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Impact of US Monetary Policy on Emerging Economies: The Role of Dollar Debt Reliance and Financial Openness

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Abstract

This paper studies how country heterogeneities, especially in their (1) net exposure to dollar debt and (2) financial openness affect the propagation of US monetary shocks into peripheral advanced and emerging economies. We contribute to the understanding of how interest rate and GDP responses of emerging countries depend on both their dollar liability and financial openness, as well as the interaction between these two factors. Specifically, we find that economies with higher debt dollarization have higher interest rate responses to contractionary US monetary shocks to prevent negative balance sheet effects. We also find that GDP decreases by more for economies with high debt dollarization if their financial openness is high. Using capital control as the de jure measure of financial openness, we obtain similar results that GDP decreases by more for countries net short of dollar if capital control is low, and at the same time, GDP is higher for countries with higher capital control if they are more indebted in dollar. Combined, the results imply that capital control helps dampen negative US monetary spillover, and the benefit from imposing capital control is larger for countries that are more indebted in dollar.

Keywords: liability dollarization, financial openness, global financial cycle, US monetary spillover, capital control

JEL Classification: E5, F3

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1. Introduction

Recently there is expansive interest in the validity of the policy trilemma and the international transmission of monetary policy shocks. Conventionally, the policy trilemma has served as a benchmark for central bankers to think about monetary and exchange rate policy making: Out of the three objectives of free capital mobility, fixed exchange rate and monetary autonomy, an economy can only hope to simultaneously achieve two. However, increasing financial integration has put the validity of policy trilemma into question, in that monetary shocks within center economies may be transmitted to peripheral countries regardless of peripheral countries' exchange rate policy choice due to the large scale capital inflows from the center to peripheral countries (see, for example, Rey (2013)). The implication is the policy trilemma may 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. In view of the global transmission of center monetary shocks and the subsequent synchronization of financial conditions across countries — a phenomenon dubbed "global financial cycles" — a natural question to ask is what can help peripheral countries to reduce the impact of monetary spillover from center economies.

In this paper, we study how heterogeneous country characteristics shape monetary spillover from the US as the center economy. In particular, we look at how heterogeneous exposure to dollar or dollar debt and financial openness contribute to the variations in peripheral countries' interest rate and output responses following a contractionary US monetary shock. To do so, we adopt a two-stage empirical strategy. In the first stage, we simulate the impulse responses of interest rate and output of peripheral countries to a contractionary US monetary shock. In the second stage, we regress the mean of the impulse responses over 10 quarters on net exposure to dollar or dollar debt and financial openness measures while controlling for other country heterogeneities, including the manufacturing share in production and trade openness. We

employ the two-stage design to allow us to examine multiple country characteristics simultaneously.

Using a sample of 56 countries and cross-section units consisting of both advanced and emerging economies, we find that contractionary US monetary shocks cause the GDP responses of peripheral economies to decline both for the full sample period from 1999 Q1 to 2019 Q4 and for the pre- and post-global financial crisis subperiods in the first-stage global vector autoregression (GVAR) estimation. Meanwhile interest rates tend to lower, accommodating the negative US monetary spillovers.

In the second stage, we find significant effect of negative dollar debt exposure on US monetary spillover. Specifically, we find that the interest rate response is higher and GDP contraction is larger for countries that have higher net borrowings in dollar debt instruments. One possible explanation for the higher interest rate response is that countries that are net borrowers in dollar may either increase their interest rates by more or lower their interest rates by less to avoid negative balance sheet effects. The effect of negative net dollar borrowing on US monetary spillover to peripheral countries' GDP is significant for the emerging country group but insignificant for advanced economies, suggesting possible disparity in US monetary transmission channels for the two groups of countries.

We also find non-linearity in the effects of negative dollar exposure and financial openness on US monetary spillover. In particular, GDP decreases by more for economies that are net borrowers in dollar debt instruments if their financial openness is high. In other words, high financial openness amplifies the effect of negative dollar exposure on US monetary spillover. We draw the implication from this result that capital control and macroprudential policies that limit large capital in- and outflows may act as a buffer against the negative effects of center economy monetary shocks. Indeed, by using capital control as a de jure measure of financial openness, we find that GDP decreases by more for countries net short of dollar if capital control

is low, and at the same time, GDP is higher for countries with higher capital control if they are more net short in dollar. Combined, the results again suggest that implementing capital control might help dampen negative US monetary spillover, and the benefit is particularly larger for countries that are more net short in dollar. Our results are robust to controlling for financial centers and institutional quality.

Our findings in this paper are related to the literature studying the validity of policy trilemma. Obstfeld (2015), for example, examines the ability of emerging market economies (EMEs) to sustain domestic monetary policy autonomy in the face of external monetary shocks by regressing peripheral economies' short-run and long-run interest rate changes on base country's short-run and long-run interest rate changes controlling for exchange rate flexibility and other factors. He finds that while EMEs with flexible exchange rate in general can maintain short-run interest rate autonomy, they tend to have less control over long-run interest rate, which comoves more with the base country's interest rate. Using panel regression frameworks, Han and Wei (2018) and Cheng and Rajan (2019) both document a 2.5-lemma. Han and Wei (2018) find that when the center economy lowers interest rate, peripheral countries would follow while Cheng and Rajan (2019) find the opposite. An important aspect in evaluating policy trilemma validity is whether floating exchange regime can better shield domestic economy from external shocks. Passari and Rey (2015) document correlations of stock prices and credit growth with global financial cycle proxied by the VIX or US Fed Funds rate. In general, they do not find systematic heterogeneities in the correlations across different exchange rate regimes.

We depart from previous studies by examining how country heterogeneities, especially in their (1) exposure to dollar and dollar debt and (2) financial openness, as well as the *interaction* of these two channels affect the propagation of US monetary shocks into both advanced and emerging economies. It is important to examine the *interaction* of net dollar exposure and financial openness because, for instance, it not only tells us whether higher capital control

reduces GDP loss, but also which countries will benefit more from imposing capital control. Other studies that have also estimated heterogeneous impact of US monetary shocks on emerging countries include Georgiadis (2016) and Iacoviello and Navarro (2019), but they did not consider exposure to dollar or dollar debt which we argue is an important factor intensifying negative effect of contractionary US monetary spillover. Shousha (2019) estimated the cross-sectional heterogeneity in the impact of dollar appreciation on EMEs due to different country characteristics, but the effects of these country characteristics are not jointly estimated. Our empirical strategy closely follows Georgiadis and Mehl (2016). They focus on heterogeneous *domestic* monetary shock transmission while we study US monetary spillover.

The remaining of the paper is structured as follows. Section 2 presents the empirical strategy and data. Section 3 discusses the results of both the first-stage estimation and the second-stage regression. We conduct several robustness checks in section 4 and finally, section 5 concludes.

2. Empirical modelling strategy

The purpose of our empirical strategy is to identify the dominant one out of the two financial channels of (1) exposure to net foreign currency, especially US dollar, and (2) exposure to global financial cycles, and how the interaction between the two determine the differences in the induced peripheral economies' interest rate and GDP responses to US monetary policy shocks. Specifically, we ask to what degree the differences in how US monetary policy shocks are transmitted to the peripheral economies can be accounted for by the variations in their exposure to global financial cycle and exposure to net foreign currency composition, holding all other things constant. To achieve this goal, we adopt a two-stage empirical procedure outlined below.

2.1 First-stage global vector autoregression model

In the first stage, we will estimate and solve a mixed cross-section global vector autoregression (MCSGVAR) model following Georgiadis and Mehl (2016). MCSGVAR is a variation of GVAR models that allows for the inclusion of monetary unions and individual countries under a unified framework. MCSGVAR retains the benefits of a conventional GVAR model, in that first, as with other vector autoregression models, we could capture the dynamics governing the evolution of multiple macroeconomic variables; second, it allows interactions across countries to be explicitly modelled, and hence is highly suitable for our analysis of international monetary policy transmissions in which international trade and financial linkages need to be accounted for. Similar to the standard GVAR model, the MCSGVAR model builds on country specific VARX models:

$$\boldsymbol{x}_{it} = \alpha_i + \sum_{j=1}^{p_i} \phi_{ij} \cdot \boldsymbol{x}_{i,t-1} + \sum_{j=1}^{p_i^*} \Gamma_{ij} \cdot \boldsymbol{x}_{i,t-1}^* + u_{it}, i = 1,2,\dots,N, \quad (1)$$

where $\boldsymbol{x}_{it}$ is the vector of domestic endogenous variables of cross-section unit i and $\boldsymbol{x}_{it}^*$ denotes the vector of foreign variables. After the MCSGVAR model is estimated and solved, we will then simulate the interest rate and GDP responses of each sample country to a contractionary US monetary policy shock.

We consider five clusters of cross-sectional units to be included in the MCSGVAR model, including the non-US and non-euro area economies, the US economy, the euro area economies, the European Central Bank (ECB) and a commodity (oil) block. We summarize the endogenous and foreign variables entering each unit's VARX model below.

For each non-euro area and non-US economy:

Endogenous variables $\boldsymbol{x}_{it}$	Foreign variables $\boldsymbol{x}_{it}^*$
output	trade-weighted foreign output
prices	trade-weighted foreign prices
interest rates	trade-weighted foreign interest rates

	ECB interest rate
exchange rates	oil prices

For the US economy:

Endogenous variables $\boldsymbol{x}_{it}$	Foreign variables $\boldsymbol{x}_{it}^{*}$
output	trade-weighted foreign output
prices	trade-weighted foreign prices
interest rates	trade-weighted foreign interest rates
	trade-weighted foreign exchange rates
	euro exchange rate vis-à-vis US dollar
	ECB interest rate
	oil prices

For each euro-area economy:

Endogenous variables $\boldsymbol{x}_{it}$	Foreign variables $\boldsymbol{x}_{it}^{*}$
output	trade-weighted foreign output
prices	trade-weighted foreign prices
	trade-weighted foreign interest rates
	ECB interest rates
	euro exchange rate vis-a-vis US dollar
	oil prices

For ECB:

Endogenous variables $\boldsymbol{x}_{it}$	Foreign variables $\boldsymbol{x}_{it}^{*}$
ECB interest rate	GDP-weighted euro area output
euro exchange rate vis-a-vis US dollar	GDP-weighted euro area prices
	GDP-weighted foreign interest rates
	oil prices

Oil block:

Endogenous variables $\boldsymbol{x}_{it}$	Foreign variables $\boldsymbol{x}_{it}^{*}$
oil prices	GDP-weighted output
	GDP-weighted prices
	GDP-weighted interest rates
	GDP-weighted exchange rates
	ECB interest rate

Considering the size and impact of US economy on the rest of the world, we specify US as a dominant unit, in the sense that its endogenous variables would additionally enter all other units as foreign variables. In the baseline setup, we impose sign restrictions to identify a contractionary US monetary policy shock. In particular, US interest rate is required to increase on impact, its CPI inflation to decline after three quarters reflecting nominal rigidity and that US dollar appreciates against other currencies on impact.

2.2. Second-stage cross-section regression

In the second stage, we extract the mean responses of peripheral countries' interest rate and GDP to a US monetary policy shock over 10 quarters. To formally test by how much the differences in mean responses of peripheral economies' interest rate and other macroeconomic variables are due to these economies' different exposure to foreign currency liabilities and exposure to global financial cycle, we regress the mean responses in interest rate and GDP of the peripheral economies, s_i, on their average net foreign currency exposure, NFX_i, and average exposure to global financial cycle, IFI_i, over the sample period while controlling for a vector of country-specific factors, $\boldsymbol{w_i}$. The regression model is laid out in equation (2) below. Intuitively, the sign and magnitude of the two estimated coefficients (β^{IFI} and β^{NFX}) for the average susceptibility to global financial cycle (IFI_i) and the average net foreign currency asset holdings (NFX_i) shall tell us in what direction and by how much the two financial channels

affect the peripheral economies' interest rate responses and the monetary autonomy they still enjoy.

$$s_i = \alpha + \boldsymbol{\gamma} \cdot \boldsymbol{w_i} + \beta^{IFI} \cdot IFI_i + \beta^{NFX} \cdot NFX_i + u_i \quad (2)$$

We now describe in detail the construction of IFI_i, which measures the exposure of peripheral economies to the global financial cycle, and the construction of NFX_i, which captures the net foreign currency exposure of country i. IFI_{it} is calculated as the sum of gross foreign assets and liabilities that country i holds relative to its GDP level. In the international finance literature, IFI_{it} is often used to measure an economy's financial integration level. We then take the time average of IFI_{it} over the sample period for each economy. So, IFI_i measures the average exposure to global financial cycles of economy i over the given sample period. To quantify the importance of the exposure to net foreign currency composition, we use the index NFX_{it} which captures the net worth gains or losses that country i experiences from its holdings of net foreign currency denominated assets following an exchange rate fluctuation induced by a US interest rate shock. It is calculated as in equation (3) below, following Benetrix, Lane, and Shambaugh (2015):

$$NFX_{it} = \left(s_{it}^{A} \cdot \omega_{it}^{A,FC} - s_{it}^{L} \cdot \omega_{it}^{L,FC}\right) \cdot IFI_{it}, \quad (3)$$

where $\omega_{it}^{A,FC}$ denotes the share of country i's *foreign currency* assets out of its total foreign assets. Similarly, $\omega_{it}^{L,FC}$ denotes the share of country i's *foreign currency* liabilities out of its total foreign liabilities. s_{it}^{A} denotes the share of country i's foreign assets out of its sum of foreign assets and liabilities. s_{it}^{L} denotes the share of country i's foreign liabilities out of its sum of foreign assets and liabilities. NFX_{it} tells us country i's exposure to foreign currency, in that country i's net worth from its holdings of foreign assets and liabilities will improve with $\omega_{it}^{A,FC}$

and deteriorate with $\omega_{it}^{L,FC}$ following a depreciation of its currency. Since US monetary policy shock is of the focus and that dollarization of liabilities may be an important factor in shaping small open economies' monetary policy responses, we construct two more indices capturing country i's exposure to US dollar NFX_i^{us}, and US dollar denominated debt $NFX_{debt,i}^{us}$ as in equation (4). $\omega_{it}^{A,USD}$ and $\omega_{it}^{L,USD}$ denote US dollar foreign assets and liabilities held by country i in period t, whereas $\omega_{it}^{A,USD:debt}$ and $\omega_{it}^{L,USD:debt}$ are US dollar debt assets and liabilities held by country i in period t. Therefore, following US dollar appreciation, country i's net worth will improve with $\omega_{it}^{A,USD}$ and $\omega_{it}^{A,USD:debt}$, but deteriorate with $\omega_{it}^{L,USD}$ and $\omega_{it}^{L,USD:debt}$. We then take the time average of NFX_{it}, NFX_{it}^{us}, and $NFX_{debt,it}^{us}$ over the sample period for each economy i, so that NFX_i, NFX_i^{usd}, and $NFX_{debt,i}^{usd}$ measure the economy i's average exposure to net foreign currency asset positions, to net dollar assets, and to net dollar denominated debt instruments over the given sample period, respectively. Further, negative values of NFX_i, NFX_i^{usd}, and $NFX_{debt,i}^{usd}$ mean that the economy i is a net borrower in foreign currency, in dollar, and in dollar denominated debt instruments.

$$\begin{aligned} NFX_{it}^{usd} &= s_{it}^{A} \cdot \omega_{it}^{A,USD} - s_{it}^{L} \cdot \omega_{it}^{L,USD}, \\ NFX_{debt,it}^{usd} &= s_{it}^{A} \cdot \omega_{it}^{A,USD:debt} - s_{it}^{L} \cdot \omega_{it}^{L,USD:debt} \end{aligned} \tag{4}$$

2.3. Data

The data we use in the first stage MCSGVAR estimation include quarterly GDP growth, inflation, interest rate change, oil price change, change in exchange rate vis-à-vis US dollar of peripheral advanced and emerging economies, which are collected from IMF International Financial Statistics (IFS) database. For the US, we use shadow rate from Wu and Xia (2016) as its interest rate. The full sample period runs from 1999 Q1 to 2019 Q4 and covers 56 cross-section units as in Table 1. We also run estimations using two subsamples from 1999 Q1 to

2009 Q4 and 2008 Q1 to 2019 Q4 based on structural break tests, which we detail in section 2.4. Additionally, the ECB and oil are two individual blocks also included in the estimation. Estonia, Latvia and Lithuania are grouped as Baltics while Venezuela, Ecuador and Saudi Arabia are subsumed into an oil exporting countries group.

Table 1: Sample countries

Region	Countries
Individual units	ALB, AUS, AUT, BAL+, BEL, BGR+, BRA, CAN, CHE, CHL, CHN, COL, CRI+, CZE, DEU, DNK, ECB+, ESP, FIN, FRA, GBR, GRC, HKG, HRV*, HUN, IDN, IND, IRL, ISR, ITA, JOR, JPN, KOR, LUX+, MAR, MEX, MYS, NLD, NOR, NZL, OIL+, OPC*+, PER, PHL, POL, PRT, PRY, ROU, RUS, SGP, SVK*, SWE, THA, TUR, USA+, ZAF
Baltics (BAL)	EST, LVA, LTU
Oil exporting countries (OPC)	VEN, ECU, SAU

Notes: Countries with an asterisk are absent from post-GFC sample and full sample in the first-stage estimation due to lack of data availability. Cross-section units with a cross are excluded from second-stage regression.

For the second stage regression, we extract mean impulse responses of interest rate and GDP estimated from MCSGVAR in the first stage as dependent variables[1]. The two regressors of interest, NFX_i and IFI_i are constructed following Benetrix, Lane, and Shambaugh (2015), and extended to 2017 based on Benetrix et al. (2020), while NFX_i^{usd} and $NFX_{debt,i}^{usd}$ are constructed based on equation (4). We use industry mix and trade openness to control for other country characteristics.

Industry mix is a proxy for the importance of manufacturing sector relative to service sector of an economy. A country with higher industry mix is found to be more prone to monetary

[1] Bulgaria (BGR), Costa Rica (CRI) and Luxembourg (LUX) are excluded from all second stage regressions due to the lack of foreign currency exposure (NFX) and financial openness (IFI) data. Baltics and oil exporting countries are excluded from second stage regressions as they are estimated as a group. US is also excluded as it is the center economy.

shocks as its demand is more interest rate sensitive as documented in Bernanke and Gertler (1995). We measure industry mix as the difference between industry share out of total value added and service share out of total value added, collected from World Development Indicators (WDI) database.

Trade openness measures an economy's trade linkages with the rest of the world. Specifically, it is calculated as the sum of exports and imports of goods and services measured as a share of gross domestic product downloaded from WDI. It is ex-ante inconclusive whether higher trade openness can mitigate or worsen the negative external shock a country experiences, for on the one hand it may suffer a negative foreign demand shock while on the other hand an export increase following a domestic currency depreciation induced by a contractionary US monetary shock can provide some cushioning effect.

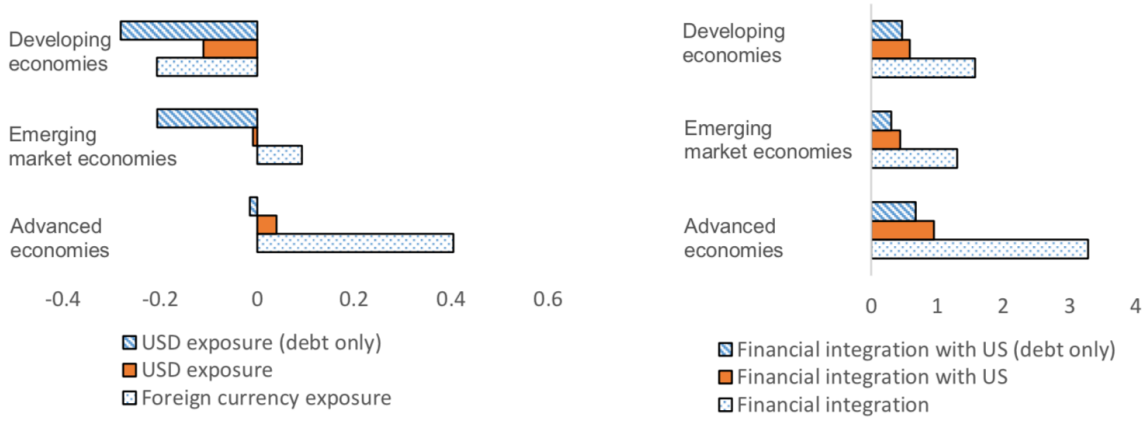

Figure 1: Measure of exposure to foreign currency, US dollar and US dollar debt (left panel) and exposure to global financial cycle/financial openness (right panel) of the advanced, emerging and developing countries.

We summarize advanced, emerging market and developing countries' average exposure to foreign currency and financial openness over the period of 1999Q1 - 2009Q4 in Figure 1[2]. In general, most advanced economies have positive average NFX values (blue dotted bar, left panel), meaning they could reap a net worth gain if their exchange rate depreciates uniformly

[2] Plots for longer sample period (1999-2012 and 1999-2017) look similar and are available upon request.

against all other currencies in which their foreign assets and liabilities are denominated. However, on average their currency exposure vis-a-vis US dollar, NFX^{usd} (orange solid bar, left panel), is much smaller, and their exposure to US dollar debts, NFX^{usd}_{debt} (blue slashed bar, left panel), is negative, meaning on average, these advanced economies are net borrowers in US dollar. On average emerging market economies have positive foreign currency exposure, NFX, but suffer a negative exposure to US dollar and US dollar denominated debts, meaning if their currency depreciates vis-a-vis US dollar they would experience a net worth loss. Developing economies are generally net borrowers in foreign currencies, including US dollar. In terms of exposure to global financial cycle which we measure using financial openness, for advanced and emerging countries, their total US dollar assets and liabilities as a share of GDP, IFI^{us} (orange solid bar, right panel), account for less than half of their total foreign assets and liabilities, IFI (blue dotted bar, right panel). Across the three types of economies, their total gross assets and liabilities denominated in US dollar are mainly composed of debt assets and liabilities (blue slashed bar, right panel).

Table 2: Rejection rates of the null of parameter constancy across country-specific models

	Test statistics					
Significance level	PK_{sup}	PK_{msq}	NYB	QLR	MW	APW
10%	0.28	0.28	0.14	0	0.02	0
5%	0.21	0.19	0.05	0	0.01	0
1%	0.10	0.08	0.03	0	0.01	0

Notes: The table displays share of equations that rejects the null of parameter stability at different significance levels. PK_{sup} and PK_{msq} refer to the Ploberger and Kramer (1992) maximal OLS cumulative sum statistic and its mean square variant; NYB refers to the Nyblom (1989) test; QLR refers to the Quandt (1960) likelihood ratio test statistic; MW and APM are the Andrews and Ploberger (1994) mean Wald statistic and the exponential average statistic. The critical values are computed based on the bootstrapped samples under the assumption of parameter stability.

2.4. Pre-estimation Tests

We check for potential structural breaks present in our long sample from 1999 Q1 to 2019 Q4, during which the world experienced both the global financial crisis and episodes of

quantitative easing by major central banks. Table 2 shows the rejection rates of tests for parameter stability out of the total number of equations estimated. At 10 percent significance level, both the maximal OLS cumulative sum statistic and its mean square version suggest possible structural breaks.

Figure B1 in Appendix B plots the distribution of estimated structural break dates according to Ploberger and Kramer's (1992) maximal OLS cumulative sum statistic, which suggests 2009 Q4 might be a break point. Avdjiev et al. (2020) similarly estimates 2009 Q1 to be a structural break date for global credit flow variables. We therefore conduct the subsequent estimations using two subsamples: 1999 Q1 – 2009 Q4 and 2008 Q1 – 2019 Q4. Ideally, our second subsample would span from 2010 Q1 – 2019 Q4, but having any starting period later than 2008 Q3 will result in instability issues in VARX estimation. Our results are robust to having either 2008 Q1 or 2008 Q3 as the beginning period. We therefore choose 2008 Q1 as the beginning period to take advantage of a longer sample length.

Additionally, we report the structural break tests for the two subsample periods in Table A1 in the Appendix. The rejection rates of parameter stability across all test statistics are substantially lower. Table A2 reports the share of equations with the null of no serial correlation in residuals is rejected at lag one to lag four based on Lagrange multiplier test. The residuals are largely uncorrelated given the low rejection rates, especially at 1 percent significance level. In the country VARX model shown in equation (1), lag lengths p_i and p_i^* are selected based on Akaike information criterion (AIC).

3. Results

3.1 First-Stage Estimation

We first present the impulse responses of key macroeconomic variables of peripheral countries following a contractionary US monetary shock that raises US interest rate by 27 basis points on impact. In Figure 2 we report the country level impulse responses of the interest rates

excluding the US, jointly with their 32nd and 68th percentiles using the 1999 Q1 – 2009 Q4 subsample. While interest rates of some peripheral economies including Brazil[3] increase on impact, they generally ease over time following a contractionary US monetary shock to accommodate the economic contractions. Indeed, Figure 3 shows that output of the peripheral economies decreases and reaches the trough between 4 – 8 quarters after the US monetary shock.

Figure 4 shows the impulse responses of interest rates using the 2008 Q1 – 2019 Q4 subsample. Interest rate responses across the economies appear more synchronised with more economies responded by increasing their interest rates. Figure 5 shows that GDP contraction is larger and more persistent. Monetary policy and economic output synchronisation are similarly documented by Avdjiev et al. (2020) and Pescatori (2013).

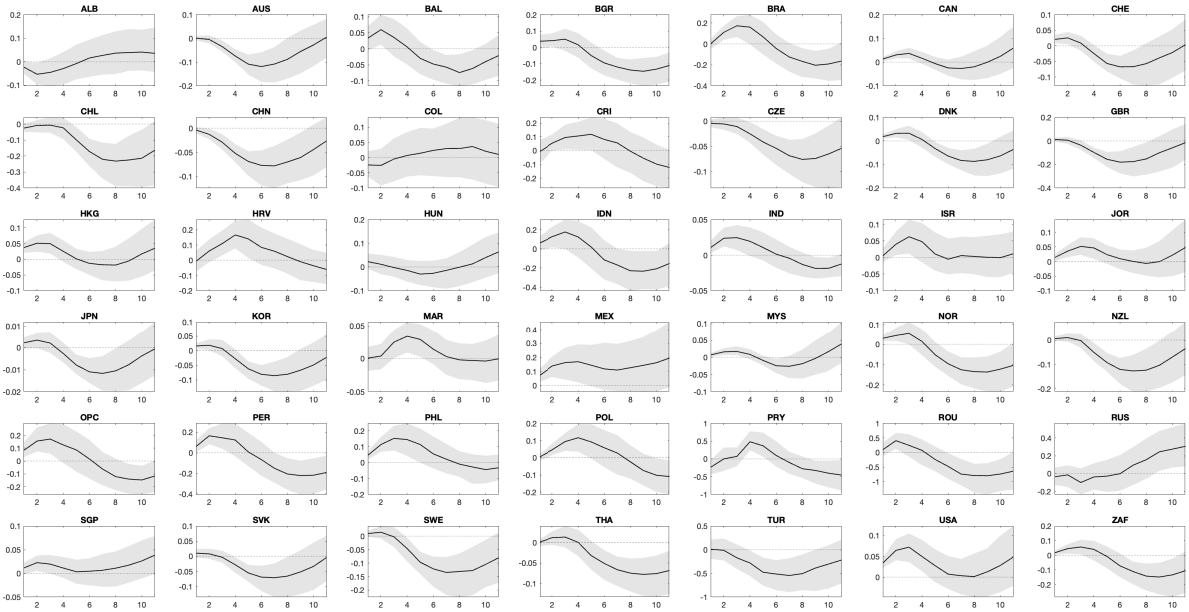

Figure 2: Interest rate responses by country to a contractionary US monetary policy shock that raises the US interest rate by 27 basis points on impact, 1999 Q1 – 2009 Q4 subsample. Shaded area: 32nd and 68th percentiles.

[3] The country code of Brazil is BRA.

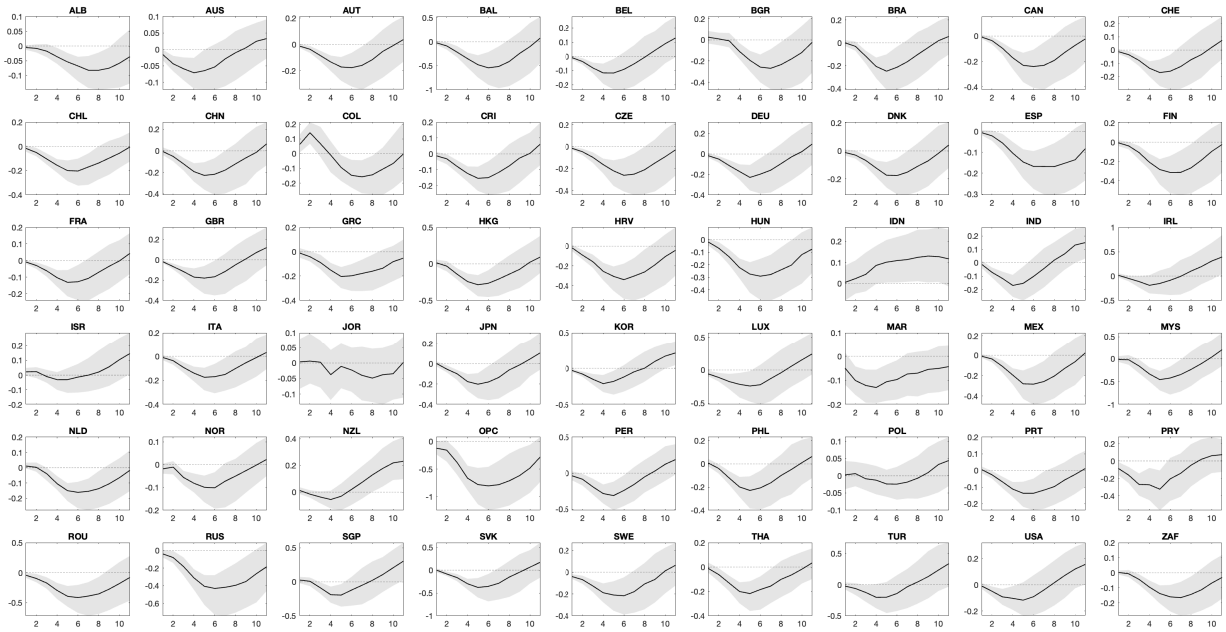

Figure 3: GDP responses by country to a contractionary US monetary policy shock that raises the US interest rate by 27 basis points on impact, 1999 Q1 – 2009 Q4 subsample. Shaded area: 32nd and 68th percentiles.

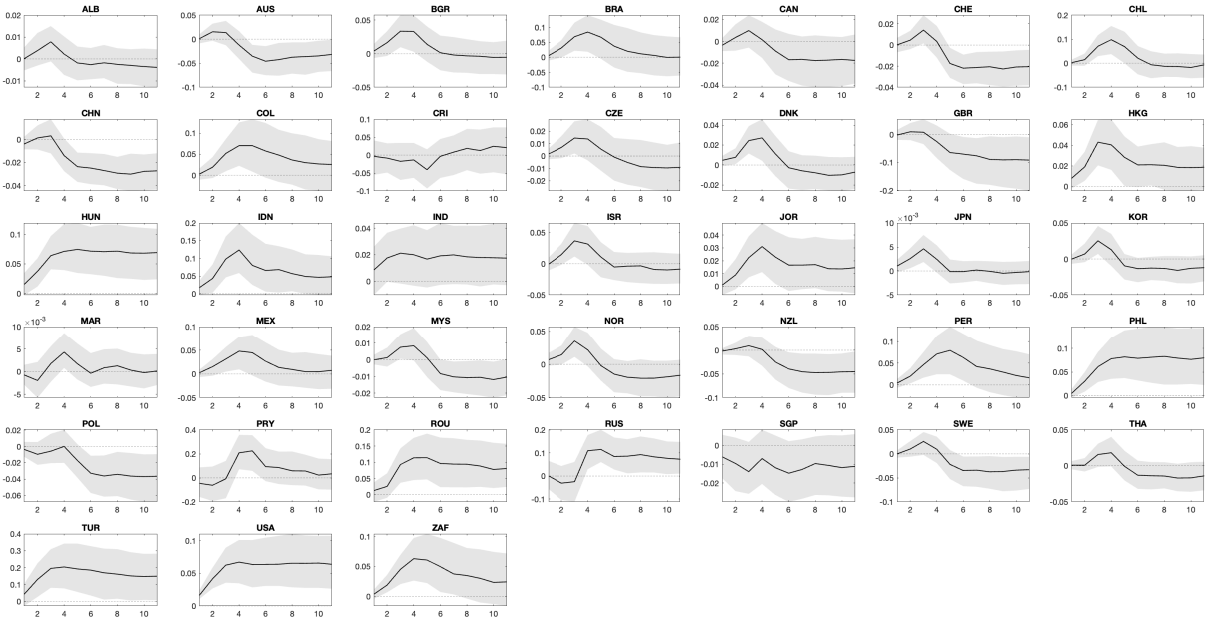

Figure 4: Interest rate responses by country to a contractionary US monetary policy shock that raises the US interest rate by 27 basis points on impact, 2008 Q1 – 2019 Q4 subsample. Shaded area: 32nd and 68th percentiles.

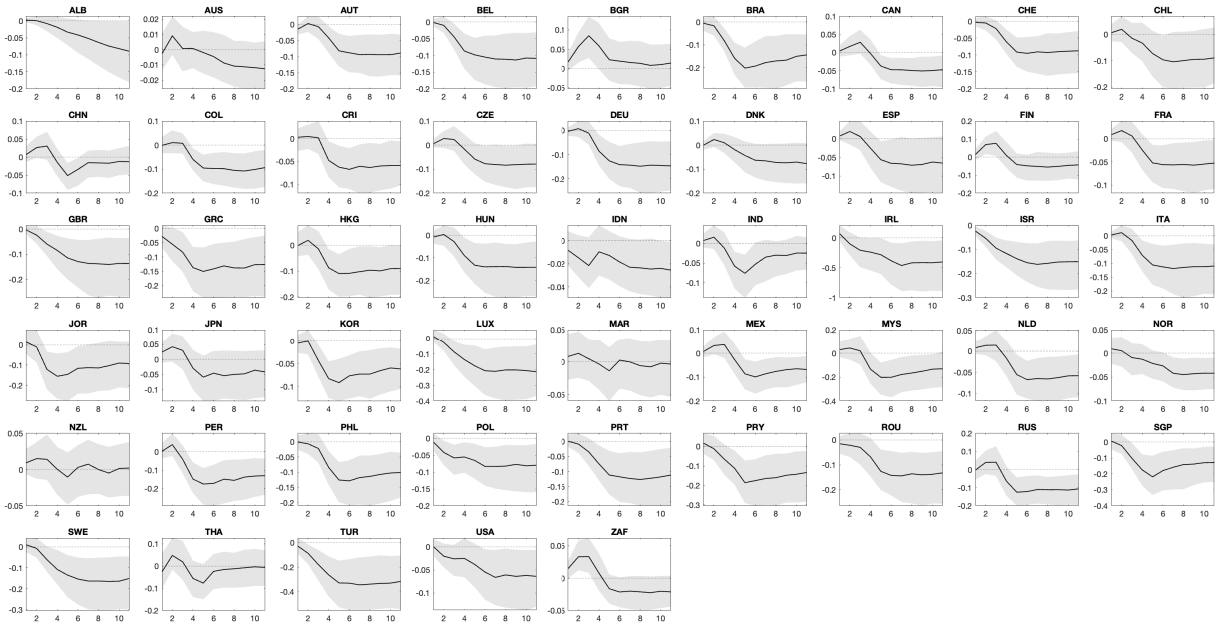

Figure 5: GDP responses by country to a contractionary US monetary policy shock that raises the US interest rate by 27 basis points on impact, 2008 Q1 – 2019 Q4 subsample. Shaded area: 32nd and 68th percentiles.

3.2 Second-Stage Estimation

In this section, we present and discuss how heterogeneity in country characteristics leads to variations in the sample peripheral countries' interest rate and output responses following contractionary US monetary spillover for both periods of 1999-2009 and 2008-2019.

3.2.1 Determinants of Spillover to Mean Interest rates

We first examine the US monetary spillover to peripheral countries' interest rates by extracting and regressing the mean interest rate responses of the individual sample economies[4] on their net foreign currency exposure (NFX) and exposure to global financial cycle (IFI) while controlling for other country characteristics. The results are shown in Table 3 Columns (1) and

[4] Euro area economies (Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherland, and Portugal) are excluded from this exercise. Recall that interest rate is not an endogenous variable of euro area economies in the MCSGVAR specification, but an endogenous variable in the ECB block.

(5), for periods of 1999-2009 and 2008-2019, respectively. The coefficients on IFI are negative and significant for both periods. As domestic credit conditions and asset prices in countries with high financial openness are susceptible to global financial cycle, the central banks in these economies would have the tendency to conduct accommodating monetary policies to counter the tightening effect of the US contractionary monetary shock on their credit and asset markets. However, the room for such countermeasure hinges on the countries' resilience towards the capital flow reversals that could result from the interest rate differential that is usually weaker in emerging and developing economies (see for example, Joyce and Nabar, 2009). Indeed, when we estimate the effect of IFI on mean interest rate responses of the advanced and the emerging economies separately, we find that only the advanced economies would lower their interest rate by more if they are more financially open. The results are reported in Table A3 in the Appendix.

The coefficient on NFX is not significant during 1999-2009 and only weakly significant during 2008-2019. This is not too surprising since NFX is net exposure to *all* foreign currencies. We conjecture that net exposure to dollar denominated assets and liabilities may better capture the heterogeneous spillover effects of US monetary shocks. The choice of dollar as the focus is motivated by the belief that policy makers are often concerned with negative balance sheet effects following dollar appreciation due to peripheral countries' high liability dollarization. We therefore replace NFX with NFX^{usd} in Columns (2) and (6) and with NFX^{usd}_{debt} in Columns (3) and (7). NFX^{usd}_{debt} is net exposure to US dollar denominated debt assets and liabilities. We singled out US dollar denominated debts because compared to equity, debt and especially short-term debt financing is considered riskier. In the period of 2008-2019, the estimated coefficient is negative albeit insignificant for NFX^{usd} and is negative and significant at 5% level for NFX^{usd}_{debt}. The negative signs of the coefficients imply that the more US dollar debts

the peripheral country borrows in, the higher its interest rate response is[5] — either it raises the interest rate in response to contractionary US monetary shock to prevent negative balance sheet effects, or it eases the domestic interest rate but eases by less due to fear of currency depreciation and increased debt burden. For countries that are net borrowers in US dollar debts, a 10 percentage increase in their share of US dollar debt liability relative to assets would translate to an additional 1.6 basis point increase in their interest rate responses (0.1×0.16). The results hold and the adjusted R^2 improves significantly after controlling for the country outliers[6] in Columns (4) and (8).

3.2.2 Determinants of Spillover to Mean GDP

We next examine the heterogeneous US monetary shock spillovers into peripheral countries' real economy by regressing mean GDP responses on net foreign currency exposure, exposure to global financial cycle, and the same set of controlling factors. The results are presented in Table 4.

The coefficients on trade openness are mostly significant over the period 1999-2009 across the specifications of Columns (1)-(4), substantiating that countries that are more open to trade encounter larger reduction in GDP in response to a contractionary US monetary shock.

Financial openness variable exhibits positive and statistically significant coefficients in the period of 1999-2009. This is at odds with the theory of global financial cycle that postulates real and financial conditions in peripheral countries with higher financial openness are more prone to the monetary spillovers from the core economies, in particular the US that plays a dominant role in the international monetary and financial system. However, a visual inspection of Figures 6(a) and (c) in the panel of 1999-2009 subsample that plot the mean responses of

[5] Note that negative NFX_{debt}^{usd} values are associated with economies that are net borrowers in dollar debt instruments.

[6] We identify outliers by running the regression without outlier dummy and plot the predicted residuals. Countries with exceptionally large residuals were identified as outliers.

GDP to the US contractionary monetary shock against financial openness shows that the estimated positive coefficient in the 1999-2009 period is primarily driven by the extreme values of a few regional financial centers. As shown from Figure 6, the financial centers are the economies highlighted in blue squares, including Belgium, Ireland, and Switzerland within the sample of advanced economies (AEs), as well as Singapore and Hong Kong within the sample of emerging market economies (EMEs). The correlation between mean GDP response and financial openness becomes seemingly negative after removing the financial centers from the country sample, as illustrated by Figure 3(b) and 3(d) in the top panel. We therefore further control for financial centers and re-estimate equation (2) for the two subperiods for AEs and EMEs separately, and the results are presented in Table 5 Columns (2), (4), (6), and (8). Indeed, the positive coefficients on IFI loses statistical insignificance once financial openness is controlled for.

Next, focussing on the effect of net foreign currency exposure (NFX), Table 4 Column (1) shows that the estimated coefficient on NFX is not significant in the period of 1999-2009 but is positive and significant at 5% level in the period of 2008-2019. Given that NFX essentially measures the net foreign currency foreign asset positions, the estimated positive correlation between NFX and mean GDP response means that countries net short in foreign currency on its external balance sheet tend to experience a larger drop in GDP in the face of US contractionary monetary shocks. We next replace NFX with NFX_{debt}^{usd}, a measure of net dollar foreign debt assets, such as dollar bonds, in Columns (3), (4), (7), and (8), motivated by dollar dominance in the global financial system, and additionally control for country outliers in Columns (4) and (8). The coefficient on NFX_{debt}^{usd} is positive and even larger than the estimated coefficient on NFX in both periods. For example, Column (4) suggests that a worsening in net dollar debt asset positions (NFX_{debt}^{usd}) by 10 percent translates to an additional fall in output by 1.5 basis points in response to a US monetary tightening (0.1×0.15). Visually, plots (f) and

(h) of both panel (I) and (II) in Figure 6 also show that output responses improve as net exposure to dollar debt turns from negative to positive. Overall, our results are in line with the notion of 'original sin' proposed by Eichengreen and Hausmann (1999), which describes developing countries' predicament for not being able to extend external debts in their own currencies, but the foreign currency debts can become a source of balance sheet frailty when their local currencies depreciate. Indeed, Table 5 shows the estimated coefficient on net exposure to dollar debt is positive and larger in magnitude in EMEs than AEs, especially for 1999-2009 period, corroborating that EMEs are more vulnerable to the negative balance sheet effect induced by contractionary monetary shock emanated from the US.

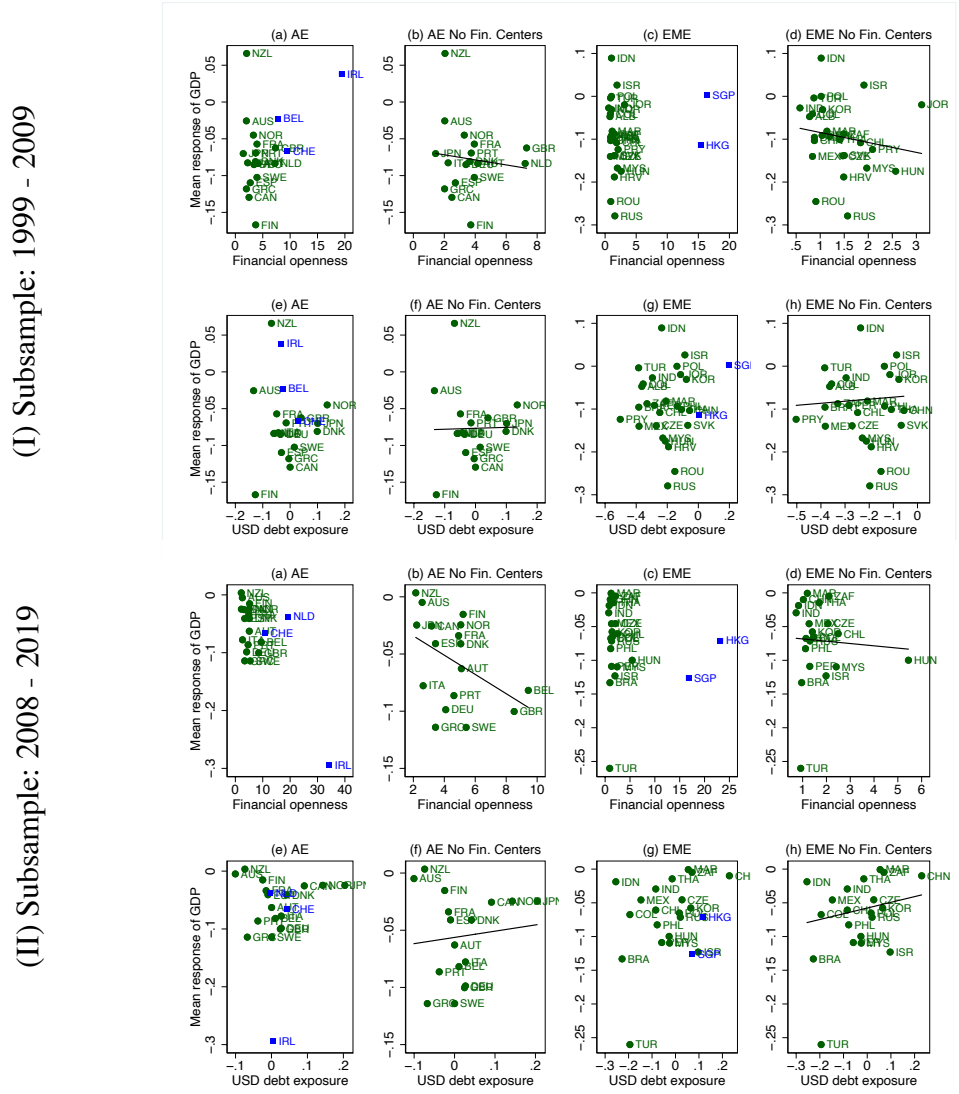

Figure 6: Financial openness, net exposure to dollar debt, and GDP responses following a contractionary US monetary shock. Panel (I): Sample period: 1999 Q1 – 2009 Q4. Panel (II): Sample period: 2008 Q1 – 2019 Q4.

Table 3: Determinants of peripheral countries' mean interest rate response

Dependent variable:	1999 - 2009				2008 - 2019			
Mean interest rate response	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Foreign currency exposure	0.012				0.019*			
(NFX)	(0.453)				(0.073)			
Net exposure to USD		0.104				-0.157		
(NFX^{usd})		(0.487)				(0.192)		
USD debt exposure			0.003	-0.056			-0.161**	-0.105***
(NFX^{usd}_{debt})			(0.977)	(0.372)			(0.014)	(0.006)
Financial openness	-0.011**	-0.008**	-0.007**	-0.006	-0.010**	-0.004	-0.002	-0.003
(IFI)	(0.020)	(0.024)	(0.051)	(0.117)	(0.022)	(0.179)	(0.472)	(0.281)
Industry mix	−0.008	-0.007	−0.009	−0.007*	0.001	-0.001	0.001	-0.002
	(0.254)	(0.352)	(0.180)	(0.055)	(0.923)	(0.863)	(0.868)	(0.580)
Trade openness	0.028***	0.027***	0.029***	0.021***	0.007	0.012	0.009	0.011
	(0.004)	(0.006)	(0.008)	(0.032)	(0.543)	(0.301)	(0.396)	(0.309)
Constant	-0.007	-0.010	-0.011	−0.008	0.032**	0.043**	0.021*	0.021*
	(0.718)	(0.536)	(0.608)	(0.614)	(0.028)	(0.039)	(0.099)	(0.098)
Country outlier dummy	No	No	No	Yes	No	No	No	Yes
Observations	37	37	37	37	31	31	31	31
Adjusted R^2	-0.033	-0.018	-0.038	0.662	-0.014	0.039	0.158	0.492

Notes: p-values in parentheses. Robust standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. To control for outliers, Model (4) includes Romania and Turkey dummies, and Model (8) includes Turkey dummy.

Table 4: Determinants of peripheral countries' mean GDP response

Dependent variable:	1999 - 2009				2008 - 2019			
Mean GDP response	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Foreign currency exposure	-0.010				0.015**			
(NFX)	(0.423)				(0.049)			
Net exposure to USD		0.019				0.143		
(NFX^{usd})		(0.819)				(0.360)		
USD debt exposure			0.037	0.150*			0.191*	0.086
(NFX^{usd}_{debt})			(0.506)	(0.084)			(0.067)	(0.243)
Financial openness	0.010***	0.008***	0.008***	0.011***	-0.008**	-0.005*	-0.005**	-0.007**
(IFI)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)	(0.073)	(0.041)	(0.024)
Industry mix	0.001	0.002	0.004	0.007	-0.003	-0.004	-0.002	0.002
	(0.876)	(0.767)	(0.664)	(0.292)	(0.588)	(0.501)	(0.624)	(0.659)
Trade openness	0.016	-0.021*	-0.021**	–0.041***	-0.003	0.006	0.005	0.016
	(0.210)	(0.054)	(0.040)	(0.007)	(0.786)	(0.605)	(0.667)	(0.274)
AE dummy				–0.050				0.025
				(0.172)				(0.178)
Constant	-0.087***	-0.081***	0.074***	–0.068***	-0.048***	-0.055**	-0.042***	-0.041***
	(0.000)	(0.000)	(0.000)	(0.004)	(0.001)	(0.014)	(0.003)	(0.002)
Country outlier dummies	No	No	No	Yes	No	No	No	Yes
Observations	48	48	48	48	42	42	42	42
Adjusted R^2	0.025	0.017	0.021	0.357	0.168	0.172	0.239	0.480

Notes: p-values in parentheses. Robust standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. To control for outliers, Model (4) includes Romania and Russia dummies, and Model (8) includes Turkey dummy.

Table 5: Determinants of peripheral countries' mean GDP response: AEs Versus EMEs

Dependent variable: Mean GDP response	1999-2009				2008-2019			
Country Subsample	*AE*		*EME*		*AE*		*EME*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
USD debt exposure	-0.006	-0.019	0.236*	0.236*	0.035	0.015	0.105	0.103
(NFX^{usd}_{debt})	(0.977)	(0.931)	(0.051)	(0.061)	(0.743)	(0.884)	(0.266)	(0.294)
Financial openness	0.007*	0.005	0.019***	0.017	-0.007**	-0.010***	0.002	0.006
(IFI)	(0.058)	(0.186)	(0.003)	(0.587)	(0.040)	(0.004)	(0.768)	(0.543)
Industry mix	-0.003	-0.003	0.014	0.014*	0.004	0.005	0.008	0.009
	(0.775)	(0.808)	(0.177)	(0.088)	(0.643)	(0.425)	(0.303)	(0.274)
Trade openness	-0.015	-0.024	-0.068***	-0.067**	0.001	0.000	-0.014	-0.015
	(0.567)	(0.263)	(0.004)	(0.021)	(0.958)	(0.997)	(0.586)	(0.572)
Financial center		0.039		0.034		0.098		-0.068
		(0.333)		(0.932)		(0.139)		(0.519)
Constant	-0.015	-0.106***	-0.071**	-0.067	-0.018	-0.004	-0.068***	-0.075**
	(0.567)	(0.002)	(0.040)	(0.133)	(0.373)	(0.850)	(0.009)	(0.020)
Country outlier dummies	No	No	Yes	Yes	No	No	Yes	Yes
Observations	20	20	28	28	20	20	22	22
Adjusted R^2	-0.024	0.063	0.489	0.465	0.45	0.545	0.487	0.462

Notes: p-values in parentheses. Robust standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. Financial center is a dummy variable for the financial center countries, including Switzerland, Hong Kong, Ireland, Netherland, and Singapore. To control for outliers, Models (3) and (4) include Romania and Russia dummies, and Models (7) and (8) include Turkey dummy.

3.3 Non-linearity in peripheral countries' GDP responses

In this section, we examine whether there is non-linearity in US monetary spillover effects through the channel of net exposure to US dollar debt for countries at high and low levels of financial openness, which we interpret as exposure to global financial cycles. Likewise, we also examine whether there is nonlinearity in spillover effects associated with exposure to global financial cycles for countries at different levels of net exposure to dollar debt.

We motivate this exercise with the following simple thought experiment: Consider a country that is a net borrower in US dollar debt ($NFX_{debt}^{usd} < 0$). Following domestic currency depreciation due to contractionary US monetary shocks. The country will likely suffer from negative balance sheet effects that are detrimental to its economy. Such adverse impact is further intensified if the country has high exposure to global financial cycle (IFI), which may cause the country to experience large credit crunch due to capital outflows and aggravate its output drop. To formally test for non-linearity in GDP responses due to the interaction between net dollar debt exposure and exposure to global financial cycles, we re-specify the baseline model to be:

$$s_i = \delta + \boldsymbol{\gamma} \cdot \boldsymbol{w_i} + \beta^{IFI} \cdot IFI_i + \beta^{NFX} \cdot NFX_{debt,i}^{usd} + \lambda \cdot IFI_i \cdot NFX_{debt,i}^{usd} + v_i, \quad (5)$$

where $IFI_i \cdot NFX_{debt,i}^{usd}$ is the interaction term between financial openness and net exposure to US dollar debt, and λ captures the interaction effect.

Table 6 presents the non-linearity in peripheral countries' GDP response. The results show that there is non-linearity in the effects of both net exposure to dollar debt and financial openness on the US monetary spillovers. First, Columns (1) and (3) in the top panel shows the estimated coefficients on NFX_{debt}^{usd} across the different levels of IFI are positive in sign, meaning the correlation between GDP response and net exposure to dollar debt is positive. So, economies that are net borrowers of dollar debt will experience larger output fall compared to

economies that are net lenders of dollar debt. Further, the drop in GDP is particularly larger if their financial openness is high, which can be seen from the increasing magnitude of the coefficients as financial openness (IFI) increases from the lowest to the highest level of the sample. This implies that for countries indebted in dollar, limiting their financial openness may help dampen the negative US monetary spillover effects on the real economy.

Panel (b) of Table 6 presents the non-linearity in financial openness effect across the different levels of net exposure to dollar debt. The changing signs of the estimated coefficients in Columns (1) and (3) of the lower panel suggest that the direction of the effect of financial openness, IFI, on US monetary spillover to peripheral economies' GDP is not uniform. With US monetary tightening, peripheral economies' exposure to global financial cycle will cause output loss if they are net short and highly indebted in dollar debt. These are the economies at the lower percentiles of NFX_{debt}^{usd}. However, the exposure to global financial cycle will help ameliorate the negative impact of US contractionary monetary shock on peripheral economies' output if they are net long in dollar debt, especially those at the higher percentiles of NFX_{debt}^{usd} [7]. This is because net dollar debtors have limited leeway in using easing monetary policy to fend against US contractionary monetary shock, as not following the US's monetary stance would prompt local currency depreciation and weaken their balance sheet positions. Therefore, they have to endure unfavourable domestic credit and macroeconomic conditions transmitted from the US if their financial openness is high. By the same token, net dollar creditors in the same circumstance have the incentive and ability to hold or even ease their monetary policy stance, as they will benefit from the strengthening balance sheets when dollar appreciates.

[7] The lowest 47 percentile of countries have negative positions in dollar debt, $NFX_{debt}^{usd} < 0$.

4. Robustness

We carry out robustness checks by considering (1) using capital control, KA, as the alternative variable for financial openness indicator, replacing IFI, and (2) the inclusion of institutional quality variables to control for potentially omitted variables.

Table 6: Non-linearity in peripheral countries' GDP response

Dependent variable: Mean GDP response		1999 - 2009		2008 - 2019	
		(1) $\tilde{\beta}_k + \tilde{\lambda} \cdot x_j$	(2) p-value	(3) $\tilde{\beta}_k + \tilde{\lambda} \cdot x_j$	(4) p-value
Hypothesis (a): The marginal effect of net exposure to dollar debt on GDP is magnified when financial openness is high					
$NFX^{usd}_{debt} \times x_j,\ x_j$: IFI	at min	0.079	0.439	0.038	0.645
	at p^{25}	0.096	0.321	0.063	0.409
	at p^{50}	0.126	0.157	0.116	0.111
	at p^{75}	0.183**	0.022	0.226**	0.035
	at max	0.708***	0.003	1.478*	0.094
Hypothesis (b): The marginal effect of financial openness on GDP is positive (negative) when net exposure to dollar debt is positive (negative)					
$IFI \times x_j,\ x_j$: NFX^{usd}_{debt}	at min	-0.006	0.460	-0.018**	0.048
	at p^{25}	0.003	0.502	-0.010**	0.023
	at p^{50}	0.008**	0.020	-0.007**	0.021
	at p^{75}	0.010***	0.001	0.005**	0.044
	at max	0.017***	0.000	0.003	0.561

Notes: Delta-method standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. The table reports estimates of the marginal effect of interacted determinants of the peripheral countries' GDP response to US contractionary monetary policy evaluated at different values of the interacting variable x_j.

4.1 Alternative measure for financial openness

As the first robustness check, we test whether our regression results are robust to using capital control as an alternative measure of exposure to global financial cycles. We use the capital control data compiled by Fernandez et al. (2015), which are based on the de jure information from IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).

Table 7 reports the robustness test result for the country subsample analysis using mean GDP response as the dependent variable. We obtain largely similar results as those of Table 5. The coefficient on net dollar debt exposure is positive and significant for EMEs over 1999-2009

period, suggesting nonadvanced economies with greater negative exposure to dollar debt experience larger decline in their GDP given the contractionary US monetary shock. The estimated coefficient of capital control is positive and significant in Columns (1) and (4), suggesting that the higher the capital control is the less a country's GDP is negatively affected. This corroborates our finding in the previous non-linearity exercise that the negative impact of contractionary US monetary spillover for an economy net short of dollar would be intensified if its exposure to global financial cycles is high, providing incentives for countries to adopt capital control as a prudential policy.

Table 7: Capital Control and US Monetary Spillover: AEs Versus EMEs

Dependent variable: Mean GDP response	1999-2009		2008-2019	
Country Subsample	*AE*	*EME*	*AE*	*EME*
	(1)	(2)	(3)	(4)
USD debt exposure	0.128	0.273*	0.106	0.084
(NFX^{us}_{debt})	(0.595)	(0.062)	(0.614)	(0.265)
Capital control	0.233*	-0.005	0.149	0.071**
(KA)	(0.059)	(0.932)	(0.435)	(0.016)
Industry mix	-0.006	0.015*	-0.001	0.007
	(0.592)	(0.075)	(0.914)	(0.175)
Trade openness	0.009	-0.059***	-0.068	0.002
	(0.688)	(0.004)	(0.103)	(0.934)
Financial center	0.054	0.234**	0.007	0.002
	(0.231)	(0.020)	(0.907)	(0.980)
Constant	-0.095***	-0.032	-0.090**	-0.100***
	(0.001)	(0.598)	(0.011)	(0.000)
Country outlier dummies	No	Yes	No	Yes
Observations	20	24	20	22
Adjusted R^2	-0.027	0.579	0.235	0.595

Notes: p-values in parentheses. Robust standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. Financial center is a dummy variable for the financial center countries, including Switzerland, Hong Kong, Ireland, Netherland, and Singapore. To control for outliers, Model (2) includes Romania and Russia dummies, and Model (4) includes Turkey dummy.

We further examine the non-linearity effects of net exposure to dollar debt and exposure to global financial cycles proxied by capital control on mean GDP responses. Table 8 presents the results. Panel (a) shows that GDP decreases by more for countries net short of dollar debt if capital control is low. This is similar to the previous result that GDP decreases by more for countries net short of dollar debt if financial openness is high (see Table 6). Panel (b) shows

that countries with higher capital control has higher mean GDP responses, and this benefit from imposing capital control is in particular larger for countries that are highly indebted in dollar. Combined, the results from this exercise again suggests that implementing capital control might help dampen negative US monetary spillover for countries that are net borrowers in dollar.

Table 8: Non-linearity in peripheral countries' GDP response with capital control as de jure measure of financial openness

Dependent variable: Mean GDP response		1999 - 2009		2008 - 2019	
		(1) $\tilde{\beta}_k + \tilde{\lambda} \cdot x_j$	(2) p-value	(3) $\tilde{\beta}_k + \tilde{\lambda} \cdot x_j$	(4) p-value
Hypothesis (a): GDP decreases by more for countries net short of dollar debt if capital control *(KA)* is low					
$NFX_{debt}^{usd} \times x_j,\ x_j$: KA	at min	0.228*	0.063	0.182	0.190
	at p^{25}	0.214*	0.067	0.176	0.180
	at p^{50}	0.188*	0.079	0.165	0.161
	at p^{75}	0.065	0.542	0.107	0.128
	at max	-0.051	0.753	0.061	0.500
Hypothesis (b): GDP is higher for countries with high capital control *(KA)* if they are more net short in dollar debt					
$KA \times x_j,\ x_j$: NFX_{debt}^{usd}	at min	0.093	0.223	0.088	0.116
	at p^{25}	0.016	0.697	0.065*	0.067
	at p^{50}	-0.026	0.587	0.056*	0.097
	at p^{75}	-0.044	0.436	0.051	0.146
	at max	-0.105	0.258	0.028	0.609

Notes: Delta-method standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. The table reports estimates of the marginal effect of interacted determinants of the peripheral countries' GDP response to US contractionary monetary policy evaluated at different values of the interacting variable x_j.

4.2 Inclusion of Institutional Quality

We next check the sensitivity of our baseline results to the inclusion of institutional quality indicators as additional control variables of country-specific characteristics. We employ data provided by the Worldwide Governance Indicators project funded by the World Bank, which encompasses six indicators of institutional quality, including Voice and Accountability, Political Stability, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption (See Table A4 in the appendix for more detailed descriptions).

Table 9: Inclusion of institutional quality variables as determinants of peripheraly countries' interest rate responses

Dependent Variable: Mean Interest Rate	1999-2009						2008-2019					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
USD debt exposure (NFX^{us}_{debt})	-0.012	0.015	0.039	0.025	0.064	0.04	-0.106**	-0.074*	-0.043	-0.081*	-0.060	-0.059
	(0.883)	(0.847)	(0.708)	(0.792)	(0.455)	(0.652)	(0.010)	(0.068)	(0.354)	(0.063)	(0.197)	(0.175)
Financial openness (*IFI*)	-0.004	-0.005	-0.006	-0.005	-0.005	-0.005	0.000	0.000	0.001	0.001	0.001	0.002
	(0.237)	(0.185)	(0.118)	(0.191)	(0.171)	(0.247)	(0.963)	(0.965)	(0.714)	(0.822)	(0.725)	(0.592)
Voice & accountability	-0.001						-0.000					
	(0.167)						(0.116)					
Political stability		-0.001**						-0.000**				
		(0.030)						(0.027)				
Govt effectiveness			-0.001						-0.001***			
			(0.111)						(0.001)			
Regulatory quality				-0.001*						-0.001***		
				(0.070)						(0.006)		
Rule of law					-0.001**						-0.001***	
					(0.020)						(0.001)	
Control of corruption						-0.001**						-0.001***
						(0.032)						0.000
Observations	37	37	37	37	37	37	31	31	31	31	31	31
Adjusted R^2	0.683	0.692	0.688	0.699	0.721	0.711	0.532	0.575	0.643	0.621	0.651	0.655

Notes: p-values in parentheses. Robust standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. We also included other determinants, such as trade openness and industry mix in the regression, but omitted from the reporting here to save space. Particularly, we included regressors used in column (4) of Table 3 for the 1999-2009 subsample, and column (8) of Table 3 for the 2008-2019 subsample, but not reported to save space.

Table 10: Inclusion of institutional quality variables as determinants of peripheral countries' GDP responses

Dependent Variable: Mean GDP	1999-2009						2008-2019					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
USD debt exposure	0.149	0.166*	0.167*	0.164*	0.154	0.155	0.085	0.081	0.069	0.088	0.083	0.081
(NFX^{us}_{debt})	(0.108)	(0.065)	(0.093)	(0.099)	(0.129)	(0.112)	(0.285)	(0.304)	(0.374)	(0.217)	(0.270)	(0.283)
Financial openness	0.011***	0.010***	0.010***	0.011***	0.011***	0.011***	-0.007**	-0.007**	-0.007**	-0.007**	-0.007**	-0.007**
(*IFI*)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.026)	(0.030)	(0.028)	(0.027)	(0.028)	(0.025)
Voice & accountability	0.000						0.000					
	(0.618)						(0.948)					
Political stability		-0.001*						0.000				
		(0.074)						(0.665)				
Govt effectiveness			0.000						0.000			
			(0.578)						(0.597)			
Regulatory quality				-0.001						0.000		
				(0.437)						(0.751)		
Rule of law					0.000						0.000	
					(0.899)						(0.814)	
Control of corruption						0.000						0.000
						(0.834)						(0.714)
Observations	48	48	48	48	48	48	42	42	42	42	42	42
Adjusted R^2	0.346	0.406	0.346	0.352	0.341	0.342	0.465	0.468	0.471	0.466	0.466	0.467

Notes: p-values in parentheses. Robust standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. We also included other determinants, such as trade openness and industry mix in the regression, but omitted from the reporting here to save space. Particularly, we included regressors used in column (4) of Table 4 for the 1999-2009 subsample, and column (8) of Table 4 for the 2008-2019 subsample, but not reported to save space.

Table 11: Inclusion of institutional quality variables as determinants of peripheral countries' GDP responses: EME subsample

Dependent Variable: Mean GDP	1999-2009						2008-2019					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
USD debt exposure	0.236*	0.250**	0.252*	0.257*	0.240*	0.247*	0.085	0.115	0.152	0.115	0.127	0.129
(NFX^{us}_{debt})	(0.076)	(0.041)	(0.074)	(0.071)	(0.087)	(0.071)	(0.371)	(0.227)	(0.107)	(0.138)	(0.124)	(0.130)
Financial openness	0.019***	0.017***	0.019***	0.019***	0.019***	0.020***	0.003	0.002	0.001	0.002	0.002	0.003
(*IFI*)	(0.001)	0.000	(0.006)	(0.001)	(0.003)	(0.004)	(0.675)	(0.780)	(0.816)	(0.732)	(0.799)	(0.674)
Voice & accountability	0.000						0.000					
	(0.621)						(0.352)					
Political stability		-0.001**						-0.001				
		(0.020)						(0.203)				
Govt effectiveness			0.000						-0.001			
			(0.749)						(0.225)			
Regulatory quality				-0.001						-0.001*		
				(0.414)						(0.067)		
Rule of law					0.000						-0.001	
					(0.937)						(0.271)	
Control of corruption						0.000						-0.001
						(0.735)						(0.233)
Observations	28	28	28	28	28	28	22	22	22	22	22	22
Adjusted R^2	0.475	0.586	0.468	0.482	0.465	0.468	0.484	0.494	0.516	0.57	0.504	0.517

Notes: p-values in parentheses. Robust standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. We also included other determinants, such as trade openness and industry mix in the regression, but omitted from the reporting here to save space. Particularly, we included regressors used in column (4) of Table 4 for the 1999-2009 subsample, and column (8) of Table 4 for the 2008-2019 subsample, but not reported to save space. The results are robust to adding financial center dummy which includes Switzerland, Hong Kong, Ireland, and Singapore.

Table 9 shows sensitivity test results when mean interest rate response is the dependent variable. The estimated coefficient on dollar debt exposure (NFX_{debt}^{usd}) is mostly negative and statistically significant for the 2008-2019 subperiod (See Columns (7), (9), and (10) of Table 8), and has larger magnitude than the estimated coefficient on financial openness. It does not alter the main conclusion drawn from Table 3 Columns (4) and (8), in which the exposure to dollar denominated debt compared to exposure to global financial cycle is a more important factor contributing to lower monetary policy autonomy of peripheral countries. Moreover, the negative and significant coefficients on most institutional quality indicators suggest that countries with stronger governance may adopt more accommodating monetary policy against the US contractionary monetary shock, though the impact is not strong given the small coefficient values.

We replace dependent variable by mean GDP response and perform the same sensitivity analysis. The results are presented in Table 10 and are largely similar to the baseline results as reported in Table 4 Columns (4) and (8). Again, the findings corroborate that debt dollarization exerts stronger adverse impact on peripheral countries' GDP than financial openness, and the effect is more pronounced when we only consider EMEs as shown in Table 11. Overall, the robustness check in this section shows that the primary results from our baseline analysis hold even after we control for institutional quality of the peripheral economies.

5. Conclusion

In this paper, we study how heterogeneous country characteristics contribute to variations in the impact of US monetary spillover. We find that economies with higher debt dollarization have higher interest rate responses to contractionary US monetary shocks— either by raising interest rates to prevent negative balance sheet effects, or by easing domestic interest rate by less due to fear of currency depreciation and increased debt burden. For countries that are net borrowers in US dollar debts, a 10 percentage increase in their share of US dollar debt liability

relative to assets would translate to about 1.6 basis point increase in their interest rate responses. We also find that GDP decreases by more for economies with higher debt dollarization and it is especially so for EMEs and if the economies' financial openness is high. In other words, high financial openness amplifies the effect of negative dollar exposure on US monetary spillover. Using capital control as the de jure measure of financial openness, we find that GDP decreases by more for countries net short of dollar if capital control is low, and at the same time, GDP is higher for countries with higher capital control if they are more net short in dollar. Combined, the results point to the clear policy implication that capital control helps dampen negative US monetary spillover, and the benefit from imposing capital control is particularly large for countries that are more indebted in dollar.

Appendix A: Supplementary Tables

Table A1: Rates of Rejection of the Null of No Parameter Instability

	Test Statistics					
Significance Level	PK_{sup}	PK_{msq}	R	QLR	MW	APW
Sample Period: 1999 Q1 – 2019 Q4						
10%	0.28	0.28	0.14	0.01	0.02	0.01
5%	0.21	0.20	0.05	0	0.01	0
1%	0.10	0.08	0.03	0	0.01	0
Sample Period: 1999 Q1 – 2009 Q4						
10%	0.15	0.15	0.09	0	0	0
5%	0.10	0.07	0.05	0	0	0
1%	0.02	0.01	0.02	0	0	0
Sample Period: 2008 Q1 – 2019 Q4						
10%	0.12	0.09	0.06	0	0	0
5%	0.05	0.06	0.03	0	0	0
1%	0.02	0.01	0.01	0	0	0

Notes: This table displays the share of equations with the null of no parameter stability rejected. PK_{sup} and PK_{msq} refer to the Ploberger and Krämer's (1992) CUMSUM test with OLS residuals and the mean square version; R represents Nyblom's (1989) parameter constancy test; QLR denotes Quandt's (1960) likelihood ratio test; whereas MW and APW are mean Wald statistic of Hansen (1992) and Andrews and Ploberger's (1994) Wald statistic based on the exponential average. Bootstrapped samples for the GVAR model are used to obtain the critical values of the test statistics under the null of parameter stability.

Table A2: Rates of Rejection of the Null of No Serial Correlation

	Significance Level		
Lags	10%	5%	1%
Sample Period: 1999 Q1 – 2019 Q4			
1	0.10	0.06	0.03
2	0.16	0.11	0.07
3	0.19	0.17	0.11
4	0.18	0.17	0.11
Sample Period: 1999 Q1 – 2009 Q4			
1	0.10	0.08	0.03
2	0.14	0.11	0.07
3	0.16	0.15	0.13
4	0.22	0.20	0.16
Sample Period: 2008 Q1 – 2019 Q4			
1	0.10	0.06	0.03
2	0.13	0.11	0.07
3	0.11	0.11	0.09
4	0.19	0.19	0.17

Notes: This table displays the share of equations with the null of no serial correlation is rejected at lag one to lag four based on Lagrange multiplier test.

Table A3: Interest Rate Responses: Advanced and Non-advanced Economies

Dependent variable:	AE			EME		
Mean interest rate response	(1)	(2)	(3)	(5)	(6)	(7)
Foreign currency exposure	0.070***			-0.011		
(NFX)	(0.010)			(0.578)		
Net exposure to USD		0.523**			-0.021	
(NFX^{usd})		(0.021)			(0.810)	
USD debt exposure			0.089			-0.011
(NFX^{usd}_{debt})			(0.519)			(0.905)
Financial openness	-0.027**	-0.007+	-0.004	0.001	-0.003	-0.003
(IFI)	(0.022)	(0.243)	(0.626)	(0.852)	(0.549)	(0.540)
Industry mix	-0.013**	-0.009+	-0.000	-0.011**	-0.010**	-0.010**
	(0.021)	(0.153)	(0.993)	(0.029)	(0.040)	(0.023)
Trade openness	0.008	0.043	0.012	0.003	0.006	0.006
	(0.761)	(0.254)	(0.813)	(0.832)	(0.716)	(0.675)
Constant	-0.006	-0.055*	-0.026	-0.001	0.004	0.001
	(0.836)	(0.097)	(0.575)	(0.943)	(0.732)	(0.948)
Country outlier dummy	No	No	No	Yes	Yes	Yes
Observations	9	9	9	28	28	28
Adjusted R^2	0.460	0.377	-0.772	0.700	0.698	0.697

Notes: p-values in parentheses. Robust standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. To control for outliers, Models (5)-(7) include Romania and Turkey dummies.

Robustness Checks

(I) Robustness to Inclusion of Institutional Quality

Table A4: Measures of Institutional Quality

Index	Definition
Voice & accountability	Perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media
Political stability no violence	Perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism
Government effectiveness	Perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.
Regulatory quality	Perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development
Rule of law	Perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence
Control of corruption	Perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

Notes: The institutional quality index data are downloaded from the Worldwide Governance Indicators (WGI) project funded by the World Bank, which covers more than 200 countries over the span from 1996 to 2020.

(II) Robustness to Inclusion of Financial Centers

Table A5: Determinants of peripheral countries' mean GDP response: AEs Versus EMEs Controlling for Financial Centers, 1999 – 2009

	(1)	(2)	(3)	(4)	(5)	(6)
	(a) AE			(b) EME		
Foreign currency exposure	-0.032*			0.001		
	(0.057)			(0.987)		
USD exposure		-0.058			0.081	
		(0.821)			(0.525)	
USD debt exposure			-0.019			0.236*
			(0.931)			(0.061)
Financial openness	0.008***	0.005	0.005	0.012	0.015	0.017
	(0.002)	(0.165)	(0.186)	(0.738)	(0.670)	(0.587)
Industry mix	-0.001	-0.002	-0.003	0.012	0.014	0.014*
	(0.943)	(0.844)	(0.808)	(0.386)	(0.184)	(0.088)
Trade openness	-0.045**	-0.027	-0.024	-0.044*	-0.051**	-0.067**
	(0.020)	(0.252)	(0.263)	(0.055)	(0.039)	(0.021)
Financial center	0.076**	0.042	0.039	0.069	0.05	0.034
	(0.014)	(0.297)	(0.333)	(0.901)	(0.915)	(0.932)
TUR dummy				-0.211***	-0.216***	-0.235***
				0.000	0.000	0.000
Constant	-0.111***	-0.105***	-0.106***	-0.112**	-0.115**	-0.067
	(0.001)	(0.007)	(0.002)	(0.034)	(0.020)	(0.133)
Observations	20	20	20	28	28	28
Adjusted R^2	0.072	(0.059)	(0.063)	0.351	0.365	0.465

Notes: p-values in parentheses. Robust standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. TUR dummy is dummy variable for Turkey. Financial center dummy includes Belgium, Switzerland, Hong Kong, Ireland, and Singapore.

Table A6: Determinants of peripheral countries' mean GDP response: AEs Versus EMEs Controlling for Financial Centers, 2008 – 2019

	(1)	(2)	(3)	(4)	(5)	(6)
	(c) AE			(d) EME		
Foreign currency exposure	-0.01			0.035*		
	(0.628)			(0.093)		
USD exposure		0.054			0.019	
		(0.651)			(0.911)	
USD debt exposure			0.015			0.103
			(0.884)			(0.294)
Financial openness	-0.009**	-0.010***	-0.010***	-0.015	0.006	0.006
	(0.050)	(0.004)	(0.004)	(0.387)	(0.575)	(0.543)
Industry mix	0.007+	0.005	0.005	0.008	0.009	0.009
	(0.241)	(0.467)	(0.425)	(0.336)	(0.271)	(0.274)
Trade openness	-0.003	0.001	0	0.006	-0.009	-0.015
	(0.900)	(0.953)	(0.997)	(0.854)	(0.727)	(0.572)
Financial center	0.118	0.096	0.098	-0.006	-0.074	-0.068
	(0.141)	(0.154)	(0.139)	(0.936)	(0.544)	(0.519)
TUR dummy				-0.202***	-0.206***	-0.195***
				(0.000)	(0.000)	(0.000)
Constant	-0.004	-0.006	-0.004	-0.051	-0.078**	-0.075**
	(0.859)	(0.787)	(0.850)	(0.185)	(0.024)	(0.020)
Observations	20	20	20	22	22	22
Adjusted R^2	0.553	0.549	0.545	0.469	0.414	0.462

Notes: p-values in parentheses. Robust standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01. TUR dummy is dummy variable for Turkey. Financial center dummy includes Switzerland, Hong Kong, Ireland, Netherlands, and Singapore.

Appendix B: Supplementary Figures

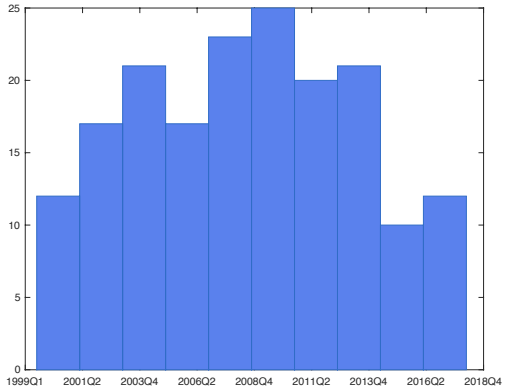

Figure B1: Distribution of estimated structural break dates according to Ploberger and Kramer's (1992) maximal OLS cumulative sum statistic.

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