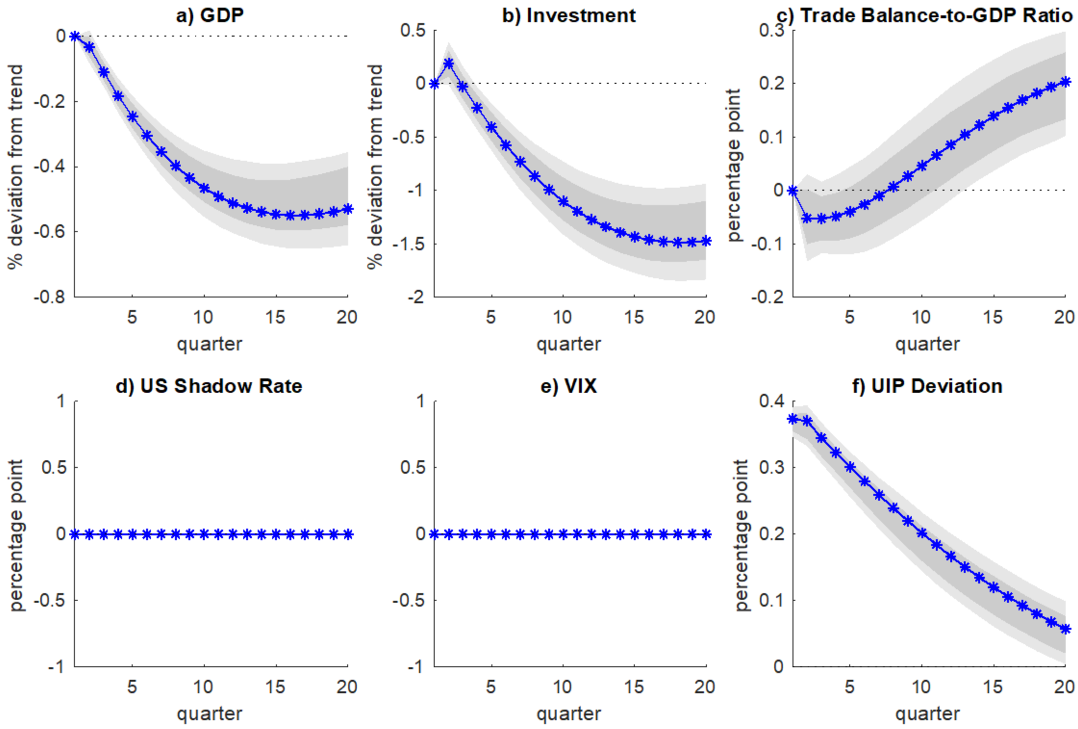

Figure 25: Impulse responses to a one standard deviation shock to UIP deviation. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Sample period: 2010 Q1 – 2019 Q4.

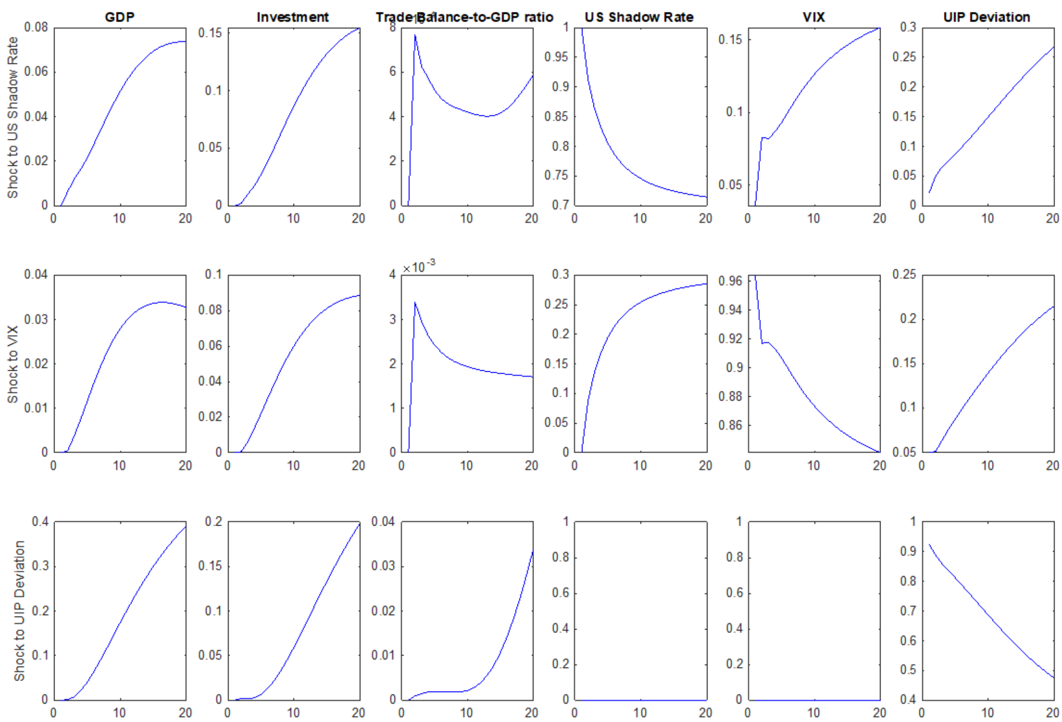

Figure 26: Forecast error variance decomposition — post-GFC period. Notes: Solid lines show the fraction of the h-period ahead forecast error variance explained by the Fed Funds shocks (first row), by global financial risk shocks (second row) and by UIP deviation shocks (third row).

6.2 Alternative Estimation Methods

Fixed effect estimator could be biased if the true slope parameters are also heterogeneous across the sample countries. We thus re-estimated the VAR model with mean group estimator proposed in Pesaran and Smith (1995) and confirm that our baseline results are not sensitive to this alternative estimation method. Specifically, we estimate the VAR model country-by-country and average their impulse responses. Hong Kong was excluded from this exercise. Colombia and Egypt were excluded for having missing values. In Fig. 27 and Fig. 28 below, starred solid lines are the mean impulse responses and grey lines are the impulse responses of the individual sample countries. The impulse responses of the real variables and UIP deviation to contractionary US monetary shocks and VIX shocks remain qualitatively similar to results obtained using fixed effect estimator.

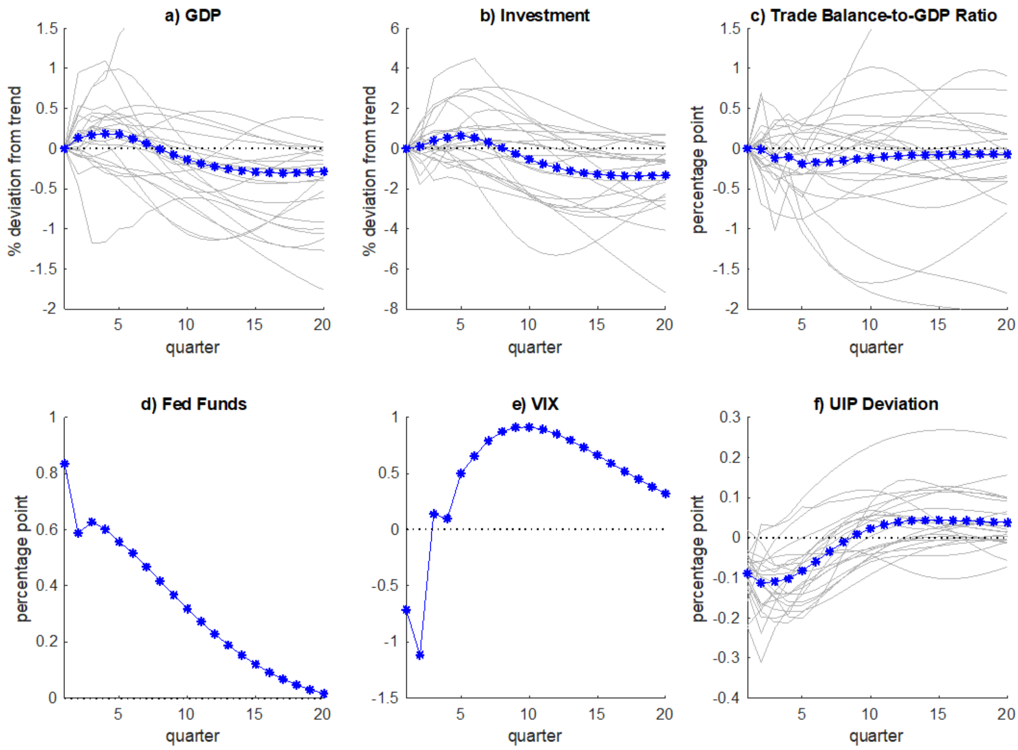

Figure 27: Impulse responses to a one standard deviation contractionary US Fed Funds shock. Notes: Starred solid lines are the mean impulse responses. Light grey lines are the impulse responses of 23 sample countries (Colombia, Egypt and Hong kong excluded).

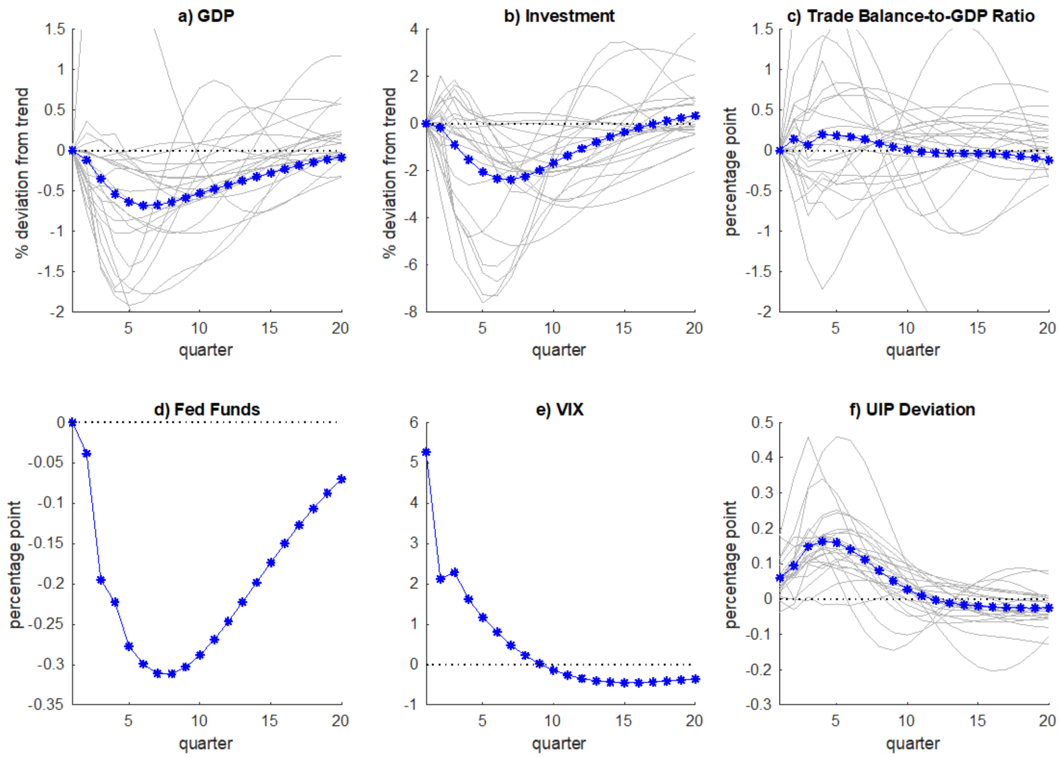

Figure 28: Impulse responses to a one standard deviation shock to VIX. Notes: Starred solid lines are the mean impulse responses. Light grey lines are the impulse responses of 23 sample countries (Colombia, Egypt and Hong kong excluded).

Another potential issue with using fixed effect estimator (or LSDV estimator) is that least squares estimates might be inconsistent due to endogeneity caused by unobserved country fixed effect and lagged dependent variables, but the estimation bias decreases in time dimension T. Thus, for large T panels, LSDV estimator is suitable. A widely used alternative estimation method is Arellano Bond estimator which uses a mixed combination of "GMM-style" and standard instrument variables to deal with endogeneity. We thus re-estimate the panel VAR model (1) using Arellano Bond estimator (GMM). For each equation, variables ordered before the dependent variable are treated as predetermined variables and variables that are ordered after the dependent variable are treated as endogenous variables. It is known that for large T panels, using too many instruments may lead to finite sample bias similar to fixed effects estimator. Thus, as an alternative specification we limit the maximum number of lags for GMM-style instruments to be four (GMM: Max Lag=4). We find that that the impulse responses using GMM and GMM: Max Lag=4 mostly lie within 90% bootstrap bands of impulse responses generated using LSDV estimator.

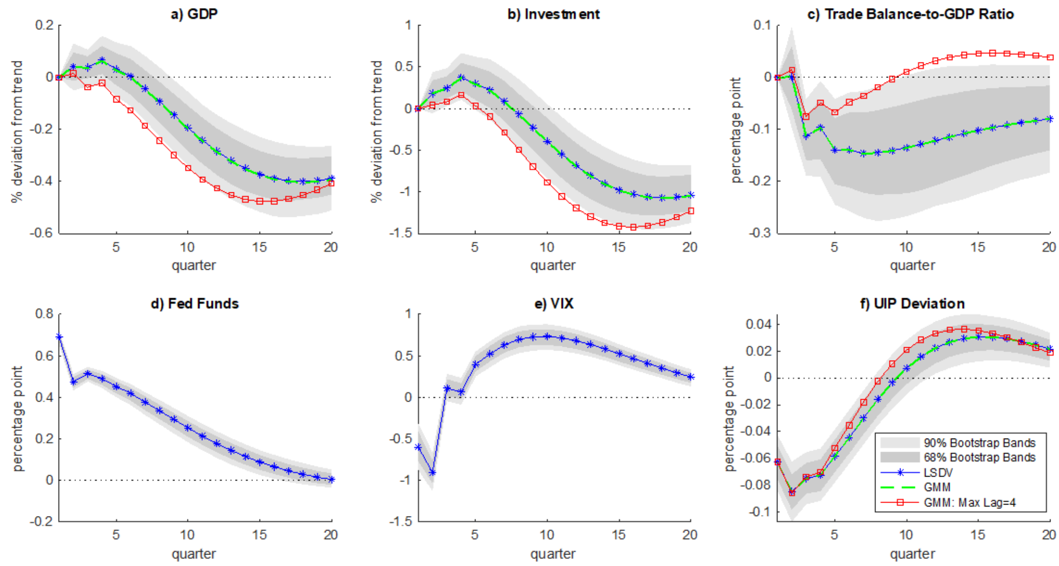

Figure 29 Impulse responses of GDP, investment, trade balance-to-GDP ratio and UIP deviation to one standard deviation contractionary shock to Fed Funds. 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. The blue starred lines are LSDV point estimates, green dashed lines are GMM point estimates, red squarred lines are GMM: Max Lag=4 point estimates.

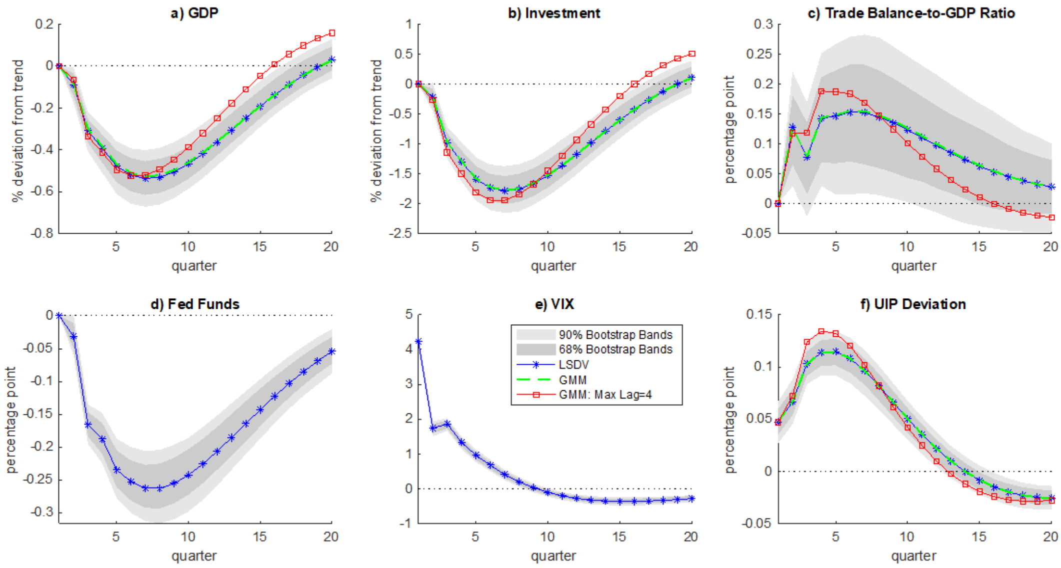

Figure 30: Impulse responses of GDP, investment, trade balance-to-GDP ratio and UIP deviation to one standard deviation shock to the VIX. 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. The blue starred lines are LSDV point estimates, green dashed lines are GMM point estimates, red squarred lines are GMM: Max Lag=4 point estimates.

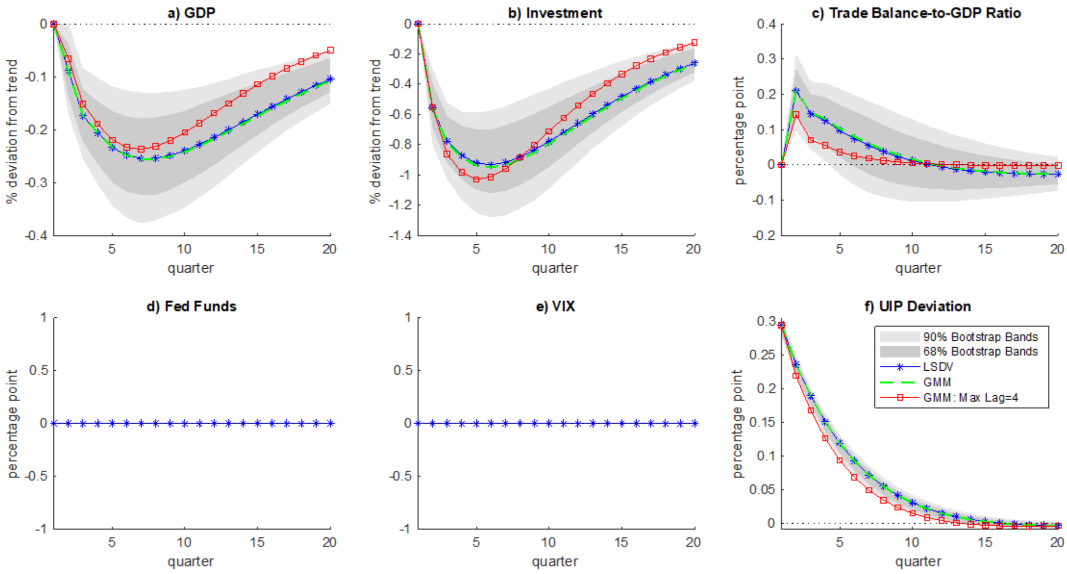

Figure 31: Impulse responses of GDP, investment, trade balance-to-GDP ratio and UIP deviation to one standard deviation shock to UIP deviation. 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. The blue starred lines are LSDV point estimates, green dashed lines are GMM point estimates, red squarred lines are GMM: Max Lag=4 point estimates.

6.3 Alternative Global Financial Risk Measures

In this section we consider two alternative proxies for global financial risk: (1) average cross-sectional credit spread on senior unsecured corporate bonds issued by nonfinancial firms constructed by Gilchrist and Zakrajšek (2012)(GZ spread); and (2) the difference between Baa- and Aaa-rated long-term corporate bond yields. Fig. 32 and Fig. 33 show that our main results hold that one standard deviation shocks to Fed Funds and proxies of global financial risk lead to a reduction in real GDP and investment.

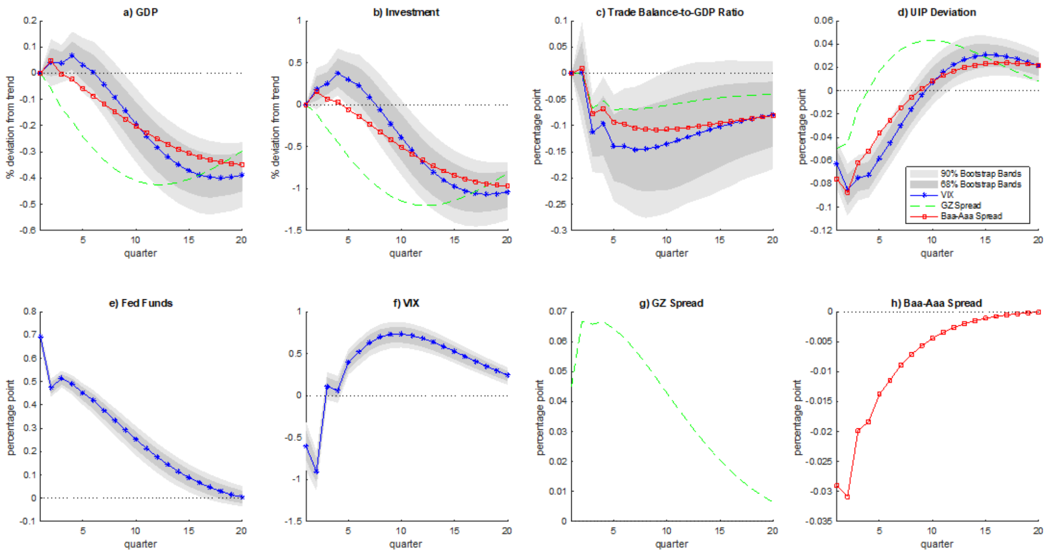

Figure 32: Impulse responses to a one standard deviation contractionary shock to Fed Funds—with alternative global financial risk measures. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000

replications. The starred lines are point estimates using VIX as the risk proxy, dashed lines are point estimates using GZ spread as the risk proxy, squarred lines are point estimates using Baa-Aaa spread as the risk proxy.

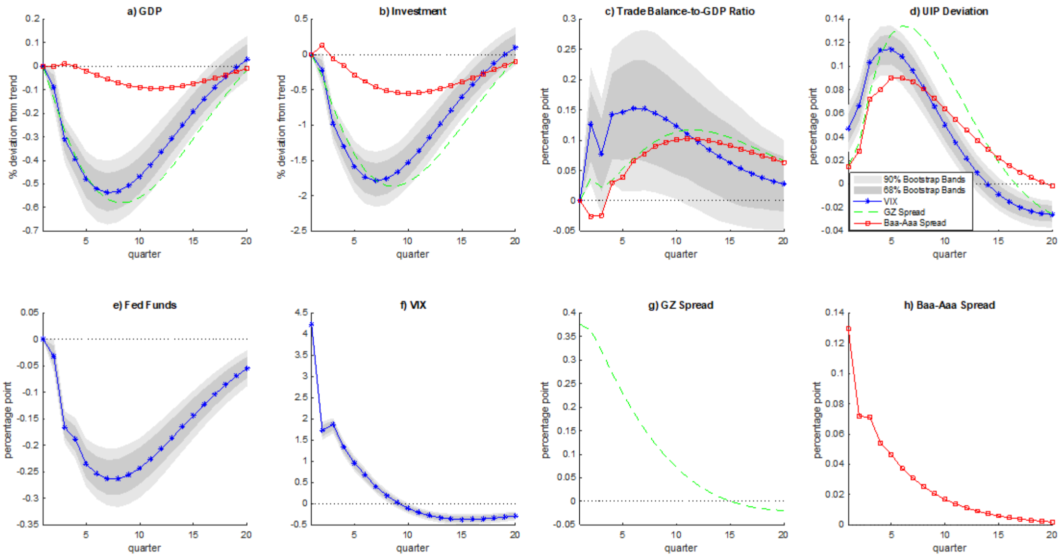

Figure 33: Impulse responses to a one standard deviation increase in the global financial risk— with alternative global financial risk measures. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. The starred lines are point estimates using VIX as the risk proxy, dashed lines are point estimates using GZ spread as the risk proxy, squarred lines are point estimates using Baa-Aaa spread as the risk proxy.

6.4 Alternative Identification

So far, our identification has largely rested upon the recursive structure of the VAR adopted. In this section, we identify US monetary shock using a narrative approach. We use Romer and Romer (2004) shock series extended to December 2007 by Miranda-Agrippino and Rey (2015). Romer and Romer (2004) shock series are residuals from regressing changes in the intended funds rate on Greenbook forecasts on FOMC meeting dates, which are then converted to monthly frequency. By construction, it should be relatively free of policymakers' anticipation of future paths of macroeconomic variables. We further summed the monthly shock series into quarterly frequency, and augmented our baseline panel VAR model by ordering it before Fed Funds rate[24], so that we have a tri-variate exogenous block consisting of the Romer and Romer (2004) shock series, Fed Funds rate, and the VIX.

Figure 34 below show the point estimates of impulse responses of the endogenous variables in green dashed lines. The estimated dynamics are largely similar to our baseline results.

[24] Here we follow Ramey (2011) in ordering the external instrument, the Romer and Romer (2004) shock series in this case, first in the tri-variate exogenous variable block. In two separate exercises, we also used three alternative instruments (all summed to quarterly frequency), including Gertler and Karadi's (2015) three month ahead Fed Funds futures surprises around FOMC announcements summed to monthly series, the same monthly Gertler and Karadi series but purged of Greenbook forecasts by Ramey (2016), and the monthly informationally robust instrument by Miranda-Agrippino and Ricco (2021), in the VAR framework ordered before Fed Funds rate. The results are largely similar. Further, using the latter three instruments in a proxy VAR framework yields similar dynamics of UIP deviation.

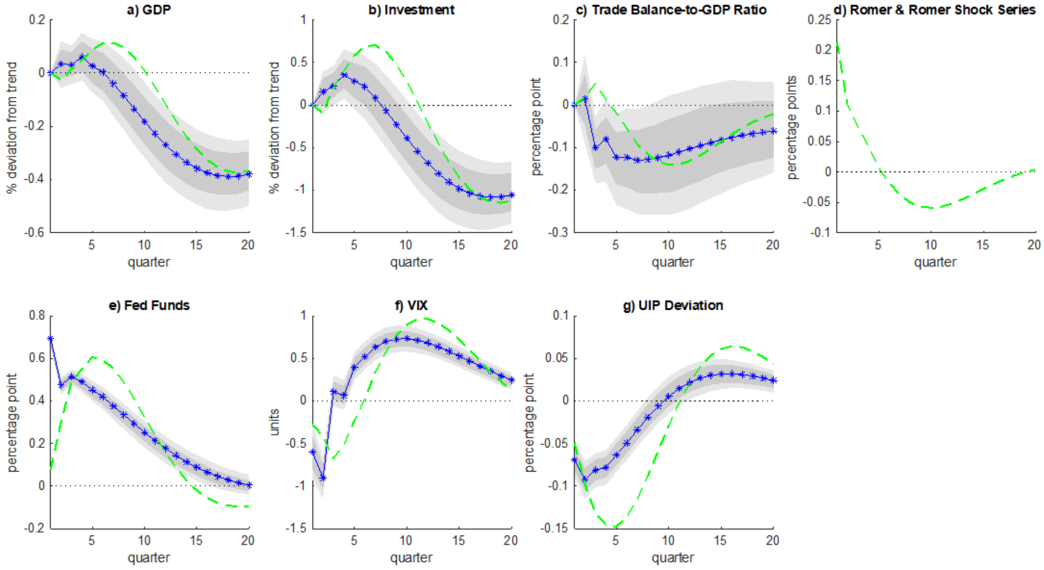

Figure 34: Impulse responses to a one standard deviation (around 20 basis point) increase in the Romer and Romer (2004) shock series. Notes: Green dashed lines are the point estimates of the impulse responses to a one standard deviation increase in the Romer and Romer (2004) shock series. The starred lines are point estimates of the baseline model.

6.5 Sign Asymmetry

In this section we modify the baseline VAR system (1) and allow asymmetric impulse responses following contractionary and expansionary US monetary policy shocks. Since variance decompositions show that domestic real variable shocks are not significant factors influencing the variations in the financial variables (i.e. UIP deviation and domestic interest rate), we hence specify and estimate a three-variable VAR instead of the full model so as to keep the VAR system parsimonious for the period from 1995 Q4 to 2007 Q4. As impulse responses in nonlinear models are dependent on the history of the observations and on the magnitude of the shocks, we follow Kilian and Vigfusson (2011) in simulating generalized impulse responses.

Figure 35 displays the impulse responses to one standard deviation shock to real US effective Fed Funds rate. The starred lines are the impulse responses to an expansionary US Fed Funds shock with the sign reversed for ease of comparison, and the circled lines are impulse responses to a contractionary US Fed Funds shock. There does not seem to be much asymmetry in terms of the magnitude in peak or trough response of EME domestic interest rate[25].

We then ask whether the responses of EME interest rate and Fed Funds are asymmetric to positive (global financial risk hike) and negative (global financial risk reduction) shock to the VIX. To this end, the three variable VAR model is re-estimated with responses of Fed Funds and EME interest rate contingent on the change in the VIX being positive or negative. Again, the shock size to the VIX is set to be one standard deviation. Figure 36 shows that not only the magnitude of (sign-reversed) peak

[25] We also checked the impulse response to 3-, 5-, and 10-standard deviation shocks to Fed Funds and as noted in Kilian and Vigfusson (2011), as the shock size increases, the asymmetry also becomes more prominent.

response of domestic interest rate in response to a decrease in the VIX is larger than the trough response of domestic interest rate in response to an increase in the VIX, domestic interest rate responds faster to a decrease in the VIX than an increase as well. Three quarters after a reduction in the VIX, the increase in domestic interest rate is close to the increase in Fed Funds rate while three quarters after an increase in the VIX the change in domestic interest rate is not much different from zero[26].

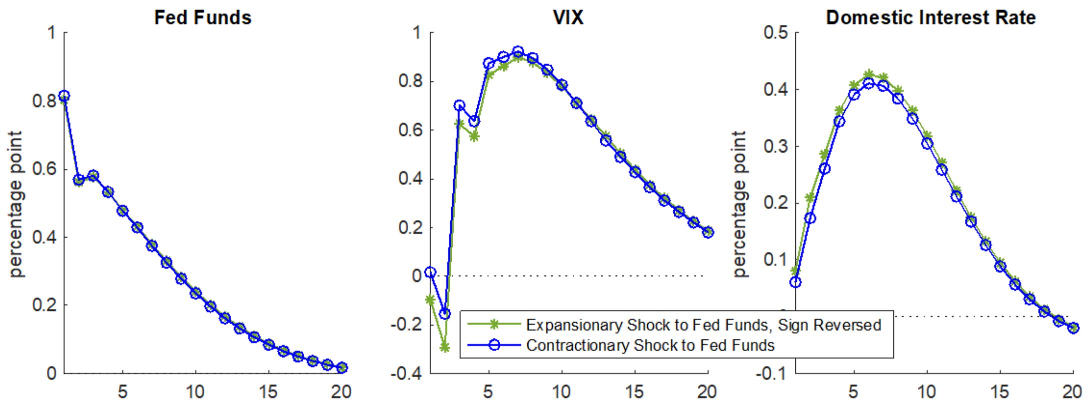

Figure 35: Impulse responses of the VIX and domestic interest rate to a one standard deviation expansionary (starred line) and contractionary (circled line) shock to US effective Fed Funds rate.

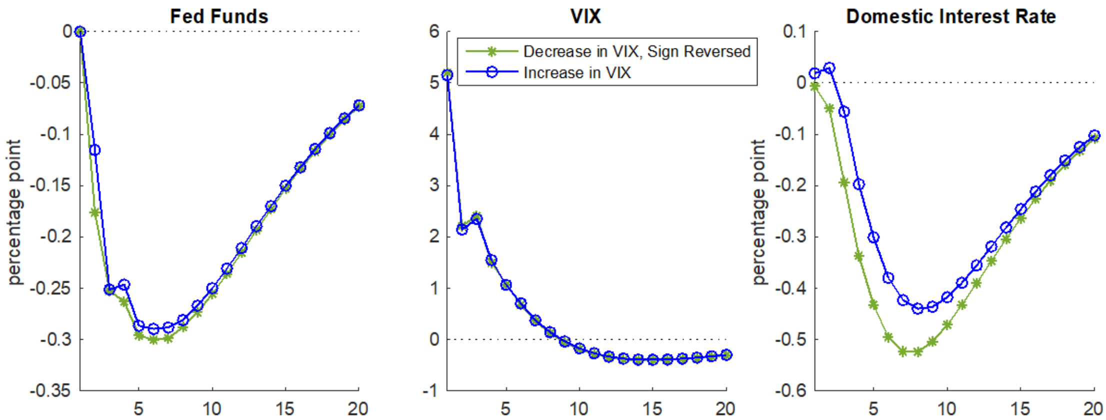

Figure 36: Impulse responses of the VIX and domestic interest rate to a one standard deviation expansionary (starred line) and contractionary (circled line) shock to US effective Fed Funds rate.

7 Conclusion

[26] We interpret the results to be suggesting that EM countries are concerned of possible valuation losses when global financial risk is high and are constrained in easing interest rates, since typically during crisis period capital flows out of the country and asset price drops. In contrast, EME interest rate response is faster and larger when global financial risk is low. The implication follows that policy makers should take advantage of more ample policy space when global financial risk is low and make preparation during "good times" by accumulate reserves so they can serve as buffer during crisis periods, or to deflate housing bubbles early.

This paper examines international transmission of conventional US monetary policy and global financial risk spillover to a sample of twenty-six emerging countries. We find that domestic interest rates of emerging countries track US interest rate in a way that counters the global financial cycle proxied by the VIX. We further show that the changes in emerging countries' interest rates, however, are limited by global financial risk conditions which results in a differential between domestic and US interest rate that co-moves with the global financial cycle. We provide possible explanations for the predictability reversal puzzle put forth in Engel (2016). Namely, the one-period ahead excess return is positively correlated with interest rate differential at time t, but this correlation reverses sign as the horizon extends. We show that key to predictability reversal is the high dependence of UIP deviation on VIX. We also provide evidence for the transmission of US monetary shocks and risk spillovers to emerging countries' private sector financing costs. An increase in US Fed Funds rate is followed by an increase in emerging countries' lending rates, and an increase in global financial risk is followed by a decrease in emerging countries' lending rates, reflecting emerging countries' easing monetary policy stance. Cross-border credit flows into emerging countries also decrease following an increase in VIX. Through its impact on the global financial risk proxied by VIX, contractionary US monetary shock also contracts credit flows into emerging countries with a delay.

Overall, our results are consistent with the view that policy trilemma has morphed into a dilemma and that center economies' monetary policy may be imported to peripheral emerging economies. Given that US monetary shock can affect emerging country real economy through its impact on the VIX and UIP deviation, and that shocks to the VIX have large impacts on output and investment at emerging countries, the implications of our results echo Rey (2013) in that policy needs to tackle with changing global financial risk conditions and global financial cycles. Implementing capital control or macroprudential policies may be a useful option to curb capital flows as has been proposed in existing literature. More fundamentally, improving institutional quality, macroeconomic fundamentals and investors' confidence in the economy may be a long-term goal[27].

[27] Brunnermeier et al. (2020), for example, provides a discussion on the issuance of safe assets by emerging countries. The idea is to offer a safe asset that investors have confidence in under a multilateral initiative among a few emerging countries to tackle heightened risk under bad market conditions.

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Appendix A: Supplemental Figures and Tables

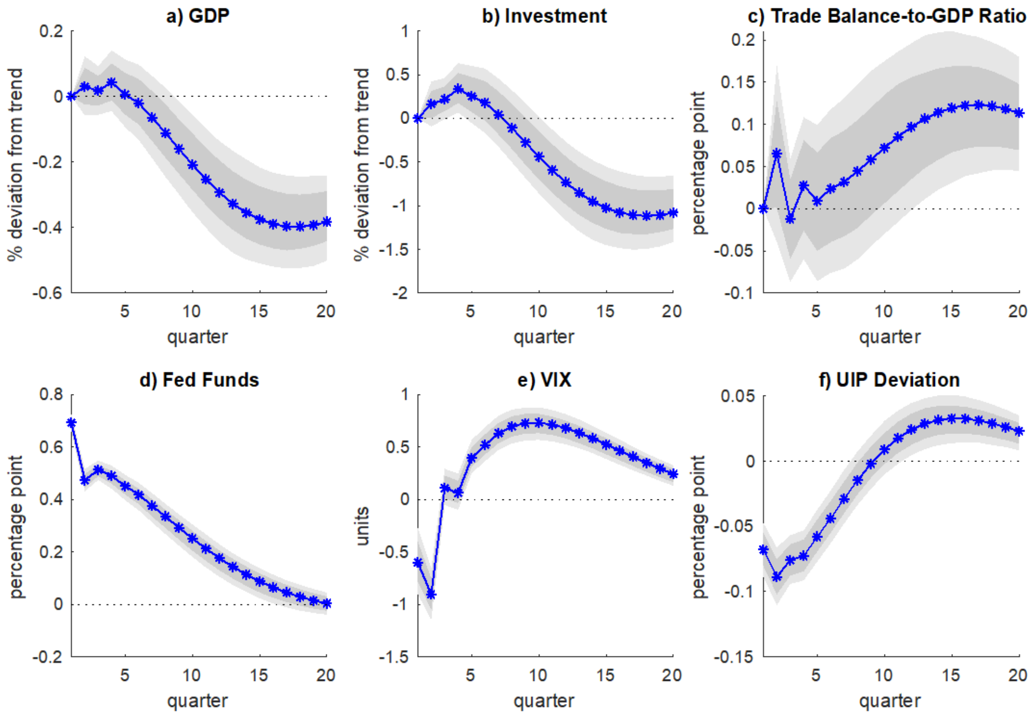

Figure A1: Impulse response to a one standard deviation contractionary shock to Fed Funds. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

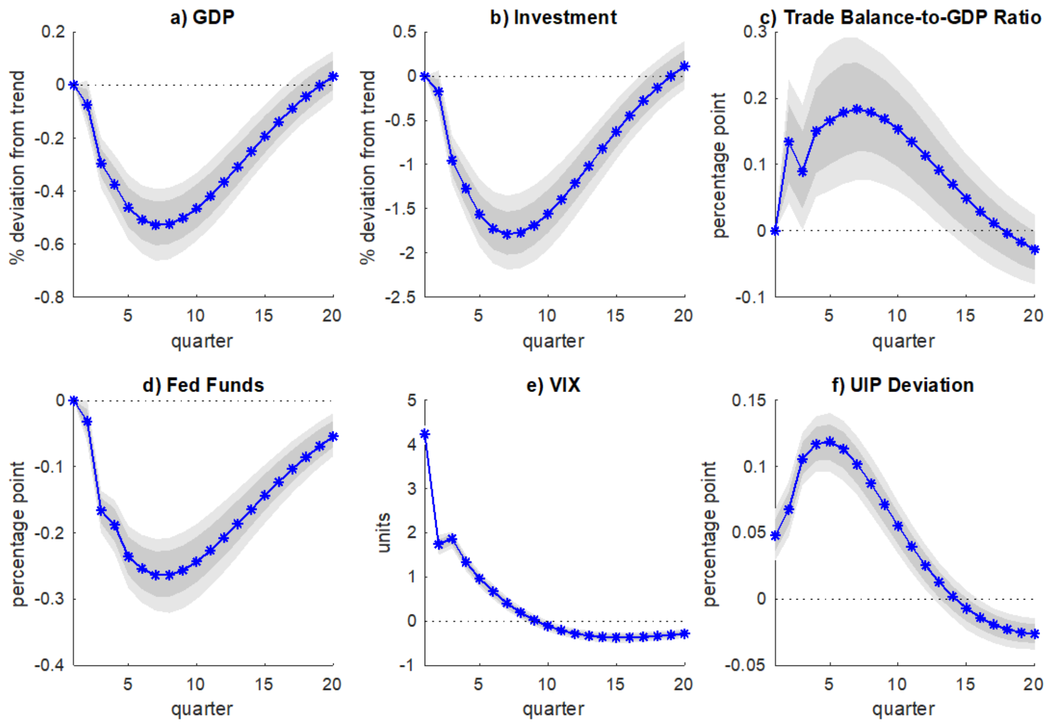

Figure A2: Impulse response to a one standard deviation shock to VIX. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

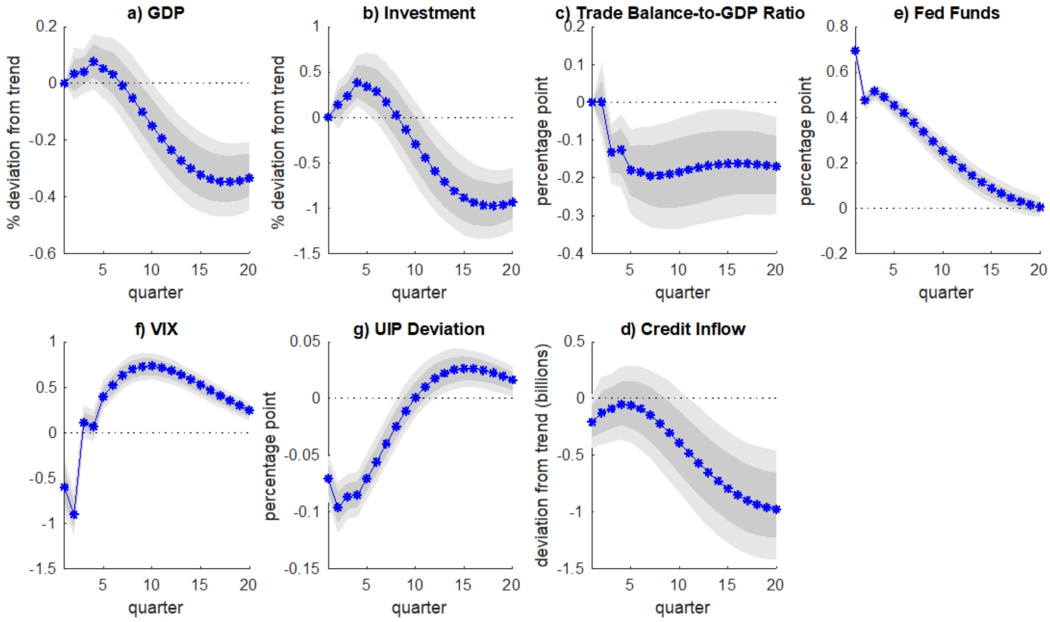

Figure A3: Impulse response to a one standard deviation contractionary shock to Fed Funds. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

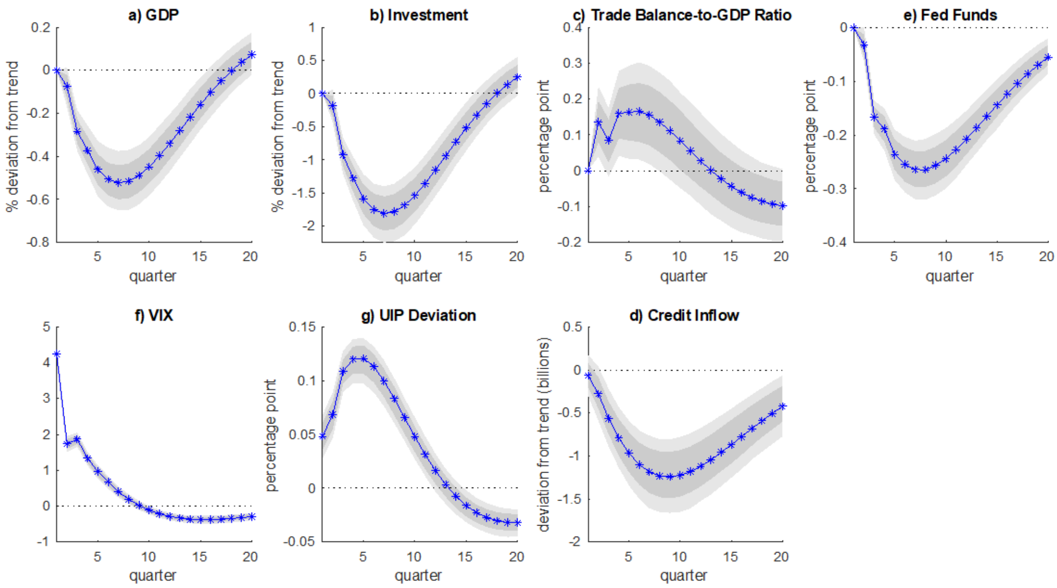

Figure A4: Impulse response to a one standard deviation shock to VIX. Notes: 68% (dark grey) and 90% (light grey) bootstrap confidence bands are shown with 1000 replications. Starred lines are point estimates of the impulse responses.

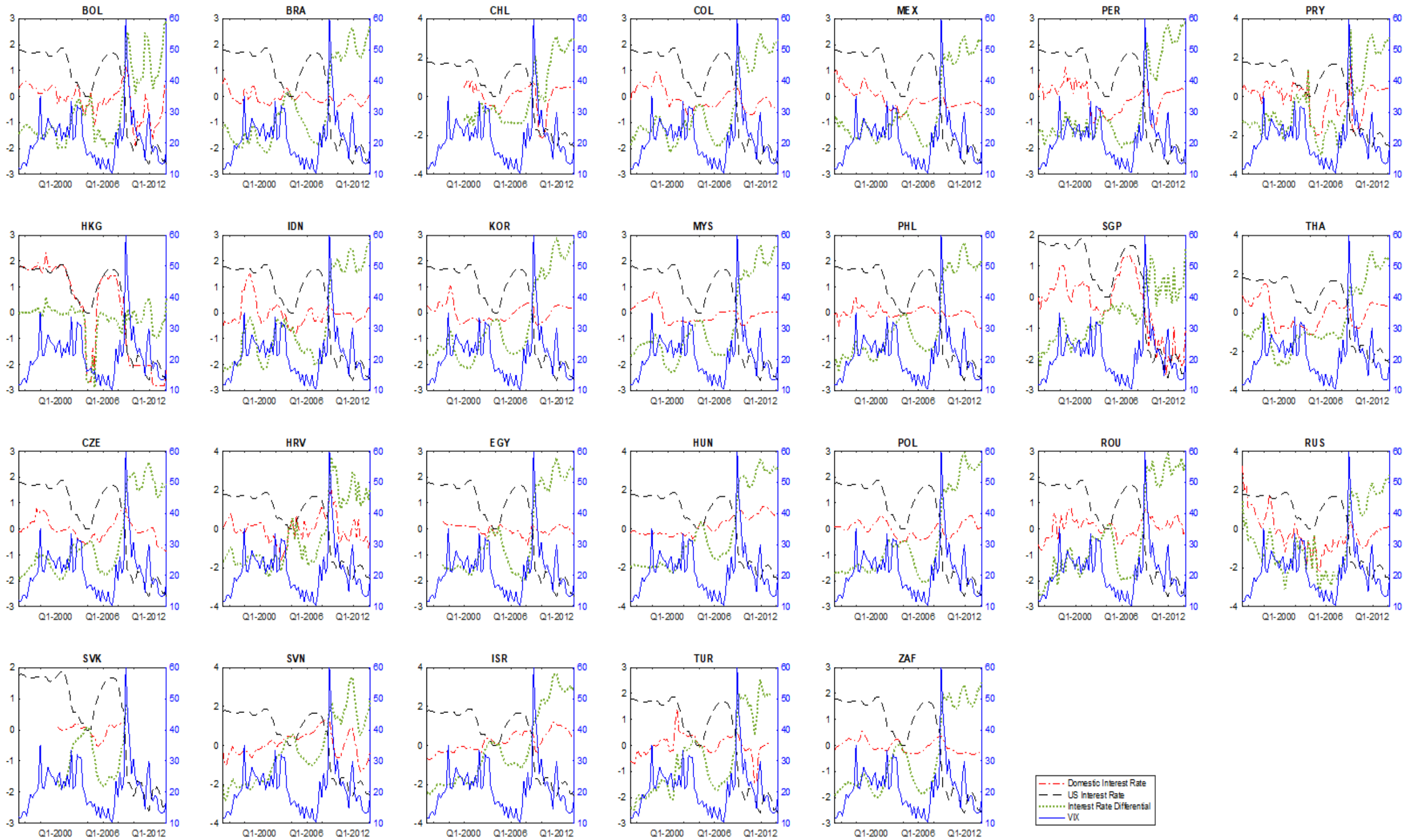

Figure A5: Domestic Interest Rate, US Interest Rate, Interest Rate Differential and the VIX. Notes: Domestic interest rate (dash-dotted line) is calculated as the de-trended log money market rate of the respective countries. US interest rate (dashed line) is the log US money market rate. Interest rate differential (dotted line) is calculated as the difference between domestic interest rate and US interest rate.

Table A1: Country Classifications

Country	Period	Category	Fixed/Flexible (vis-à-vis USD)	Country	Period	Category	Fixed/Flexible (vis-à-vis USD)
BOL	Nov 1991 - Oct 2008	2	Flexible	PER	Nov 1993 - Dec 2002	2	Flexible
	Nov 2008 - Oct 2016	1	Fixed		Jan 2003 - June 2012	3	Flexible
					July 2012 - Sep 2016	2	Flexible
BRA	Apr 1989 - July 1994	4/5	Flexible				
	July 1994 - May 1995	3/5/6	Flexible	PHL	May 1993 - Aug 1995	3	Flexible
	June 1995 - Jan 1999	5/3	Flexible		Sep 1995 - June 1997	1	Fixed
	Jan 1999 - Aug 1999	5	Flexible		July 1997 - Dec 1997	4/5	Flexible
	Sep 1999 - Sep 2016	3	Flexible		Dec 1997 - Nov 1999	3	Flexible
					Dec 1999 - Sep 2016	2	Flexible
CHL	Jan 1992 - Jan 1997	2	Flexible				
	Jan 1997 - Oct 2016	3	Flexible	POL	May 1993 - May 1995	2	Flexible
					May 1995 - Aug 2016		Flexible
COL	Jan 1994 - Sep 2016	3	Flexible				
				PRY	Feb 1991 - June 1999	2	Flexible
CZE	Sep 1990 - Sep 2016		Flexible		July 1999 - Sep 2016	3	Flexible
EGY	Oct 1991 - Jan 2001	1	Fixed	ROU	Nov 1991 - Sep 2016		Flexible
	Jan 2001 - June 2015	2	Flexible				
				RUS	Jan 1992 - July 1996	5	Flexible
HKG	Oct 1983 - Oct 2016	1	Fixed		Aug 1996 - Aug 1998	2	Flexible
					Aug 1998 - Nov 1999	5	Flexible
HRV	Oct 1994 - Oct 2016		Flexible		Dec 1999 - Nov 2008	2	Flexible
					Dec 2008 - Oct 2014	3	Flexible
HUN	May 1994 - Sep 2016		Flexible		Nov 2014 - Feb 2016	5	Flexible
					Mar 2016 - Sep 2016	3	Flexible
IDN	Nov 1978 - July 1997	2	Flexible				
	Aug 1997 - Mar 1999	4/5	Flexible	SGP	June 1973 - Oct 2016	3	Flexible
	Apr 1999 - June 2007	3	Flexible				
	July 2007 - Feb 2014	2	Flexible	SVK	Feb 1993 - Oct 2016		Flexible
ISR	Feb 1991 - Sep 2016	3	Flexible	SVN	Apr 1993 - Oct 2016		Flexible
KOR	Nov 1994 - Nov 1997	2	Flexible	THA	Mar 1978 - July 1997	1	Fixed
	Dec 1997 - June 1998	5	Flexible		July 1997 - Jan 1998	4/5	Flexible
	July 1998 - Mar 2015	3	Flexible		Jan 1998 - Sep 1999	3	Flexible
					Oct 1999 - Sep 2016	3	Flexible
MEX	Dec 1994 - Mar 1996	4/5	Flexible				
	Apr 1996 - Oct 2016	3	Flexible	TUR	May 1984 - Jan 1998	3/5	Flexible
					Feb 1998 - Jan 1999		Flexible
MYS	Sep 1975 - July 1997	3	Flexible		Jan 1999 - Jan 2001	3/5	Flexible
	Aug 1997 - Sep 1998	4	Flexible		Feb 2001 - Mar 2003	5/4	Flexible
	Sep 1998 - June 2005	1	Fixed		Apr 2003 - Oct 2016	3	Flexible
	July 2005 - Sep 2016	3	Flexible				
				ZAF	Sep 1985 - Oct 2016	3	Flexible

Notes: Course classifications of Ilzetzki, Reinhart, and Rogoff (2019) are used. Category 1 is defined to be fixed exchange rate regime. Countries with non-US dollar base currencies are classified as flexible exchange rate regimes vis-à-vis US dollar.