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Monetary policy spillovers and the trilemma in the new normal: Periphery country sensitivity to core country conditions

Joshua Aizenman [a], Menzie D. Chinn [b,c], Hiro Ito [d,*]

[a] University of Southern California, University Park, Los Angeles, CA 90089-0043, USA
[b] Robert M. La Follette School of Public Affairs, University of Wisconsin, 1225 Observatory Drive, Madison, WI 53706, USA
[c] Department of Economics, University of Wisconsin, 1180 Observatory Drive, Madison, WI 53706, USA
[d] Department of Economics, Portland State University, 1721 SW Broadway, Portland, OR 97201, USA

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ABSTRACT

We investigate why and how the financial conditions of developing and emerging market countries (peripheral countries) can be affected by the movements in the center economies – the U.S., Japan, the Eurozone, and China. We apply a two-step approach. First, we estimate the sensitivity of countries' financial variables to the center economies [policy interest rate, stock market prices, and the real effective exchange rates (REER)] while controlling for global and domestic factors. Next, we examine the association of the estimated sensitivity coefficients with the macroeconomic conditions, policies, real and financial linkages with the center economies, and the level of institutional development. In the last two decades, for most financial variables, the strength of the links with the center economies have been the dominant factor while the movements of policy interest rate also appear sensitive to global financial shocks around the emerging market crises of the late 1990s and since the global financial crisis of 2008. While certain macroeconomic and institutional variables are important, the arrangement of open macropolicies such as the exchange rate regime and financial openness are also found to have direct influence on the sensitivity to the center economies. An economy that pursues greater exchange rate stability and financial openness faces a stronger link with the center

* Corresponding author. Tel.: +1 503 725 3930/3945.
E-mail address: ito@pdx.edu (H. Ito).

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economies through policy interest rates and real effective exchange rate (REER) movements. We also find that exchange market pressure (EMP) in peripheral economies is sensitive to the movements of the center economies' REER and EMP during and after the global financial crisis. Open macro policy arrangements, especially exchange rate regimes, also have indirect effects on the strength of financial linkages, interacting with other macroeconomic conditions. Thus, trilemma policy arrangements, including exchange rate flexibility, continue to affect the sensitivity of developing countries to policy changes and shocks in the center economies.

1. Introduction

The integrated nature of the financial system was amply demonstrated by the turmoil in emerging market currency and bond markets in the wake of Fed Chairman Bernanke's statements regarding the normalization of U.S. monetary policy in 2013 ("taper tantrum"). Following close on the heels of complaints about unconventional monetary policy implementation in the preceding years, it is clear that – at a minimum – policymakers in emerging market economies perceive an increasing vulnerability to the whims of the global financial system.

The idea that the monetary policies of financial center countries have large spillover effects on the smaller economies is not new. During the mid-1990s, when advanced economy central bankers raised policy rates, after several years of negative real interest rates, similar complaints were lodged, and some may partly trace the financial crises in Latin America and subsequently in East Asia to the cycle in core country policy interest rates.

One key difference is that in the earlier episode's aftermath, the semi-fixed exchange rate regimes were tagged as a contributing factor. In contrast, countries adhering to a variety of exchange rate regimes all experienced challenges in insulating their economies in the most recent episode. This has led to a grand debate about the continued relevance of the "impossible trinity" or "monetary trilemma."

Since Mundell (1963) outlined the hypothesis of the monetary trilemma, fundamental policy management in the open economy has been viewed as policy trade-offs among the choices of monetary autonomy, exchange rate stability, and financial openness.[1] The hypothesis and its extensions in recent years suggest a continuous trade-off between the three trilemma dimensions, with the possibility that a fourth policy goal, financial stability, may augment it and turn it into a quadrilemma where international reserves may play a role as buffers (Aizenman, 2013).

In contrast, in the aftermath of the global financial crisis (GFC), Rey (2013) concluded that the economic center's (CE) monetary policy influences other countries' national monetary policy mostly through capital-flows, credit growth, and bank leverages, making the types of exchange rate regime of the non-CEs irrelevant. In other words, the countries in the periphery (PH) are all sensitive to a "global financial cycle" irrespective of exchange rate regimes. In this view, the "trilemma" reduces to an "irreconcilable duo" of monetary independence and capital mobility. Consequently, restricting capital-mobility may be the only way for non-CE countries to retain monetary autonomy. The recent experience of Brazil, India, Indonesia, South Africa, and Turkey – the "Fragile Five" – during the taper tantrum episode may make the "irreconcilable duo" view convincing to many observers.

In this paper, we investigate whether Rey's (2013) view means the end of the trilemma hypothesis or a prematurely prediction that is not supported by the data. Inferences based on the data from the times of heightened volatility emanating from the CE might be modified once we examine how

[1] See Aizenman et al. (2010, 2011, 2013), Obstfeld (2014), Obstfeld et al. (2005), and Shambaugh (2004) for further discussion and references dealing with the trilemma.

the propagation of large shocks from the CE can be affected by economic structures and measures of the trilemma variables. In a world of more than a hundred countries, one ignores heterogeneity at one's own risk. For instance, the trade-offs facing the OECD countries may differ from emerging markets economies and developing countries as well as whether they are manufacturing- or commodity-based economies.[2] Furthermore, large shocks from the EC during the GFC and the following Euro debt crisis may have altered the transmission dynamics, especially in comparison to the preceding decade of illusory tranquility.[3]

Many studies such as Ahmed and Zlate (2013), Forbes and Warnock (2012), Fratzscher (2011), and Ghosh et al. (2012) have documented the importance of global factors such as advanced economy interest rates and global risk appetite in affecting capital flows to small open economies. Nonetheless, these studies have also highlighted that domestic, country-specific factors also retain importance. In particular, the institutional and macroeconomic policy frameworks of the emerging market economies also determine the variations in flows.

Given this context, we focus on the questions of why movements in the major advanced economies often have large effects on other financial markets, how these cross-market linkages have changed over time, and what kind of factors contribute to explaining the sensitivity to the movements in the major economies. More specifically, we will conduct an empirical analysis on what determines the sensitivity of economies to factors pertaining to the core economies in the world, namely, the U.S., the Euro area, Japan, and China.

In Section 2, we will detail the framework of the estimation exercise we employ for our empirical exploration. We will report and discuss the estimation results in Section 3. In Section 4, We will conduct further analysis by investigating the sensitivity of the exchange market pressure (EMP) in peripheral economies to the movements of the center economies' financial variables and its determinants. In Section 5, we will make concluding remarks.

2. The empirical methodology

For our empirical exploration, we employ an estimation process similar to that employed by Forbes and Chinn (2004), which is composed of two steps of estimations. First, we investigate the degree of the sensitivity of several important financial variables to global, cross-country, and domestic factors. Second, treating the estimated sensitivity as a dependent variable, we will examine their determinants among a number of country-specific variables. In so doing, we will disentangle roles of countries' macroeconomic conditions or policies, real or financial linkage with the center economy, or the level of institutional development of the countries.

2.1. The first-step: estimating sensitivity coefficients

The main objective of this first step estimation is to estimate the correlation of a specific financial variable between country i and each of the center economies while controlling for global and domestic factors. The estimated coefficient of our focus is $\hat{\gamma}^C_{Fi}$. A significantly positive $\hat{\gamma}^C_{Fi}$ indicates a closer linkage between country i and economic center country C, as shown in Equation (1):

$$R^F_{it} = \alpha_{Fit} + \sum_{g=1}^{G} \beta^G_{Fit} Z^G_{it} + \sum_{c=1}^{C} \gamma^C_{Fit} X^C_{it} + \phi_{Fit} Y_{it} + \varepsilon_{it} \tag{1}$$

where the Z^G_i is a vector of global factors, the X^C_i is a vector of cross-country factors, and Y_{it} is a control variable for domestic factors. C represents the center economies: the U.S., the Euro area, Japan, and

[2] For example, maintaining exchange rate stability could be more important for developing countries whose growth strategy is reliant on the exports of a narrower variety of manufactured goods or commodities than advanced economies with more diversified economic structures.

[3] As one indirect evidence, Aizenman et al. (2015a) show that the global financial crisis of 2008 caused structural changes in the patterns of holding international reserves (IR).

China. $\hat{\gamma}_{ii}^{C}$, the estimate of our focus, represents the extent of sensitivity of a financial variable (R_{it}^{F}) to cross-country factors, or more specifically, linkages to the four major economies. As for the financial variable as the dependent variable, we are interested in the short-term policy interest rate and the rate of change in the real effective exchange rate (REER). We also tested the linkages of stock market price changes and the sovereign bond spread between the center and non-center economies. However, the results turn out much less robust or indicative of insightful economic discussions at times. Hence, we omit reporting and discussing the results, although they can be found in our working paper version of this article (Aizenman et al., 2015b).

We use money market rates to represent policy short-term interest rate. In recent years, all of the advanced major economies, the U.S., the Euro area, and Japan, have implemented extremely loose monetary policy in the aftermath of the global financial crisis (GFC). Given that both the U.S. and Japan have lowered their policy interest rates down to or near zero, using official policy interest rates may not capture the actual state of monetary policy. In recent years, many researchers have estimated "shadow interest rates" to represent the actual state of liquidity availability by allowing the estimated shadow rates to drop below the zero bound. We use these shadow rates for the three advanced economies to estimate more realistic correlations between the policy interest rates of the center economies and the sample countries. For the U.S. and the Euro area, we use the shadow interest rates estimated by Wu and Xia (2014). For Japan, we use the shadow rates estimated by Christensen and Rudebusch (2014). We use the REER indices from the IMF's *International Financial Statistics* (*IFS*).

For a vector of global factors (Z_i^G), we have two subsets of global factors. The first subset of global factors include "real" variables – global interest rates (for which we will use the first principal component of U.S. Federal Reserve, ECB, and Bank of Japan's policy interest rates); oil prices; and commodity prices. When we estimate for the policy interest rate correlation, we do not include the first component of U.S. FRB, ECB, and Bank of Japan's interest rates as part of the global factor vector because it would overlap with X^C. To avoid multicollinearity or redundancy, we also use the first principal component of oil and commodity prices as a control variable for input or commodity prices.[4]

The second subset is "financial." In this group, we include the VIX index from the Chicago Board Options Exchange (CBOE), as a proxy for the extent of investors' risk aversion, and the "Ted spread," which is the difference between the 3-month Eurodollar Deposit Rate in London (LIBOR) and the 3-month U.S. Treasury Bill yield. This latter measure gauges the general level of stress in the money market for financial institutions. The same set of global factors, except for the principal components of the global interest rates, is used for all the estimations regardless of the dependent variable.

The vector of cross-country linkage factors (X^C) corresponds to the dependent variable. For example, if the short-term interest rate for country *i* is the dependent variable, X_i^C includes the short-term interest rates of the four center economies.[5] We implement the estimation for each of the sample countries for the two dependent variables and for the sample period of 1986 through 2012. To control for domestic economic conditions, we include the year-on-year growth rate of industrial production index. All the data used for this estimation exercise are monthly frequency. The same set of explanatory variables (except for the world interest rate) is regressed against the two financial variables.

Because we deal with a relatively long sample period, coefficient instability is a concern. Hence, we estimate the above regressions for each of the three-year non-overlapping panels, starting in 1986.[6] That means that $\hat{\gamma}_{Fit}^{C}$ is time-varying across the panels.

We also estimate two specifications. One specification excludes China as one of the "center economies." In this model setup, we are testing the sensitivity of our sample economies to the

[4] To control for global macroeconomic conditions, we also tested the growth rate of world trade as one of the variables in the vector of real global factors. It turned out that including this variable does not change the results for both the first and second stage estimations. To keep the model parsimonious and save the degree of freedom, we decided not to include the variable for world trade growth.

[5] For the Euro Area's variables before the introduction of the euro in 1999, the GDP-weighted average of the variable of concern for the original 12 Euro countries is calculated and included in the estimation.

[6] We also tested using five-year panels. Since the results are qualitatively similar, we decide not to report the results.

traditionally-defined major economies of the U.S., the Euro area, and Japan.[7] The other model does include China as one of the center economies.

Our panel data are composed of about 100 countries including both advanced economies (IDC) and less developed countries (LDC), with the sample size varying depending on data availability. In our sample, the U.S. and Japan are not included in any of estimates. As for the Euro member countries, they are removed from the sample after the introduction of the euro in January 1999 or they become member countries, whichever comes first. We also have a subsample of emerging market countries (EMG) within the LDC subsample.[8]

2.2. The second step: explaining the sensitivity coefficients

Once we estimate γ^C_{Fit} for each of the dependent variables, we regress $\hat{\gamma}^C_{Fit}$ on a number of country-specific variables.

$$\hat{\gamma}^C_{Fit} = \theta_0 + \theta_1 OMP_{Fit} + \theta_2 MC_{Fit} + \theta_3 LINK_{Fit} + \theta_4 INST_{Fit} + \theta_5 CRISIS_{Fit} + u_{Fit} \quad (2)$$

There are four groups of explanatory variables. The first group of explanatory variables is a set of open macroeconomic policy choices (OMP_i), for which we include the indexes for exchange rate stability (*ERS*) and financial openness (*KAOPEN*) from the trilemma indexes by Aizenman et al. (2013).[9] A country that has a fixed exchange rate arrangement with a major country, or the base country, is more subject to financial shocks occurring to the base country if it has more open financial markets. Saxena (2008) found that the extent of pass-through from foreign interest rates to domestic interest rates is higher under *floating* exchange rate regimes than under pegging regimes, however.[10] Christiansen and Pigott (1997) also suggest that even under floating exchange rate regimes, foreign factors play an important role in affecting long-term interest rates. Hence, it is an empirical question how and to what extent both financial openness and exchange rate stability matter for transmitting financial shocks.[11] As another variable potentially closely related to the trilemma framework, we suspect the level of international reserves (IR) holding may affect the extent of cross-country financial linkages and include the variable for IR holding (excluding gold) as a share of GDP.[12]

The group MC_i includes macroeconomic conditions such as inflation volatility, current account balance, and public finance conditions. As the measure of public finance conditions, we include either gross national debt or general budget balance, both expressed as shares of GDP. We use the data from the IMF's *International Financial Statistics* and *World Economic Outlook* Database.

In addition to these groups of variables, we will include variables that reflect the extent of linkages with the center countries (*LINK*). One linkage variable is meant to capture real, trade linkage, which we will measure as: $TR\_LINK_{ip} = IMP^C_{ip}/GDP_{ip}$ where IMP^C_i is total imports into center economy *C* from country *i*, which is normalized by country *i*'s GDP. Another linkage variable is financial linkage, FIN_LINK_{ip}.

[7] Excluding China mitigates data limitations as well, especially for the second step of the estimation procedure.

[8] The emerging market countries (EMG) are defined as the countries classified as either emerging or frontier during the period of 1980–1997 by the International Financial Corporation plus Hong Kong and Singapore.

[9] As Mundell (1963) argued and Aizenman et al. (2013) and Ito and Kawai (2012) have empirically shown it holds, a country may simultaneously choose any two, but not all, of the three goals of monetary policy independence, exchange rate stability, and financial market openness to the full extent. Given this linearity, we only include the two trilemma indexes out of the three.

[10] To explain the counterintuitive results, Saxena (2008) argues that the classification of exchange rate regimes may allow some of the countries that conduct active but incomplete foreign exchange interventions to be classified as "floating" regimes so that the results for the floating regimes may include those of de facto pegging regimes. Also, she argues that countries with floating exchange rates tend to have more developed financial markets, which tend to follow the trend of the center country's financial markets.

[11] Ghosh et al. (2014, 2015) find that floating exchange rate regimes also help mitigate the extent of susceptibility to financial vulnerabilities, exchange rate vulnerability, and crisis occurrence.

[12] Aizenman et al. (2010, 2011) show that the macroeconomic impact of trilemma policy configurations can depend upon the level of IR holding.

We will measure it with the ratio of the total stock of foreign direct investment from country *C* in country *i* as a share of country *i*'s GDP ($FDINV_i^C$).[13]

Another variable that also reflects the linkage with the major economies is the variable for the extent of trade competition (*Trade_Comp*). *Trade_Comp* measures the importance to country *i* of export competition in the third markets between country *i* and major country *C*. Shocks to country *C*, and especially shocks to country *C* that affects country *c*'s exchange rate, could affect the relative price of country *C*'s exports and therefore affect country *i* through trade competition in third markets. See Appendix for the variable construction. A higher value of this measure indicates country *i* and major economic *C* exports products in similar sectors so that their exported products tend to be competitive to each other.

The fourth group is composed of the variables that characterize the nature of institutional development (*INST*), namely, variables for financial development and legal development. As Caballero et al. (2008) theoretically predict and Chinn and Ito (2006) empirically show, both financial and legal developments are important factors for the volume and directions of cross-border capital flows. Alfaro et al. (2008) argue that institutional development is also an important factor. If these factors affect cross-border capital flows, they should also affect the extent of sensitivity to financial shocks occurring to the center economies.

To measure the level of financial development, we use the first principal component of financial development (*FD*) using the data on private credit creation, stock market capitalization, stock market total value, and private bond market capitalization all as shares of GDP. Additionally, we also include as a measure of legal development the first principal component of law and order (*LAO*), bureaucratic quality (*BQ*), and anti-corruption measures (*CORRUPT*), all from the ICRG database. Higher values of these variables indicate better conditions.

The precision of $\hat{\gamma}_{Fit}^{C}$ could be reduced by economic or financial disruptions. To control for that, we include a vector of currency and banking crises (*CRISIS*). We use the crisis dummies from Aizenman and Ito (2014) to identify the two types of the crises. For currency crisis, Aizenman and Ito use the exchange market pressure (EMP) index using the exchange rate against the currency of the base country. The banking crisis dummy is based on the papers by Laeven and Valencia (2008, 2010, 2012).

The variables in *MC* and *INST* are included in the estimations as deviations from the U.S., Japanese, Chinese, and Euro Area's counterparts. The variables in vectors *OMP*, *MC*, and *INST* are sampled from the first year of each three-year panels to minimize the effect of potential endogeneity. Also, to capture global common shocks, we also include time fixed effects. Furthermore, to account for potential outliers on the dependent variable, we use the robust regression estimation technique for all the estimations.

3. Empirical results

3.1. First-step estimations

3.1.1. The contributions of different factor vectors

For the first-step estimation, we regress each of the two dependent variables, policy interest rate and REER changes, on four groups of explanatory variables: real global, financial global, cross-country link, and domestic factors for three-year, non-overlapping panels in the 1986–2012 period.

To grasp the general trend of the groups of factors that influence the financial variables, we focus on the joint significance of the variables included in the real global, financial global, cross-country, and domestic groups. Fig. 1 illustrates the proportion of countries for which the joint significance tests are found to be statistically significant (with the *p*-value less than 10%) for each of the four financial variables. The figure illustrates the proportion for the groups of advanced economies (IDC) and less

[13] We also tried the variable for bank lending provided by the center economies. However, since it turned out to be persistently insignificant across different estimation models, we dropped the variable from the estimation models.

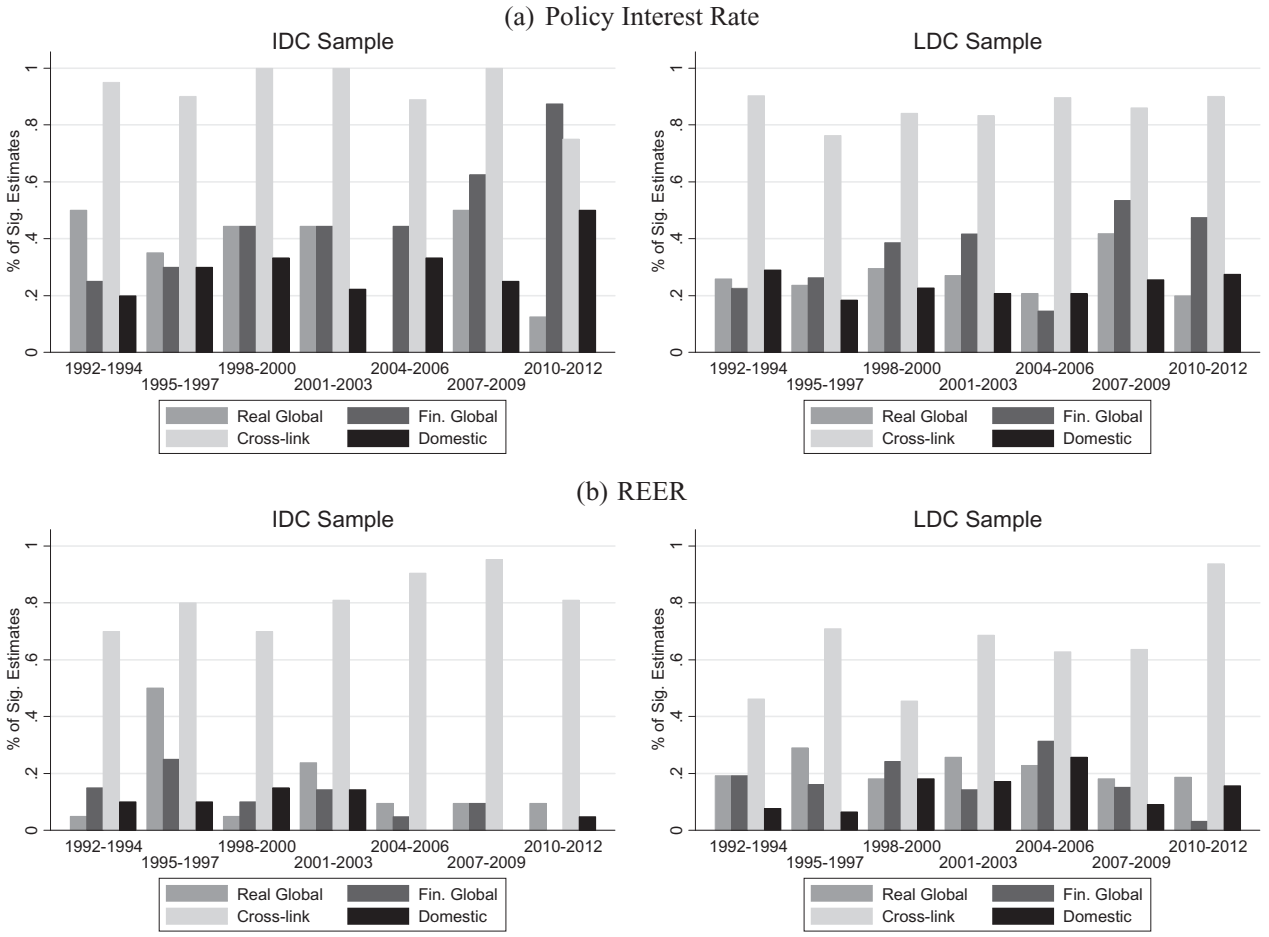


Fig. 1. Proportion of significant F-tests.

developed economies (LDC) after 1992.[14] Our discussions focus on the estimation results of developing countries although we also present the results of developed countries mainly for comparison purposes.

The graphical depictions in Fig. 1 lead to the following conclusions. First, the movements of both the policy interest rates and the real effective exchange rates of the center economies explain most joint-significantly the variation of the variables for the non-center economies, indicating that the influence of the major economies is the greatest for both financial variables.[15]

Second, as far as policy interest rate is concerned, the proportion of joint significance is also relatively high for the group of "financial global" variables, especially for the EMG countries. Unsurprisingly, the last two three-year panels indicate high proportions of joint significance for both country groups, suggesting global financial factors have been playing an important role in affecting the policy interest of countries, both developed and developing. This result is consistent with the Rey's (2013) thesis of "global financial cycles." In the panels for 1998–2000 and 2001–2003, the proportions of financial global factors also appear high for both country groups.[16] Given the emerging market crises in the 1998–2000 period, and dot com bust of the 2001–2003 period, these results suggest that economies are more exposed to global financial shocks during periods of financial turbulence while also following center monetary policies.

Third, for REER changes, the movements of the center economies are critically important for both country groups. Interestingly, the highest proportion of developing countries appears sensitive to the REER movements of the center economies in 2010–2012. These results are consistent with the reactions expressed by emerging market policy makers to the taper in Fed quantitative easing, especially those characterized as "Fragile Five."

Overall, in accord with Rey (2013), these figures suggest that economies, both advanced and developing, are subject to the financial conditions of the center economies. We investigate the determinants of the degree of sensitivity to the financial conditions of the center economies in the next subsection.

3.1.2. Contributions of China as a major economy

Before moving on to examine the determinants of the degree of sensitivity to the CE's financial conditions, let us question the assumption that China is one of the CEs, which we have assumed thus far. One can question whether China's financial influence matches its impact on real activity because, as many studies have shown, there is still much room for China to further develop and open its financial markets.[17]

Hence, we test whether the results of the previous exercise of testing the joint significance of each vector of explanatory variables would be affected if we exclude China from the group of the CEs. When we do, we find that the general characteristics observed in Fig. 1 remain qualitatively intact (not reported), suggesting that the financial influence of China must be minimal.

To test this assertion more formally, we compare the adjusted R-squared values of the two specifications for each country and each three-year panel, and for each of the two financial variables. Fig. 2 illustrates the cross-country average differences in the adjusted-R squared values between the estimation with China as one of the CEs and the one without for both of the two financial variables. The averages of the gap are calculated for the groups of developed countries, developing countries, emerging market countries, and East Asian emerging market economies as a comparison.[18]

[14] Data in Fig. 1 are based upon the specification that includes China as a major economy, while the figures based on the specification without China as a center economy yields similar observations. We also conduct the same exercise for the group of EMGs. The figures for the EMG group are qualitatively similar to those of the LDC group. Hence, we omit discussing them here.

[15] This observation is also applicable for sovereign term spreads and stock market price changes, although less significantly (not reported). The contribution of the major economies becomes bigger (not reported) for most of the financial variables, which is expected considering that this group of economies have more developed and open financial markets.

[16] Again, this is more distinct for the EMG group.

[17] See Huang et al. (2013) and Hung (2009) among others.

[18] The group of East Asian emerging market economies includes: Hong Kong, India, Indonesia, Korea, Malaysia, the Philippines, Singapore, Thailand, and Vietnam.

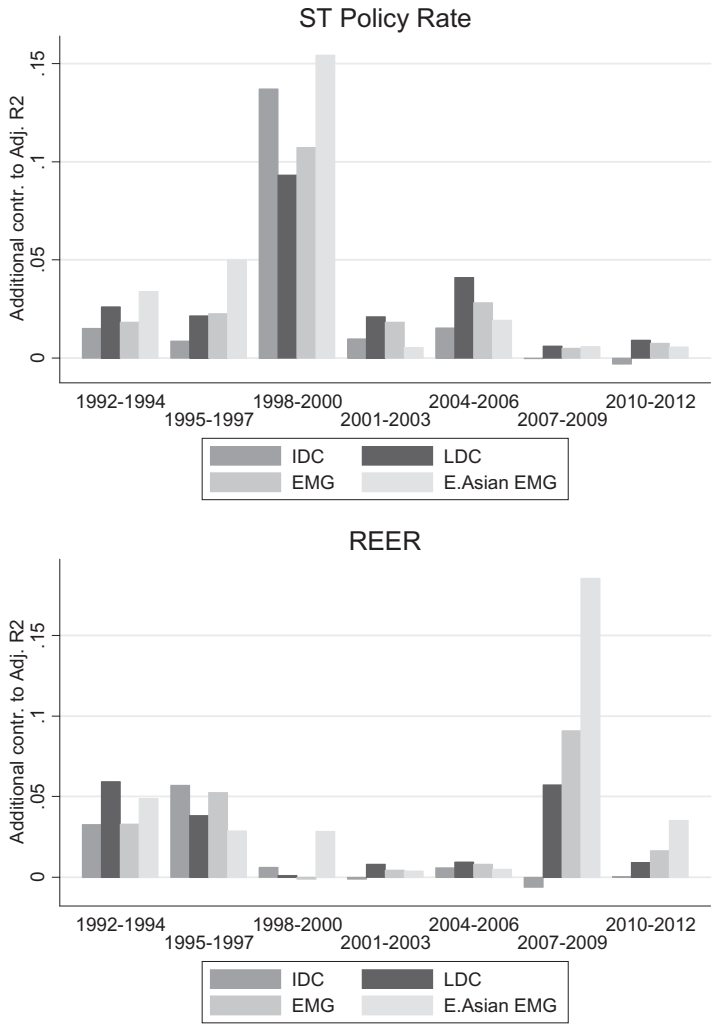


Fig. 2. Changes to adj. R2 by adding China as a CE.

In the case of the policy interest rate model, including China as a major country increases the adjusted R-squared, especially in the last three years of the 1990s that correspond to the East Asian crisis. For East Asian emerging market economies, including the Chinese policy interest rate in the estimation model increases the adjusted R-squared as much as over 15% on average. Despite the recent impressive rise as an economic power, however, China's contribution seems negligible in the last two three-year panels for the policy interest rate model.

In the REER figure, we see a high increase in the adjusted R-squared in the crisis years of 2007–2009 for emerging market countries, especially those in East Asia (with the additional contribution of about 18% to the adjusted R-squared). This may reflect the situation where international trade shrank significantly immediately after the outbreak of the global financial crisis in 2008. In the tight international trade market, trade competitiveness of the world's largest exporter may have had a large influence on other trading partners.

In the models for stock market price changes or sovereign term spreads, China does not appear influential in most of the sample period (not reported). Considering that China's financial markets only became open recently, the lack of influence of China's financial variables is unsurprising. Overall, despite certain periods when the country exerts some influence, we conclude that the financial influence of China is still minimal.[19]

3.2. Results of the second-step estimation

Now that we have $\hat{\gamma}^{C}_{Fit}$ for both policy interest rates and REER changes, we investigate the determinants of the extent of linkages using the estimation model based on Equation (2). We estimate the determinants of $\hat{\gamma}^{C}_{Fit}$ for the two financial variables but only use the dependent variable of $\hat{\gamma}^{C}_{Fi}$ from the first-step estimation that does not include China as one of the center economies because we concluded that the country's financial influence in the global financial markets is minimal. The regressions with China as a center economy yield results qualitatively similar to those without China.

Table 1a and b report the estimation results for the extent of sensitivity of policy interest rates and REER changes for the FULL, LDC, and EMG samples. The bottom rows of the tables also report the joint significance tests for each vector of explanatory variables.

As for the linkage of policy interest rates, reported in Table 1a, the variables that characterize countries' open macropolicies affect the sensitivity to the monetary policies of the center economies. In contrast with Rey's (2013) argument, we find that the type of exchange rate regimes does matter; countries with greater exchange rate stability tend to be more sensitive to changes in the CE's monetary policy, although the estimate is only marginally significant, except for model (3). Financial openness also contributes to higher degrees of sensitivity to the CE's policy interest rates, and its estimate is more persistently and strongly significant. These results suggest that developing countries or emerging market economies with more stable exchange rate movements as well as open financial markets are more subject to changes in the policy interest rates in the CEs. Interestingly, holding higher levels of foreign reserves tends to help non-CEs to shield the impact of changes in the CE's policy interest rates, i.e., to retain its monetary autonomy. Exchange rate stability, financial openness, and IR holding are jointly significant for the group of developing or emerging market countries.

Among the variables for macroeconomic conditions, only current account balance seems to matter. However, the positive estimate on current account balance appears somewhat puzzling considering that a country running current account *deficit* – not surplus – should be more susceptible to monetary policy changes of the CEs. The result indicates that a net capital exporter rather than importer is more sensitive to the monetary policies of the center economies.

As for the factors of external links, financial linkage through foreign direct investment is the most important variable in determining how shocks to the CE's monetary policies could affect those of other non-CEs for both developing and emerging market countries. A country that receives more FDI from the CEs tends to be more sensitive to changes in the monetary policies of the CEs.

Financial development also matters significantly for the LDC sample. In fact, its impact (i.e., the magnitude of the estimate) is found to be larger among LDCs than among IDCs (not reported). Countries with more developed financial markets tend to be more sensitive to the changes in the monetary policies of the CEs. That suggests that countries with deep financial markets can be good investment destinations for foreign investors, so that their arbitrage actions may lead those countries to follow the monetary conditions of the CEs more closely.

Generally, the models for REER present robust results with good goodness-of-fit as Table 1b reports. Given certain degrees of price stickiness, pursuing greater exchange rate stability would lead both nominal and real effective exchange rates to be more sensitive to that of the CEs. Our results show the positive impact of greater exchange rate stability on the REER connectivity for all the subsample country groups. Greater financial openness also contributes to greater sensitivity for developing countries, although not significantly so for the EMG group. Interestingly, irrespective of group, a country with a

[19] Our sample ends in 2012. Hence, the Shanghai stock market crash in 2015, which affected financial markets in other parts of the world, is outside the scope of our estimation.

Table 1
(a) Factors affecting policy interest rate sensitivity, 1986–2012; (b) factors affecting real effective exchange rate (REER) sensitivity, 1986–2012.

		FULL (1)	FULL (2)	LDC (3)	LDC (4)	EMG (5)	EMG (6)
(a)							
Open Macro Policy (*OMP*)	Exchange rate stability	–0.167	–0.349	4.862	3.392	3.657	3.098
		(0.796)	(0.878)	(2.693)*	(2.447)	(2.448)	(2.268)
	Financial openness	0.223	0.249	5.455	5.777	7.930	7.491
		(0.720)	(0.805)	(2.403)**	(2.259)**	(2.245)***	(2.154)***
	IR holding	–1.419	–2.034	–13.803	–11.343	–12.400	–13.557
		(2.082)	(2.277)	(7.342)*	(6.541)*	(6.254)**	(5.820)**
Macro. Conditions (*MC*)	CA balance (%)	6.550	5.943	19.282	24.284	41.092	39.017
		(2.979)**	(3.580)*	(9.666)**	(10.541)**	(10.507)***	(10.451)***
	Inflation vol.	14.135	9.400	19.270	23.910	9.839	10.727
		(11.231)	(6.003)	(34.312)	(15.012)	(28.624)	(12.515)
	Gross debt (%)	0.064	–	–0.963	–	–1.420	–
		(0.467)	–	(1.592)	–	(1.289)	–
	Budget balance (%)	–	7.715	–	–2.145	–	22.313
		–	(4.818)	–	(15.342)	–	(16.492)
External Link (*LINK*)	Trade competition	0.442	0.390	–4.540	–6.454	–11.187	–11.246
		(2.764)	(2.800)	(9.166)	(7.550)	(7.868)	(6.633)*
	Trade demand	–0.133	1.263	6.868	8.340	11.068	11.898
		(3.104)	(3.422)	(11.125)	(10.116)	(9.170)	(8.609)
	FDI from CEs	17.785	19.231	49.264	44.044	42.633	41.347
		(4.191)***	(4.791)***	(16.003)***	(15.113)***	(13.001)***	(12.732)***
Institutional Dev. (*INST*)	Fin. dev.	–0.346	0.370	9.570	7.651	8.137	7.931
		(0.699)	(0.803)	(2.500)***	(2.427)***	(2.207)***	(2.168)***
	Legal dev.	–0.718	–1.766	–4.831	–5.933	–7.132	–7.115
		(1.384)	(1.482)	(6.555)	(5.974)	(5.530)	(5.199)
Crises (*CRISIS*)	Currency crisis	–0.058	–0.739	–3.589	–2.712	–3.212	–3.422
		(0.658)	(0.704)	(2.595)	(2.178)	(2.167)	(1.872)*
	Banking crisis	0.415	0.596	0.544	1.410	0.766	1.292
		(0.532)	(0.574)	(2.096)	(1.838)	(1.870)	(1.676)
	N	611	674	386	432	327	371
	Adj. R2	0.05	0.05	0.09	0.08	0.12	0.13
	# of countries	59	59	41	41	31	31
	F-test, OMP	0.88	0.76	0.01	0.01	0.00	0.00
	F-test, macro	0.10	0.01	0.24	0.03	0.00	0.00
	F-test, ext. link	0.00	0.00	0.00	0.00	0.00	0.00
	F-test, inst. dev.	0.59	0.49	0.00	0.01	0.00	0.00
	F-test, all	0.00	0.00	0.00	0.00	0.00	0.00

(*continued on next page*)

Table 1 (*continued*)

		FULL (1)	FULL (2)	LDC (3)	LDC (4)	EMG (5)	EMG (6)
(b)							
Open Macro Policy (*OMP*)	Exchange rate stability	0.614	0.643	0.718	0.807	0.725	0.760
		(0.076)***	(0.074)***	(0.132)***	(0.121)***	(0.135)***	(0.123)***
	Financial openness	0.348	0.263	0.377	0.311	0.157	0.074
		(0.077)***	(0.075)***	(0.126)***	(0.121)**	(0.137)	(0.132)
	IR holding	0.936	0.863	1.038	0.919	0.761	0.606
		(0.208)***	(0.202)***	(0.334)***	(0.320)***	(0.331)**	(0.314)*
Macro. Conditions (*MC*)	CA balance (%)	1.096	0.668	0.921	0.459	1.360	0.684
		(0.342)***	(0.328)**	(0.545)*	(0.536)	(0.563)**	(0.553)
	Inflation vol.	3.429	–0.973	2.824	–0.840	2.706	–0.868
		(1.234)***	(0.493)**	(1.674)*	(0.671)	(1.672)	(0.634)
	Gross debt (%)	–0.078	–	–0.072	–	–0.138	–
		(0.049)	–	(0.078)	–	(0.075)*	–
	Budget balance (%)	–	0.401	–	1.018	–	2.366
		–	(0.472)	–	(0.963)	–	(0.956)**
External Link (*LINK*)	Trade competition	–1.606	–1.326	–1.625	–1.262	–1.275	–0.866
		(0.275)***	(0.244)***	(0.427)***	(0.372)***	(0.429)***	(0.374)**
	Trade demand	1.744	1.703	1.763	1.877	2.022	2.151
		(0.295)***	(0.280)***	(0.483)***	(0.460)***	(0.463)***	(0.439)***
	FDI from CEs	–0.618	–0.634	–0.335	–0.372	–0.110	–0.272
		(0.381)	(0.380)*	(0.673)	(0.668)	(0.643)	(0.639)
Institutional Dev. (*INST*)	Fin. dev.	–0.002	–0.030	–0.171	–0.211	–0.076	–0.125
		(0.071)	(0.070)	(0.119)	(0.117)*	(0.119)	(0.117)
	Legal dev.	–0.103	–0.098	–0.007	–0.212	0.076	–0.234
		(0.138)	(0.130)	(0.296)	(0.290)	(0.296)	(0.289)
Crises (*CRISIS*)	Currency crisis	0.159	0.121	0.282	0.165	0.349	0.207
		(0.066)**	(0.063)*	(0.127)**	(0.113)	(0.120)***	(0.108)*
	Banking crisis	–0.013	–0.062	0.001	–0.108	–0.092	–0.204
		(0.052)	(0.049)	(0.096)	(0.087)	(0.102)	(0.091)**
	N	537	592	294	332	254	290
	Adj. R2	0.23	0.22	0.22	0.23	0.27	0.28
	# of countries	49	49	30	30	23	23
	F-test, OMP	0.00	0.00	0.00	0.00	0.00	0.00
	F-test, macro	0.00	0.03	0.12	0.25	0.02	0.01
	F-test, ext. link	0.00	0.00	0.00	0.00	0.00	0.00
	F-test, inst. dev.	0.68	0.51	0.33	0.10	0.81	0.33
	F-test, all	0.00	0.00	0.00	0.00	0.00	0.00

Notes: The estimations are conducted with the robust regression method due to the existence of outliers. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The second estimation is conducted for the estimates $\hat{\gamma}_{fi}^{c}$ from the first-step estimation that does not include China as one of the center economies. Time fixed effects for the three-year panels and the constant are also included, although their estimates are not reported.

higher level of IR holding tends to be more sensitive to REER changes of the center economies. One interpretation is that a country could respond to changes in the center economies' real currency appreciation through foreign exchange market interventions, inducing a positive correlation; the interpretation of this coefficient is then not causal.

Emerging market countries with larger government debt or budget deficits tend to be less sensitive to the REER of the center economies. These results indicate that, due to higher inflationary expectations, such countries tend to face some difficulty in maintaining real exchange rate stabilities against the currencies of the major economies despite their general desire to pursue greater (nominal) exchange rate stability (Aizenman et al., 2013; Calvo and Reinhart, 2002).

Not surprisingly, countries with greater bilateral trade links with the center economies tend to be more sensitive to the REER movements of the center economies. The negative impact of trade competitiveness means that peripheral countries with more competitive trade structure to that of the CEs tend to become alternative investment destination if a shock occurs to the CEs. For example, if a shock happens in a way that causes real depreciation of the CE's currencies such as predicted slow output growth, an institutional change leading to greater labor rigidities, and a falling appetite for the center economies' financial assets, the demand for financial assets in peripheral economies can rise and push the real values of their currencies. Interestingly, financial linkage through FDI does not matter for the level of REER connectivity.

In contrast, countries with more developed financial markets tend to be less sensitive to the REER movements of the CEs. These results are consistent with the observation that greater financial development allows a country to have more flexible exchange rate movements. In other words, countries could afford to detach their currency values' movements from those of the center economies.

3.3. Robustness checks

In the above estimations, we implemented robust regression techniques that account for outliers in both the dependent variable and explanatory variables – the estimation keeps recursively down-weighting the outliers until it obtains converged estimates.

Since the robust regression method may not remove the effects of outliers completely, we undertake additional sensitivity analyses to ensure that the previous results are not driven by outliers.

As a first attempt, we remove both the 5th and the 95th percentiles of the $\hat{\gamma}_C$ sample, and then re-estimate by reapplying the robust regression technique to the truncated sample. The results (not reported) remain qualitatively intact. While the magnitude of the estimates changes, their statistical significance remains unchanged. When we repeat by removing the observations below the 10th percentile and above the 90th percentile of the $\hat{\gamma}_C$'s, still we obtain qualitatively similar results. These findings indicate that the results we report in Table 1a and b are not driven by outliers.

Some of the countries in our sample have experienced financial crises. During periods of financial turbulence, economic variables could exhibit anomalous behavior, leading to extreme observations. Hence, as a second way to check the robustness of the estimation results, we interact all the independent variables with a dummy for currency crises to account for potential effects of currency crisis. For all the $\hat{\gamma}_C$ s of the three financial variables, we again obtain qualitatively similar results. Therefore, we conclude that our estimation results are not driven by extreme values of the explanatory and dependent variables during financial turbulences.

4. Further analyses

4.1. Open macro policy in conjunction with other factors

In the baseline results of the previous subsection, open macro policy variables are found to affect the extent of connectivity through financial variables. While these variables may directly affect the extent of sensitivity to the center economies' financial variables, it is also possible that they affect the financial linkages indirectly through other variables.

To investigate such a possibility, we re-estimate the specifications while including interactive terms between the variables for exchange rate stability and financial openness and some selected

variables, namely, current account balances, government gross debt (both as a share of GDP), trade demand from the center economies, and the level of financial development. The results are reported in Table 2a and b for policy interest rates and the REER, respectively.[20]

We obtain several interesting results. First, while financial development alone would make developing countries more susceptible to center economies' monetary policy changes, the degree of susceptibility would be even higher if the country has more open financial markets or adopts more *flexible* exchange rate regime, although theoretically, more flexible exchange rate movements should make the country less subject to the monetary policies of the center economies, i.e., allow for greater monetary autonomy.

Table 3 illustrates the net effects of certain changes in the level of macroeconomic or institutional variables (X) depending on the levels of both exchange rate stability (ERS) and financial openness (KAOPEN) – i.e., $(\beta_0 + \beta_1 ERS + \beta_2 KAOPEN)\Delta X$. In the table, for a certain magnitude of change in X, *ERS* and *KAOPEN* take the values of 0, 0.50, or 1.00.

Table 3a shows the net impact of a 10 percentage points (ppt) increase in the level of financial development (as a deviation from the CEs). From the table, we can see that, except for the cases of having a rigidly fixed exchange rate regime with intermediately open or closed financial markets, the net impact of a 10 ppt increase in the level of financial development is usually positive. The net impact on the connectivity through policy interest rates is larger for more financially open economies or for those with more *flexible* exchange rate regimes. This counterintuitive result could possibly be rationalized by the high correlation between financial development and exchange rate flexibility; higher levels of financial development would lead a country to become more prepared to adopt greater exchange rate flexibility. Hence, a country with more developed financial markets and greater exchange rate flexibility could become a destination for investors' arbitrage-seeking behavior once the CEs change their monetary policy stance, thus leading to more synchronization of policy interest rates. This reasoning is consistent with the finding that the interactive effect between financial development and financial openness is positive.

In Table 2a, we also see a significant estimate for the interaction between ERS and import demand from the CEs. Table 3b, which reports the net impact of a 5 percentage points (ppt) increase in the level of import demand, shows that the net impact is larger, or less negative, for economies with more open financial markets or more stable exchange rate regimes. Greater trade linkage could lead to faster transmission of monetary policy from the center economies to peripheral economies in this globalized world especially when peripheral economies attempt to pursue exchange rate stability.[21]

The types of trilemma regimes could also affect the connectivity with the CEs through REER changes. According to Table 3c, the net impact of a 2 ppt *deterioration* of current account balance (CAB) would be larger for economies with more flexible exchange rate movements, while its interactive effect with financial openness is negligible and insignificant. That is, if a shock occurs to the center economies' REER, it would be transmitted to peripheral economies more through nominal exchange rate movements, especially for a country with worsening current account balances. Hence, given price rigidity, the shock to the CEs would not be passed on to peripheral economies when they try to maintain exchange rate stability.

Pursuit of greater exchange rate stability and financial openness would also make the net impact of gross debt larger for the REER connectivity (Table 3d). Holding a larger amount of debt would make a developing country more susceptible to the REER movement of the CEs currencies if it pursues greater exchange rate stability and more financial integration, which is consistent with the economic characteristics of emerging market economies that had gone through financial crisis in the past. In those crises, a policy interest rate increase in the CEs, usually the U.S., led first to real appreciation of the

[20] The estimates for inflation volatility, trade competition, legal development, and currency and banking crisis are omitted from presentation in the tables due to space limitation.

[21] Such a positive interactive effect between import demand from the center economies and greater exchange rate stability is also observed in the estimation for the stock market price connectivity model (not reported). Peripheral economies that face strong trade demand from the center economies could be more sensitive to the stock market movements of the center economies if the countries pursue more stable exchange rate movements.

Table 2
(a) Interactive effects and policy interest rate sensitivity, 1986–2012; (b) interactive effects and REER sensitivity, 1986–2012.

	FULL (1)	FULL (2)	FULL (3)	LDC (4)	LDC (5)	LDC (6)	EMG (7)	EMG (8)	EMG (9)
(a)									
Exchange rate stability	0.330	−0.619	−1.166	5.309	−7.884	−11.771	5.130	−5.971	−3.383
	(0.909)	(1.547)	(1.733)	(2.751)*	(7.206)	(8.226)	(2.570)**	(5.128)	(5.496)
Financial openness	−1.575	0.323	−1.467	−1.269	6.516	5.335	0.974	9.544	3.303
	(1.485)	(0.750)	(1.517)	(5.169)	(3.105)**	(7.412)	(4.436)	(2.450)***	(4.863)
IR holding	−2.079	−1.826	−2.209	−12.865	−13.232	−10.147	−10.817	−9.973	−9.538
	(2.370)	(2.217)	(2.477)	(7.555)*	(9.713)	(10.706)	(6.644)	(7.006)	(7.298)
CA balance (%)	6.666	13.660	11.367	28.248	41.970	63.029	19.791	32.486	21.459
	(8.238)	(6.801)**	(10.431)	(23.271)	(29.384)	(39.890)	(20.440)	(22.619)	(26.431)
Gross debt (%)	0.133	0.178	0.571	0.497	−0.544	1.770	−0.799	−0.481	0.318
	(0.997)	(0.924)	(1.299)	(3.049)	(4.196)	(5.395)	(2.508)	(2.829)	(3.406)
Trade demand	−6.866	−1.300	−11.344	−4.779	−56.321	−100.895	−2.923	−23.766	−37.035
	(8.407)	(6.050)	(10.104)	(23.448)	(26.507)**	(40.442)**	(19.569)	(18.546)	(26.549)
Fin. dev.	5.090	0.817	7.242	17.031	30.152	30.181	17.133	19.735	23.187
	(1.670)***	(1.302)	(1.986)***	(4.719)***	(5.726)***	(7.591)***	(3.992)***	(3.985)***	(4.896)***
KAO × CAB	0.682	–	2.780	−8.557	–	−35.884	41.950	–	32.968
	(10.604)	–	(10.864)	(31.196)	–	(44.266)	(28.319)	–	(31.667)
KAO × Debt	−0.076	–	−0.167	−2.212	–	−6.466	−1.060	–	−1.710
	(1.439)	–	(1.470)	(5.014)	–	(7.066)	(4.206)	–	(4.516)
KAO × Trade demand	9.961	–	10.946	16.625	–	43.098	31.202	–	33.056
	(10.026)	–	(10.224)	(29.872)	–	(41.279)	(25.211)	–	(26.674)
KAO × FD	−7.340	–	−7.209	−15.549	–	18.749	−17.676	–	−11.610
	(2.097)***	–	(2.152)***	(6.714)**	–	(9.583)*	(5.954)***	–	(6.511)*
ERS × CAB	–	−13.799	−12.085	–	−49.790	−52.504	–	7.265	−2.590
	–	(10.909)	(12.174)	–	(43.898)	(49.343)	–	(35.144)	(37.970)
ERS × Debt	–	−0.476	−1.044	–	−3.001	−1.671	–	−2.863	−2.430
	–	(1.680)	(1.878)	–	(7.163)	(7.990)	–	(4.841)	(5.062)
ERS × Trade Demand	–	2.812	8.142	–	123.275	148.706	–	67.204	62.633
	–	(10.849)	(12.105)	–	(48.777)**	(53.871)***	–	(35.799)*	(36.936)*
ERS × FD	–	−1.977	−4.651	–	−30.529	−43.333	–	−21.751	−16.831
	–	(2.200)	(2.469)*	–	(9.015)***	(10.280)***	–	(6.665)***	(7.173)**
N	611	611	611	386	386	386	327	327	327
Adj. R2	0.07	0.04	0.07	0.09	0.15	0.18	0.16	0.15	0.16
# of countries	59	59	59	41	41	41	31	31	31
F-test, OMP	0.61	0.76	0.48	0.13	0.07	0.33	0.14	0.00	0.45
F-test, macro	0.52	0.12	0.40	0.59	0.50	0.43	0.77	0.56	0.88
F-test, ext. link	0.00	0.00	0.00	0.12	0.00	0.00	0.27	0.00	0.05
F-test, inst. dev.	0.01	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F-test, int. terms	0.01	0.63	0.02	0.25	0.00	0.00	0.02	0.01	0.04
F-test, all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(*continued on next page*)

Table 2 (*continued*)

	FULL (1)	FULL (2)	FULL (3)	LDC (4)	LDC (5)	LDC (6)	EMG (7)	EMG (8)	EMG (9)
(b)									
Exchange rate stability	0.623	0.341	0.355	0.735	0.552	0.566	0.743	0.520	0.528
	(0.077)***	(0.160)**	(0.159)**	(0.134)***	(0.327)*	(0.331)*	(0.136)***	(0.329)	(0.335)
Financial openness	0.330	0.362	0.309	0.523	0.431	0.537	0.381	0.188	0.392
	(0.142)**	(0.077)***	(0.140)**	(0.277)*	(0.122)***	(0.266)**	(0.269)	(0.131)	(0.255)
IR holding	0.944	1.171	1.141	1.042	1.682	1.668	0.717	1.188	1.131
	(0.208)***	(0.212)***	(0.212)***	(0.344)***	(0.333)***	(0.342)***	(0.342)**	(0.326)***	(0.339)***
CA balance (%)	0.413	–0.194	–0.810	–0.139	–2.651	–2.966	0.110	–0.849	–1.175
	(0.737)	(0.640)	(0.895)	(1.056)	(1.024)**	(1.285)**	(1.044)	(1.036)	(1.217)
Gross debt (%)	0.064	–0.175	–0.042	–0.215	–0.435	–0.525	–0.278	–0.464	–0.541
	(0.099)	(0.090)*	(0.123)	(0.155)	(0.155)***	(0.195)***	(0.146)*	(0.147)***	(0.184)***
Trade demand	1.794	0.801	0.705	1.920	1.135	1.200	2.404	1.030	1.072
	(0.722)**	(0.547)	(0.839)	(1.019)*	(0.879)	(1.286)	(0.972)**	(0.843)	(1.212)
Fin. Dev.	–0.165	0.394	0.252	–0.253	0.461	0.371	–0.260	0.475	0.276
	(0.155)	(0.124)***	(0.182)	(0.217)	(0.195)**	(0.256)	(0.213)	(0.186)**	(0.239)
KAO × CAB	0.936	–	0.975	1.426	–	0.535	1.873	–	0.533
	(0.928)	–	(0.915)	(1.424)	–	(1.383)	(1.487)	–	(1.463)
KAO × Debt	–0.228	–	–0.208	0.258	–	0.182	0.247	–	0.151
	(0.135)*	–	(0.133)	(0.249)	–	(0.242)	(0.237)	–	(0.226)
KAO × Trade demand	–0.033	–	0.385	–0.052	–	0.052	–0.291	–	0.032
	(0.859)	–	(0.848)	(1.340)	–	(1.292)	(1.279)	–	(1.215)
KAO × FD	0.225	–	0.210	0.087	–	0.078	0.271	–	0.388
	(0.193)	–	(0.191)	(0.330)	–	(0.318)	(0.337)	–	(0.324)
ERS × CAB	–	2.010	1.827	–	4.950	4.834	–	2.873	2.722
	–	(1.128)*	(1.123)	–	(1.640)***	(1.672)***	–	(1.634)*	(1.713)
ERS × Debt	–	0.223	0.213	–	0.727	0.714	–	0.638	0.631
	–	(0.164)	(0.164)	–	(0.281)**	(0.284)**	–	(0.273)**	(0.277)**
ERS × Trade Demand	–	1.823	1.534	–	0.759	0.748	–	1.893	1.809
	–	(0.998)*	(0.996)	–	(1.750)	(1.782)	–	(1.734)	(1.761)
ERS × FD	–	–0.798	–0.820	–	–1.326	–1.280	–	–1.217	–1.263
	–	(0.223)***	(0.223)***	–	(0.348)***	(0.354)***	–	(0.341)***	(0.354)***
N	537	537	537	294	294	294	254	254	254
Adj. R2	0.23	0.26	0.26	0.21	0.32	0.31	0.27	0.37	0.36
# of countries	49	49	49	30	30	30	23	23	23
F-test, OMP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F-test, macro	0.10	0.01	0.09	0.22	0.00	0.00	0.13	0.00	0.01
F-test, ext. link	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
F-test, inst. dev.	0.23	0.01	0.32	0.47	0.03	0.23	0.46	0.02	0.29
F-test, int. terms	0.17	0.00	0.00	0.68	0.00	0.00	0.51	0.00	0.00
F-test, all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: The estimations are conducted with the robust regression method due to the existence of outliers. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The estimates for inflation volatility, FDI from the CEs, trade competition, legal development, currency and banking crisis dummies, and time fixed effects are omitted from presentation due to space limitation.

Table 3
Net effects for developing countries conditional on KAOPEN and ERS.

		KAOPEN*		
		0.00	**0.50**	**1.00**
(a) Effect of Financial Development (+10 ppt) in the MM–MM Link Estimation				
ERS*	**0.00**	3.02	3.96	4.89
	0.50	0.85	1.79	2.73
	1.00	–1.32	–0.38	0.56
(b) Effect of Trade Demand (+5 ppt) in the MM–MM Link Estimation				
ERS*	**0.00**	–5.04	–3.97	–2.89
	0.50	–1.33	–0.25	0.83
	1.00	2.39	3.47	4.55
(c) Effect of CAB *Deterioration* (–2 ppt) in the REER–REER Link Estimation				
ERS*	**0.00**	0.06	0.05	0.05
	0.50	0.01	0.01	0.00
	1.00	–0.04	–0.04	–0.05
(d) Effect of Gross Debt (+10 ppt) in the REER–REER Link Estimation				
ERS*	**0.00**	–0.05	–0.04	–0.03
	0.50	–0.02	–0.01	0.00
	1.00	0.02	0.03	0.04
(e) Effect of Financial Development (+10 ppt) in the REER–REER Estimation				
ERS*	**0.00**	0.04	0.04	0.04
	0.50	–0.03	–0.02	–0.02
	1.00	–0.09	–0.09	–0.08

Notes: "*" superscripted to KAOPEN or ERS in the tables means that the interaction term between KAOPEN or ERS and the variable of concern is found to be statistically significant in each respective estimation.

center economy's currency, then transmitted to peripheral economies especially when an indebted country pegged their currencies to the center economy's currency and had more open financial account. That may also mean that an indebted country is tempted to monetize its debt, so that the REER transmission would take place more in the form of higher inflation rather than nominal exchange rate flexibility.

Even when it adopts stable exchange rate movements, a developing country with more developed financial markets could make the extent of REER synchronization be smaller (Table 3e), although the interactive impact of financial openness is negligible or insignificant. Again, if a shock occurs to the CEs, the shock would be transmitted to peripheral economies with more developed financial markets rather through nominal exchange rate movements.

Overall, the estimation results shown in Table 2a and b show that it is safe to conclude that the types of exchange rate regimes do matter for the degree of linkage of financial variables between the center and peripheral economies, both directly and indirectly through other macroeconomic variables such as current account balances, gross government debt, trade linkages, and financial development. In this sense, our findings are different from Rey's (2013) "irreconcilable duo," in which policy makers face only the dilemma between financial openness and monetary autonomy, not the types of exchange rate regimes.

4.2. Center economy conditions and exchange market pressure

As we saw in the "taper tantrum" episode in the summer of 2013, a policy change, or a mere mention of its possibility, by one of the CEs may pressure non-center financial markets. Using the same framework, we now investigate how the financial variables of the CEs could affect the stress level of financial markets in the peripheral economies by focusing on the correlation between the financial variables of the CEs and the exchange market pressure (EMP) index in LDC or EMG economies. The CEs financial variables of our focus are policy interest rates, REER, and EMP.

To calculate the EMP index, we follow the oft-used methodology introduced by Eichengreen et al. (1995, 1996), which is as a weighted average of monthly changes in the nominal exchange rate (i.e., the rate of depreciation), the international reserve loss in percentage, and the change in the nominal interest rate with all in respect to the base country in the sense Aizenman et al. (2013) do to

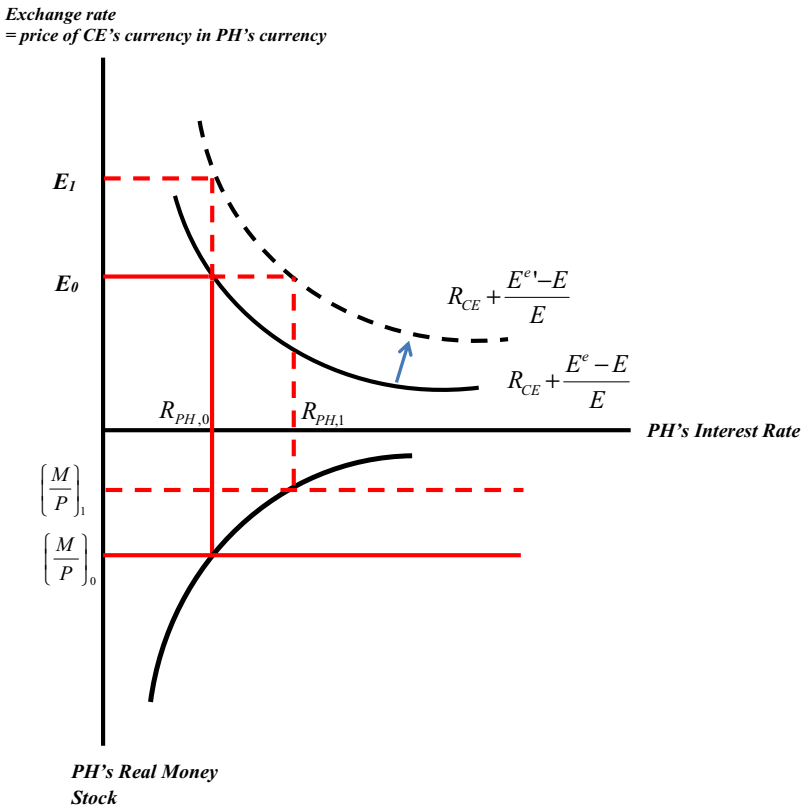


Fig. 3. Exchange rate, interest rate, and real money stock of a peripheral country (PH) in response to a rise in the *REER* of the center economies (CE).

construct the trilemma indexes.[22] The weights are inversely related to each country's variances of each of the changes in the three components.

Each of the financial variables of the CEs we focus on can theoretically be correlated with the EMP of the peripheral economies. If the policy interest rates rise in the CE, for example, that might draw more cross-border capital flows into these economies, including those that used to flow to peripheral economies. That might increase the level of financial stress on the peripheral economies, as evidenced by some emerging market economies that experienced financial difficulties after the United States started tightening its monetary policy in 2013. Hence, we should expect a positive correlation between the CE's policy interest rates and the non-center EMP.

When the CEs experience real appreciation of their currencies (i.e., a rise in the REER), given some price stickiness, that would create (expected) nominal depreciation pressure on a peripheral economy, which we depict in Fig. 3 as an outward shift of the curve for the rate of return from holding CE's assets in terms of PH's currency. If the non-center economy does not pursue exchange rate fixity, its currency would depreciate (from E_0 to E_1). If it does pursue exchange rate fixity, then the non-center's monetary authorities would have to intervene the foreign exchange market, decrease its holding of foreign reserves, and end up having a higher policy interest rate (from $R_{PH,0}$ to $R_{PH,1}$). Given that the EMP index is defined as a weighted average of monthly changes in the rate of depreciation, the

[22] See Appendix for more details.

percentage loss in international reserves, and the change in the nominal interest rate, whether non-center's monetary authorities pursue exchange rate fixity (i.e., no currency depreciation but a rise in the interest rate and a reduction in IR holding) or not (i.e., currency depreciation with no or less change in the interest rate or IR holding), its EMP should rise. Hence, the CE's REER should be positively correlated with the non-center's EMP.

Lastly, the link between the CE's EMP and the PH's EMP is essentially about whether and to what extent stress in the CE's financial markets can be contagious and affect the EMP of non-center economies. We could expect that if a non-center economy is more financially open and pursues greater exchange stability, then it might be more susceptible to an increase in the stress level of the CE's financial markets. However, at the same time, when one or more center economies experience a rise in the EMP, that would also lead to nominal (and real) *appreciation* of non-center's currencies. In such a case, whether or not the non-center economy intervenes the foreign exchange market, it could experience a *fall* in the level of EMP, suggesting a negative correlation between the CE's EMP and the non-center's EMP. After all, this poses a good empirical question. We will examine whether CE's EMP and the non-center's EMP are positively or negatively correlated.

With these theoretical predictions at hand, we first repeat the exercise based on Equation (1), but this time having the EMP indexes of the sample countries as the dependent variable for all the financial variables tested as explanatory variables. In other words, we examine the extent of sample countries' external policy vulnerability to the CE's policies, namely, the center economies' policy interest rates, the REER, and the EMP, while controlling the estimation model in the same way as in the previous analysis.

Fig. 4 is comparable to Fig. 1 in that it illustrates the proportion of countries for which the joint significance tests are found to be statistically significant (with the *p*-value less than 10%) for the three financial variables.[23] We have figures for the groups of advanced economies (IDC) and less developed economies (LDC) for each of the three financial variables, each of which includes the proportions for the four vectors of variables.

Interestingly but not surprisingly, Fig. 4 shows that among the advanced economies, the proportion of countries that received significant influence from the global financial factors (i.e., their EMP is more vulnerable to the global financial factors) is highest for all of the three financial variables in the 2007–2009 period, whereas the proportion for developing countries is higher in the 2010–2012 period immediately after the outbreak of the GFC. Generally, however, the linkages between developing countries' EMP and CE's policy interest rates appear weak. The proportion for the significant linkage rises in the 2010–2012 period, but only to less than 20%.

The EMP of developing countries is a little more vulnerable to the REER movements of the center economies. The proportion of developing countries for which the center economies' REER are jointly significant for the EMP estimation is the highest among the vectors of explanatory variables in the 2010–2012 period.

In general, the EMP of developing countries is more exposed to the influence of the center economies' EMP. Especially, during the GFC years and in their aftermath, developing countries' EMP is found to be more sensitive to the movements of the EMP of the CEs, indicating that financial stress that arose in the CEs must have been transmitted to developing countries during and after the GFC.

Fig. 5 illustrates the proportion of the countries for which the estimated coefficients of the CE's financial variables are found to have a significantly positive or negative $\hat{\gamma}_C$ with the *p*-value less than 10%. We predict $\hat{\gamma}_C > 0$ for policy interest rates and REER, and $\hat{\gamma}_C > 0$ or $\hat{\gamma}_C < 0$ for the EMP, whose results we illustrate in panels (a) through (d), respectively.

Roughly speaking, when we focus on the test of $\hat{\gamma}_C > 0$, the three center economies' financial variables are relatively equally influential on the EMP of developing countries, except for the 2007–2009 and 2010–2012 periods in which either the U.S. alone or both the U.S. and the Euro area are influential, reflecting the GFC and the Euro debt crisis. It is interesting to note, however, that the highest portion of developing countries have their EMP significantly positively affected by the policy interest rate of

[23] These figures are made using the model that does not include China as a center economy.

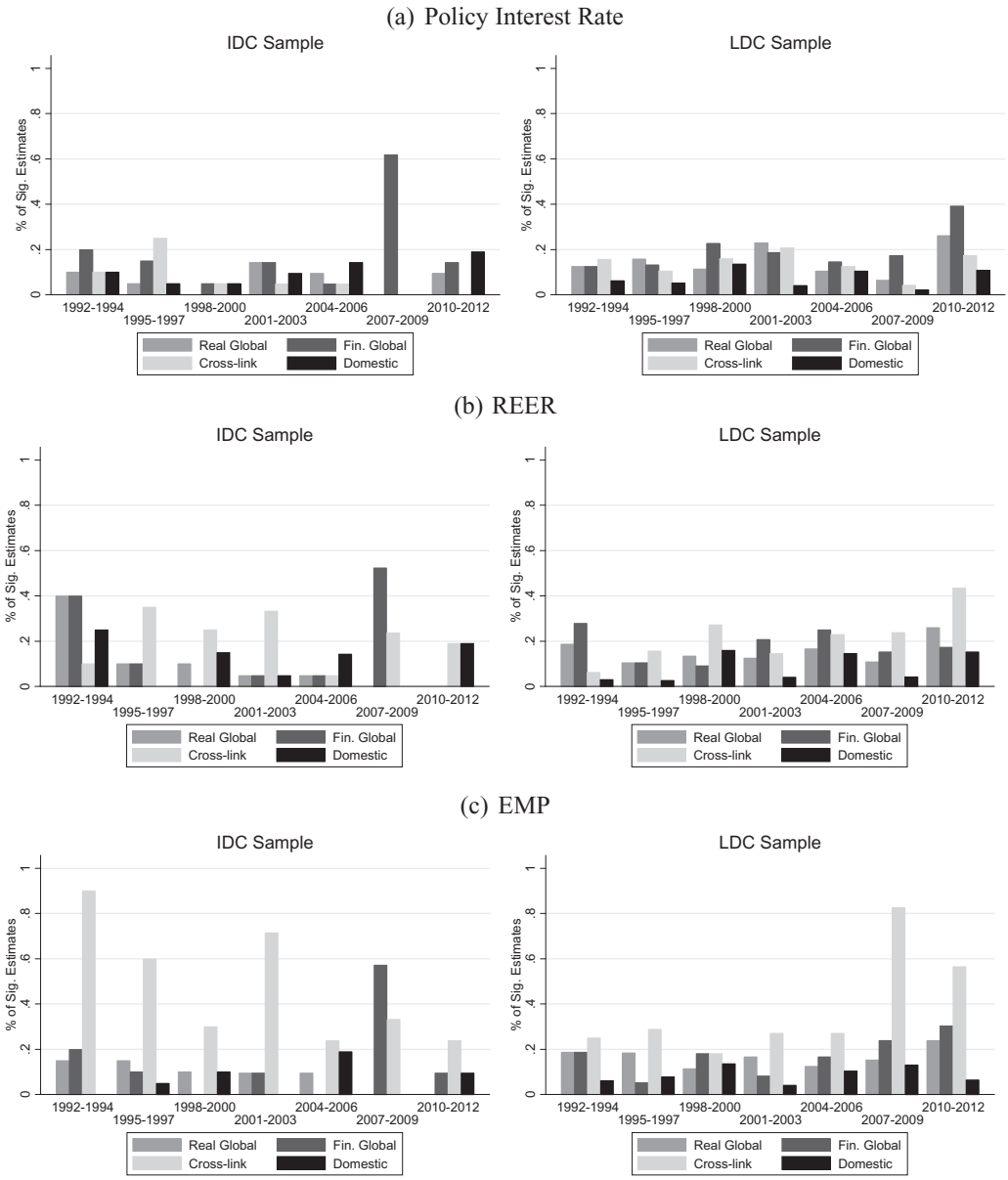


Fig. 4. Proportion of significant F-tests – EMP response.

the Euro area in most of the time periods. Also, the REER of Japan and the U.S. appear influential on developing countries' EMP in the last three-year panel. Overall, the EMP of the center economies was jointly significant as an influencer on developing countries' EMP in Fig. 4, but the result seems to be more driven by the negative effects of the center economies' EMP as panel (d) shows, indicating that the negative effects of the CE's EMP is more of a case. Considering that the US dollar and the Japanese yen had been the currencies most heavily used in carry trade and also providing safe haven for international investors during the GFC and in its immediate aftermath, the crisis in the 2007–2009

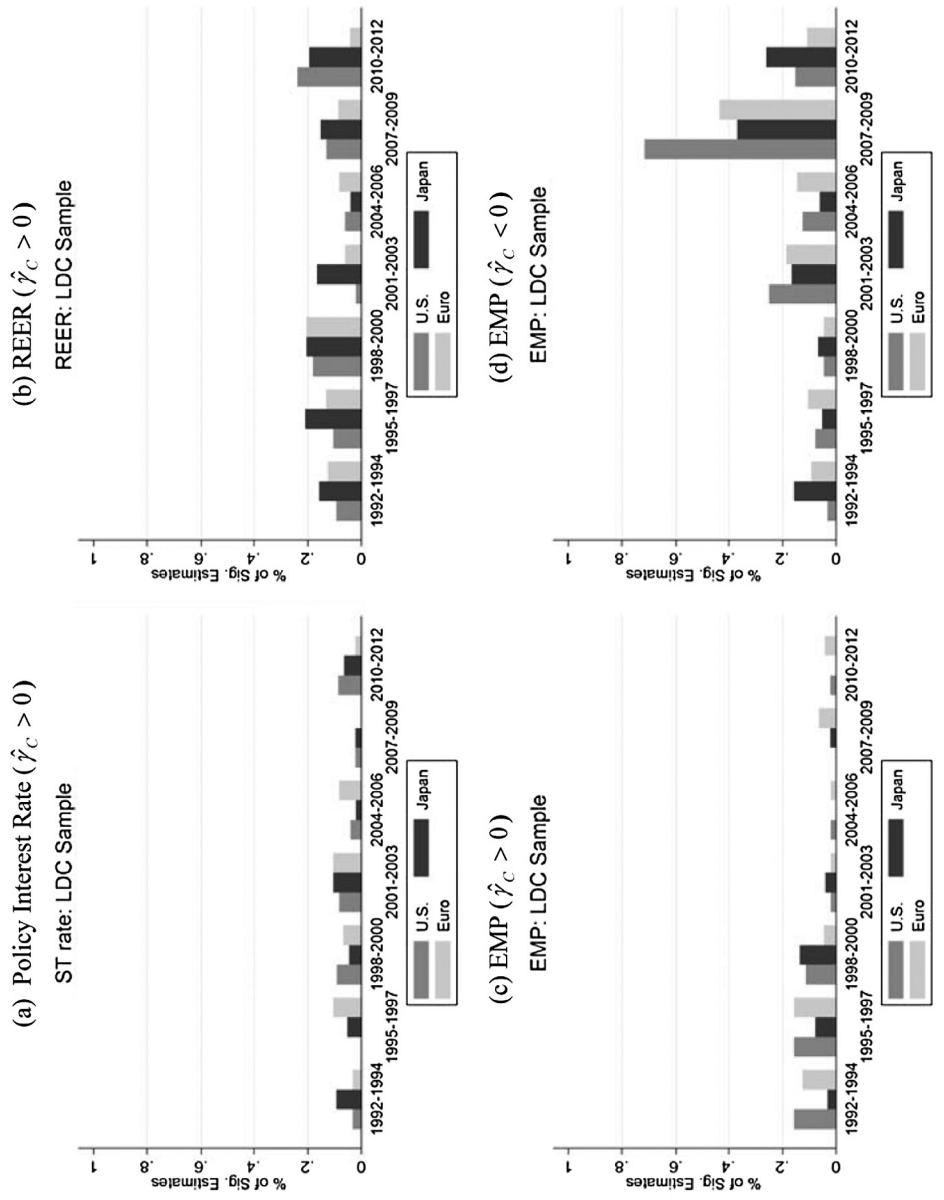
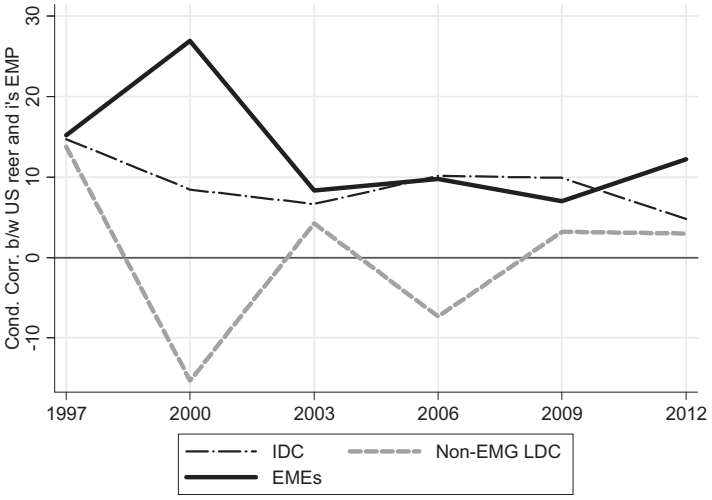


Fig. 5. Proportion of significant $\hat{\gamma}_C > 0$ or $\hat{\gamma}_C < 0$ tests.

(a) Impact of U.S. REER on Country *i*'s EMP



(b) Impact of U.S. EMP on Country *i*'s EMP

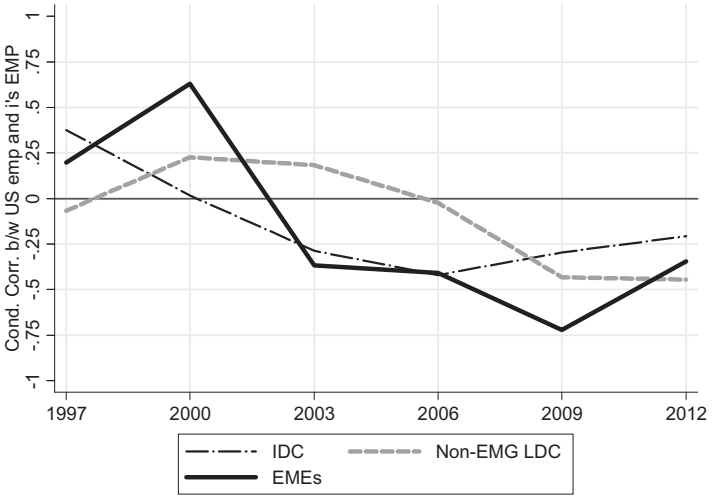


Fig. 6. Country-group average of the estimated coefficients for.

period let these currencies to appreciate significantly. The appreciation of the CE's currencies led to a fall in the EMP of these economies, which at the same time also meant depreciation of the currencies of the non-center countries. That explains the finding that more non-center countries' EMP appears to be negatively correlated with the CE's EMP during the GFC and the following period.

Fig. 6 illustrates the average estimated impacts of the U.S. REER and EMP ($\hat{\gamma}^{US}_{REER}$ and $\hat{\gamma}^{US}_{EMP}$) on non-center economies' EMP for the group of developed countries (IDC), emerging market economies (EMEs), and non-emerging market developing countries (non-EMG LDC) for the three-year panels starting with 1995–2000 through 2010–2012.[24]

[24] The x-axis of the figure only shows the last year of the three-year panels.

According to Fig. 6a, the average impact of the U.S. REER ($\hat{\gamma}^{US}_{REER}$) on the EMP fluctuates but remains persistently positive for IDC and EMEs. Interestingly, the average responsiveness of the EMEs' EMP to the U.S. REER slightly rose in the 2010–12 period.[25] Based on the estimation results, for the group of EMEs, if the U.S. REER rises (i.e., real appreciation) by 10%, the EMP on average would rise by about 1.2. This (unit-less) figure stands for about 0.6–0.8 standard deviations of major EMEs' EMP, which is not unsubstantial.

Fig. 6b shows that for the last decade or so, the impact of the U.S. EMP on sample countries' EMP has been negative for both IDC and EME groups. Using both panels of Fig. 6, we can argue that, if the U.S. raises its policy rate, that would cause U.S. REER to rise and PE's REER to fall, which leads PE's EMP to rise while the U.S. EMP falls. This is consistent with the nervousness shared among many EMEs since the U.S. Fed suggested the possibility of lifting the zero interest rate policy in the summer to fall of 2015.

Now, we repeat the second-step estimation, but the dependent variable this time will be the estimated coefficient for the impact ($\hat{\gamma}_C$) on the sample countries' EMP of the CE's financial variables: policy interest rates, the REER, and the EMP. We report the results in Table 4a to b.[26]

Table 4a shows that we do not obtain robust results when we estimate the determinants of the estimated impact ($\hat{\gamma}_C$) of the CE's policy interest rates on the sample countries' EMP. The estimate for the variables of financial development is persistently significant and negative, suggesting that a country equipped with more developed financial markets tends to be able to shield itself from the center economies' policy interest rate changes affecting its EMP. Interestingly, while we found that a country with more developed financial markets tends to have its own policy interest rates more sensitive to those of the center economies in Table 1a, here, more developed financial markets may also be able to help absorb and internalize shocks from changes in the center economies' policy interest rates. That may explain the motivation for developing countries to develop their financial markets.

Such an insulating effect of financial development is also observed in the results for the factors affecting the link between the center economies' REER and the sample countries' EMP as is shown in Table 4b. The negative coefficient on financial openness appears somewhat counterintuitive, considering that more open financial markets would allow for more rapid capital flight if center economies experience real appreciation of their currencies. However, more open financial markets often lead to more financial development (Chinn and Ito, 2006), so that it may also complement the shock-absorbing effect of general financial development. Or, it could be also possible that an economy with greater financial openness – especially toward outward capital flows – may be able to benefit from more risk sharing. While developing countries with greater inflation volatility tend to have their EMP more vulnerable to real appreciation of the CE's currencies, we also see some evidence that those with worse current account balances or *deficit*, also tend to be more vulnerable to the CE's currency values. In contrast to financial openness being a significant factor, the types of exchange rate regimes do not appear to affect the link between the CE's REER and the peripheral economies' EMP.

The estimated effect of greater import demand from the CEs is found negative. If the CE's currencies experience real appreciation, a peripheral economy that has stronger trade ties with the center economies could experience real *depreciation* especially when it has stronger trade ties with the center economies.

Table 4c reports the results of the estimates regarding the factors affecting the impact of the CE's EMP on the non-center countries' EMP. While higher levels of financial openness, inflation volatility, and financial development might lead developing countries to face higher, or more positive, degrees of connectivity between the CEs and non-center economies through their EMP, higher levels of government debt, budget deficit, current account deficit, trade demand, and legal development would lead to lower degrees of the CE-PH EMP connectivity. The latter group of significant estimates may appear puzzling. However, Fig. 5d helps us interpret these results. First of all, there are more

[25] These observations are qualitatively intact when we look at the country group medians.

[26] We continue to use the robust regression estimation technique to accommodate potential extreme values of the EMP index.

Table 4
(a) Factors affecting exchange market pressure sensitivity to core interest rates, 1986–2012; (b) factors affecting exchange market pressure sensitivity to core REER, 1986–2012; (c) factors affecting exchange market pressure sensitivity to core exchange market pressure, 1986–2012.

		FULL (1)	FULL (2)	LDC (3)	LDC (4)	EMG (5)	EMG (6)
(a)							
Open Macro Policy (*OMP*)	Exchange rate stability	19.51	42.38	109.52	116.18	–27.89	18.89
		(74.81)	(65.80)	(178.29)	(151.16)	(166.17)	(143.51)
	Financial openness	29.82	–18.37	–176.90	–267.83	–64.27	–124.24
		(69.70)	(60.91)	(153.11)	(132.45)**	(143.52)	(125.55)
	IR holding	308.11	246.58	555.75	353.87	577.64	382.42
		(198.48)	(178.78)	(478.13)	(414.46)	(413.08)	(373.90)
Macro. Conditions (*MC*)	CA balance (%)	237.08	120.23	–182.76	–530.44	251.10	343.03
		(289.19)	(274.40)	(617.52)	(622.50)	(671.41)	(611.66)
	Inflation vol.	914.73	445.22	3,224.51	608.21	457.93	196.27
		(1,245.72)	(492.18)	(2,521.27)	(949.83)	(2,134.15)	(781.49)
	Gross debt (%)	–86.98	–	–127.91	–	–152.37	–
		(45.22)*	–	(101.25)	–	(80.82)*	–
	Budget balance (%)	–	129.37	–	1,423.31	–	362.80
		–	(369.62)	–	(900.83)	–	(967.51)
External Link (*LINK*)	Trade competition	–31.18	37.31	577.77	771.16	–59.62	260.37
		(261.70)	(232.57)	(578.58)	(492.02)	(493.08)	(426.45)
	Trade demand	337.07	42.98	–173.50	–422.24	205.64	–107.52
		(293.46)	(256.64)	(704.03)	(599.29)	(574.06)	(501.74)
	FDI from CEs	–1,366.16	–973.90	–806.81	–646.05	308.98	348.21
		(387.70)***	(347.64)***	(1,017.54)	(885.59)	(816.23)	(731.21)
Institutional Dev. (*INST*)	Fin. dev.	–164.75	–144.22	–551.32	–525.94	–284.73	–316.95
		(67.36)**	(60.63)**	(159.12)***	(142.14)***	(138.00)**	(124.21)**
	Legal dev.	96.50	90.87	–33.72	–3.74	–164.35	–287.82
		(134.15)	(112.62)	(417.41)	(350.29)	(347.30)	(299.65)
Crises (*CRISIS*)	Currency crisis	66.02	41.14	75.07	51.40	128.84	53.55
		(63.20)	(53.84)	(165.46)	(130.15)	(136.54)	(109.50)
	Banking crisis	–9.38	2.81	–80.82	–54.80	–58.82	–60.30
		(51.47)	(43.73)	(133.33)	(108.92)	(118.01)	(97.87)
	N	625	678	382	418	321	355
	Adj. R2	0.14	0.11	0.09	0.09	0.10	0.11
	# of countries	59	59	40	40	30	30
	F-test, OMP	0.44	0.43	0.34	0.13	0.54	0.53
	F-test, macro	0.23	0.72	0.33	0.43	0.31	0.90
	F-test, ext. link	0.01	0.02	0.60	0.30	0.90	0.89
	F-test, inst. dev.	0.04	0.06	0.00	0.00	0.07	0.01
	F-test, all	0.01	0.05	0.08	0.05	0.39	0.14

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Table 4 (*continued*)

		FULL (1)	FULL (2)	LDC (3)	LDC (4)	EMG (5)	EMG (6)
(b)							
Open Macro Policy (*OMP*)	Exchange rate stability	–4.296	–5.331	–1.954	–4.870	1.244	–2.477
		(3.269)	(3.274)	(3.291)	(3.384)	(4.044)	(4.165)
	Financial openness	–9.415	–7.166	–7.360	–6.084	–8.324	–6.339
		(3.046)***	(3.031)**	(2.827)***	(2.965)**	(3.493)**	(3.644)*
	IR holding	–14.635	–15.171	–9.791	–10.705	–11.470	–12.454
		(8.674)*	(8.896)*	(8.827)	(9.279)	(10.053)	(10.852)
Macro. Conditions (*MC*)	CA balance (%)	–21.217	–16.464	–24.993	–15.372	–31.781	–20.494
		(12.638)*	(13.654)	(11.400)**	(13.936)	(16.339)*	(17.753)
	Inflation vol.	14.329	58.052	–2.863	73.630	13.702	80.103
		(54.439)	(24.490)**	(46.546)	(21.265)***	(51.937)	(22.682)***
	Gross debt (%)	1.207	–	–0.992	–	0.257	–
		(1.976)	–	(1.869)	–	(1.967)	–
	Budget balance (%)	–	–8.721	–	–14.180	–	–24.878
		–	(18.392)	–	(20.168)	–	(28.082)
External Link (*LINK*)	Trade competition	16.175	16.889	16.344	17.914	13.900	15.391
		(11.437)	(11.572)	(10.681)	(11.015)	(12.000)	(12.377)
	Trade demand	–14.134	–7.330	–25.070	–20.335	–33.885	–27.703
		(12.824)	(12.770)	(12.997)*	(13.417)	(13.970)**	(14.563)*
	FDI from CEs	20.388	17.320	23.582	21.515	34.115	32.611
		(16.943)	(17.298)	(18.785)	(19.826)	(19.864)*	(21.223)
Institutional Dev. (*INST*)	Fin. dev.	–8.604	–8.868	–7.133	–6.044	–8.104	–6.107
		(2.943)***	(3.017)***	(2.938)**	(3.182)*	(3.358)**	(3.605)*
	Legal dev.	21.851	24.437	7.902	7.784	15.612	15.026
		(5.862)***	(5.604)***	(7.706)	(7.842)	(8.452)*	(8.697)*
Crises (*CRISIS*)	Currency crisis	7.238	7.495	7.464	8.885	6.067	6.188
		(2.762)***	(2.679)***	(3.055)**	(2.914)***	(3.323)*	(3.178)*
	Banking crisis	5.694	7.428	2.254	3.863	7.808	9.125
		(2.249)**	(2.176)***	(2.461)	(2.439)	(2.872)***	(2.841)***
	N	625	678	382	418	320	355
	Adj. R2	0.15	0.18	0.12	0.18	0.14	0.19
	# of countries	59	59	40	40	30	30
	F-test, OMP	0.00	0.01	0.02	0.03	0.06	0.12
	F-test, macro	0.37	0.04	0.14	0.00	0.27	0.00
	F-test, ext. link	0.31	0.35	0.19	0.26	0.10	0.20
	F-test, inst. dev.	0.00	0.00	0.05	0.14	0.02	0.09
	F-test, all	0.00	0.00	0.00	0.00	0.00	0.00

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Table 4 (*continued*)

		FULL (1)	FULL (2)	LDC (3)	LDC (4)	EMG (5)	EMG (6)
(c)							
Open Macro Policy (*OMP*)	Exchange rate stability	–0.091	–0.134	0.207	0.095	0.055	0.007
		(0.115)	(0.115)	(0.140)	(0.153)	(0.167)	(0.181)
	Financial openness	0.330	0.195	0.589	0.443	0.590	0.424
		(0.107)***	(0.107)*	(0.120)***	(0.134)***	(0.144)***	(0.159)***
	IR holding	0.363	0.425	–0.254	–0.185	–0.209	–0.134
		(0.304)	(0.314)	(0.376)	(0.420)	(0.414)	(0.472)
Macro. Conditions (*MC*)	CA balance (%)	1.305	0.597	1.327	0.852	1.494	1.051
		(0.443)***	(0.482)	(0.485)***	(0.631)	(0.673)**	(0.772)
	Inflation vol.	5.177	0.502	5.963	4.604	6.017	4.199
		(1.910)***	(0.864)	(1.981)***	(0.963)***	(2.140)***	(0.987)***
	Gross debt (%)	–0.140	–	–0.252	–	–0.268	–
		(0.069)**	–	(0.080)***	–	(0.081)***	–
	Budget balance (%)	–	0.721	–	1.888	–	2.322
		–	(0.649)	–	(0.914)**	–	(1.222)*
External Link (*LINK*)	Trade competition	–0.634	–0.568	–0.355	–0.377	–0.246	–0.355
		(0.401)	(0.408)	(0.455)	(0.499)	(0.494)	(0.538)
	Trade demand	0.687	0.773	–0.829	–0.470	–0.594	–0.187
		(0.450)	(0.450)*	(0.553)	(0.608)	(0.576)	(0.633)
	FDI from CEs	–1.636	–1.859	0.428	–0.081	–0.245	–0.781
		(0.594)***	(0.610)***	(0.800)	(0.898)	(0.818)	(0.923)
Institutional Dev. (*INST*)	Fin. dev.	0.138	0.100	0.269	0.235	0.217	0.163
		(0.103)	(0.106)	(0.125)**	(0.144)	(0.138)	(0.157)
	Legal dev.	–0.311	0.019	–0.794	–0.554	–0.703	–0.405
		(0.206)	(0.198)	(0.328)**	(0.355)	(0.348)**	(0.378)
Crises (*CRISIS*)	Currency crisis	0.205	0.143	0.424	0.538	0.382	0.547
		(0.097)**	(0.094)	(0.130)***	(0.132)***	(0.137)***	(0.138)***
	Banking crisis	0.028	0.131	–0.068	0.097	–0.150	0.021
		(0.079)	(0.077)*	(0.105)	(0.110)	(0.118)	(0.124)
	N	625	678	382	418	321	355
	Adj. R2	0.22	0.19	0.31	0.27	0.32	0.30
	# of countries	59	59	40	40	30	30
	F-test, OMP	0.02	0.15	0.00	0.01	0.00	0.07
	F-test, macro	0.00	0.19	0.00	0.00	0.00	0.00
	F-test, ext. link	0.02	0.01	0.22	0.52	0.37	0.49
	F-test, inst. dev.	0.26	0.53	0.02	0.13	0.07	0.41
	F-test, all	0.00	0.01	0.00	0.00	0.00	0.00

Notes: The estimations are conducted with the robust regression method due to the existence of outliers. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The second estimation is conducted for the estimates $\hat{\gamma}_{Fi}^{C}$ from the first-step estimation that does not include China as one of the center economies. Time fixed effects for the three-year panels and the constant are also included, though their estimates are not reported.

Table 5
Interactive effects and exchange market pressure sensitivity to core exchange market pressure, 1986–2012.

	Corr. b/w CE's REER and Countries' EMP			Corr. b/w CE's EMP and Countries' EMP		
	FULL (1)	LDC (2)	EMG (3)	FULL (4)	LDC (5)	EMG (6)
Exchange rate stability	8.351	19.587	18.713	–0.277	0.402	0.439
	(6.225)	(6.890)***	(7.407)**	(0.220)	(0.302)	(0.322)
Financial openness	–10.296	–21.161	–17.558	–0.204	0.097	0.118
	(5.571)*	(6.143)***	(6.421)***	(0.197)	(0.269)	(0.280)
IR holding	–20.095	–14.726	–6.901	0.460	–0.058	–0.087
	(8.947)**	(9.031)	(10.064)	(0.317)	(0.395)	(0.438)
CA balance (%)	59.261	67.269	28.283	1.191	0.973	2.029
	(38.237)	(33.026)**	(34.914)	(1.353)	(1.446)	(1.520)
Gross debt (%)	–5.544	–2.352	–0.804	–0.029	–0.281	–0.357
	(4.768)	(4.475)	(4.500)	(0.169)	(0.196)	(0.196)*
Trade demand	39.433	8.589	14.270	–2.600	–3.573	–3.522
	(36.107)	(33.085)	(34.822)	(1.278)**	(1.448)**	(1.516)**
Fin. dev.	–11.077	–10.351	–12.094	0.827	0.495	0.240
	(7.359)	(6.344)	(6.609)*	(0.260)***	(0.278)*	(0.288)
KAO × CAB	–54.082	–24.893	–68.213	–3.164	–3.496	–2.907
	(40.153)	(36.908)	(42.483)	(1.421)**	(1.616)**	(1.849)
KAO × Debt	5.922	–7.144	–5.077	–0.108	–0.170	–0.198
	(5.373)	(5.804)	(5.926)	(0.190)	(0.254)	(0.258)
KAO × Trade demand	–21.672	18.136	–0.896	4.677	5.619	5.333
	(37.200)	(34.012)	(35.047)	(1.317)***	(1.489)***	(1.526)***
KAO × FD	–8.619	–16.551	–19.001	–0.635	–0.326	–0.243
	(7.891)	(7.932)**	(8.584)**	(0.279)**	(0.347)	(0.374)
ERS × CAB	–65.220	–108.129	–1.265	3.797	4.131	1.684
	(44.338)	(40.888)***	(50.437)	(1.569)**	(1.790)**	(2.196)
ERS × Debt	6.127	10.041	6.626	–0.013	0.313	0.431
	(6.840)	(6.647)	(6.758)	(0.242)	(0.291)	(0.294)
ERS × Trade demand	–75.257	–90.629	–89.484	–1.263	–2.984	–2.035
	(42.484)*	(44.369)**	(49.458)*	(1.504)	(1.942)	(2.153)
ERS × FD	17.335	26.167	32.941	–0.510	–0.038	0.225
	(9.273)*	(8.749)***	(10.051)***	(0.328)	(0.383)	(0.438)
N	625	382	320	625	382	321
Adj. R2	0.16	0.18	0.16	0.22	0.31	0.32
# of countries	59	40	30	59	40	30
F-test, OMP	0.03	0.00	0.01	0.17	0.48	0.46
F-test, macro	0.29	0.23	0.88	0.04	0.01	0.01
F-test, ext. link	0.05	0.07	0.17	0.02	0.06	0.13
F-test, inst. dev.	0.00	0.21	0.06	0.01	0.11	0.42
F-test, int. terms	0.11	0.01	0.02	0.00	0.00	0.02
F-test, all	0.00	0.00	0.00	0.00	0.00	0.00

Notes: The estimations are conducted with the robust regression method due to the existence of outliers. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The estimates for inflation volatility, trade competition, legal development, currency and banking crisis dummies, and fixed effects are omitted from presentation due to space limitation.

developing countries that turn out to have negative connectivity between their EMP and that of the center economies. Also, appreciation of the CE's currencies, especially the dollar and the Japanese yen, during the GFC and its aftermath contributed to lowering the EMP of the CEs. However, negative sensitivity indicates that a fall in the CE's EMP led to a rise in the PH's EMP, and our results indicate that such a movement is more applicable to economies with higher government debt or budget deficit, current account deficit, and more developed legal systems.

As we did with the original model, we now interact some of the explanatory variables with the open macrovariables of exchange rate stability and financial openness to examine if there is any interactive or indirect effects of open macro policy arrangements. We report the results in Table 5. In this table, columns (1) through (3) report the estimation results on the estimated linkage between

Table 6
Interactive effects for developing countries conditional on KAOPEN and ERS.

		KAOPEN*		
		0.00	**0.50**	**1.00**
	(a) Effect of FD (+10 ppt) in the REER-EMP Link Estimation			
ERS*	**0.00**	−1.04	−1.86	−2.69
	0.50	0.27	−0.55	−1.38
	1.00	1.58	0.75	−0.07
	(b) Effect of CAB *Deterioration* (−0.02 ppt) in the REER-EMP Estimation			
ERS*	**0.00**	−1.35	−1.10	−0.85
	0.50	−0.26	−0.02	0.23
	1.00	0.82	1.07	1.32
	(c) Effect of Trade Demand (+5 ppt) in the REER-EMP Estimation			
ERS*	**0.00**	0.43	0.88	1.34
	0.50	−1.84	−1.38	−0.93
	1.00	−4.10	−3.65	−3.20
	(d) Effect of CAB *Deterioration* (−2 ppt) in the EMP-EMP Estimation			
ERS*	**0.00**	−0.02	0.02	0.05
	0.50	−0.06	−0.03	0.01
	1.00	−0.10	−0.07	−0.03
	(e) Effect of Trade Demand (+5 ppt) by the CE in the EMP-EMP Estimation			
ERS	**0.00**	−0.18	−0.04	0.10
	0.50	−0.25	−0.11	0.03
	1.00	−0.33	−0.19	−0.05

Notes: "*" superscripted to KAOPEN or ERS in the tables means that the interaction term between KAOPEN or ERS and the variable of concern is found to be statistically significant in each respective estimation.

the CE's REER and the PH's EMP, and columns (4) through (6) report those on the estimated linkage between the CE's EMP and the PH's EMP.[27]

Since we have many interaction terms, we again estimate the marginal effects of a certain change in a macroeconomic or institutional variable for the levels of exchange rate stability and financial openness being either 0, 0.50, or 1.00 and report the results in Table 6.

According to Table 6a, for a developing country with the greater exchange rate stability or relatively closed financial openness, greater financial development could make its economy's EMP levels more sensitive to changes in the center economies' REER. If an economy of concern runs a current account *deficit*, Table 6b indicates that a peripheral economy's EMP would be more sensitive to REER changes in the center economies when it pursues greater exchange rate stability or more financial openness, although the impact of financial openness is insignificant and rather small. When a PH economy strengthens its trade ties with the center economies (by 5 percentage point), it makes the PH economy's EMP more sensitive to the CE's REER if the PH economy has more flexible exchange rate regime and more open financial markets.

When we examine the indirect effects of exchange rate stability and financial openness for the EMP-EMP connectivity between the center and non-center, peripheral economies, Table 6d shows that if a country worsens its current account balance, its impact would be larger, or less negative, on the EMP–EMP connectivity for a country that pursues greater financial openness and greater exchange rate *flexibility*. During the 2007–2009 and 2010–2012 periods particularly, a country with a worsening current account balance would face more negative EMP–EMP link with the center economies if it has more rigid exchange rate regime and more closed financial markets, while the effect of an exchange rate regime type is stronger than that of the financial openness regime.

Similar interactions with exchange rate stability and financial openness are also found for the impact of stronger trade linkages with the center economies. Having greater trade linkages with the CE would contribute to more positive EMP–EMP linkages if a country pursues greater financial openness and

[27] We do not report the results for the estimations on the link between the CE's policy interest rates and the PH's EMP due to the weak results of the main model in Table 4a.

greater exchange rate *flexibility*. However, it also means that the extent of the negative EMP–EMP relationship is stronger for a country with more closed financial markets and a more rigid exchange rate regime, although the estimate with exchange rate regimes is statistically insignificant.

Hence, as was in the previous analysis, open macro policy arrangements have not just direct but also indirect impacts on the linkage between the center economies' policy interest rates, REER, or EMP and our sample developing countries' EMP. Hence, it is safe to conclude that trilemma policy arrangements *do* affect the sensitivity of developing countries to policy changes in the center economies, although not always in accord with priors.

5. Concluding remarks

Shocks occurring to the center economies are transmitted to other parts of the world, often buffeting smaller, open economies such emerging market economies. The increasingly integrated nature of the global financial markets may require a re-think of the role of monetary policy and the trilemma hypothesis, particularly in this post-Global Financial Crisis (GFC) period.

This paper investigates the questions of whether and how the financial conditions of developing and emerging market countries are affected by the movements of financial variables in the center economies, namely, the U.S., Japan, the Euro area, and China. Our empirical method relies upon a two-step approach. We first investigate the extent of sensitivity of several important financial variables, such as policy interest rate and the real effective exchange rates, to those of the center economies while controlling for global and domestic factors. Once we measure the degree of sensitivity, we examine the determinants of sensitivity by examining a number of country-specific macroeconomic conditions or policies, real or financial linkages with the center economy, and the levels of institutional development.

We find that for both policy interest rates and the REER, the link with the CEs has been dominant for developing and emerging market economies in the last two decades. At the same time, the movements of policy interest rates are found to be more sensitive to global financial shocks around the time of the emerging markets' crises in the late 1990s and early 2000s and since the time of the GFC of 2008.

While China's weight in the world economic output has clearly increased dramatically, including China as one of the center economies does not necessarily increase the goodness of fit in the regressions estimating financial variable sensitivity. This finding suggests that, for now, China does not exert substantial influence in financial markets rivaling that of other center economies such as the U.S., the Euro area, and Japan.

The results from the second step estimates that investigate the determinants of sensitivity to the CE's financial variables suggest that while the levels of direct trade linkage, financial linkage through FDI, trade competition, financial development, current account balances, and national debt are important, the arrangement of open macropolicies such as the exchange rate regime and financial openness are also found to have direct influences on the sensitivity to the CEs. As theory suggests, we find that an economy that pursues greater exchange rate stability and financial openness would face a stronger link with the CEs through policy interest rates and REER movements.

We also find that the degree of exchange rate stability and financial openness do matter for the level of sensitivity when they are interacted with other variables such as current account balances, gross national debt, trade demand, and financial development. For example, if a developing country receives higher import demand from the CEs, that would strengthen the link between the peripheral and center economies through policy interest rates when the PH has a policy arrangement of pursuing both greater exchange rate stability and financial openness. Such a policy arrangement would also make the impact of having greater gross debt on the link between CE's and PH's REER. Thus, we conclude that open macro policy arrangements do have both direct and indirect impacts on the extent of sensitivity to the center economies.

We also investigate whether the exchange market pressure (EMP) of the PHs is sensitive to the movements of the CE's policy interest rates, REER, and EMP. We find that the EMP of the PHs is sensitive to the movements of the center economies' REER and the EMP during the GFC and the following period.

When we reapply the second-step estimation to the estimated sensitivity of our sample countries' EMP to the CE's financial variables, we find that a country with higher levels of financial development can mitigate the effect of changes in the center economies' policy interest rates on the level of EMP it faces. While the real appreciation of the CEs could lead to higher EMP of the peripheral economies, higher levels of financial development, greater financial openness, strong trade ties with the CEs, and more stable inflation would help reduce the EMP sensitivity to center economies' REER.

While higher levels of financial openness, inflation volatility, and financial development lead developing countries to face higher, or more positive, degrees of sensitivity between the CE's and non-center's EMP, higher levels of government debt or budget deficit, current account deficit, trade demand, and legal development lead to the opposite. These characteristics are consistent with those of many countries whose EMP negatively related with the CE's EMP during and after the GFC.

The impact of the interaction between open macro policy variables with macroeconomic and institutional conditions is also detected. For example, when a country pursues greater exchange rate stability but less of financial openness, more financial development makes its economy's EMP levels more sensitive to changes in the center economies' REER. If a non-center economy runs current account *deficit*, its sensitivity to the REER the center economies would rise when it pursues greater exchange rate stability. A current account deficit country finds its EMP more positively correlated with the EMP of the center economies if it pursues greater financial openness and greater exchange rate *flexibility*. Having greater trade linkages with the CE contributes to more positive EMP–EMP linkages if a country pursues greater financial openness. Thus, trilemma policy arrangements *do* affect the sensitivity of developing countries to policy changes in the center economies both directly and indirectly.

In this study, not only do we evidence that the open macro policy choice is "*still*" dictated by the hypothesis of the trilemma, but also we provide much more nuanced, indirect effects of trilemma policy arrangements. Particularly, unlike the recent "irreconcilable duo" argument, we do find that the types of exchange rate regimes do affect the extent of sensitivity to changes in financial conditions or policies in the center economies. Hence, the requiem for the trilemma need not yet be written.

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Appendix. data descriptions and sources

Policy short-term interest rate – money market rates extracted from the IMF's *International Financial Statistics* (*IFS*).

Stock market prices – stock market price indices from the IFS.

Sovereign bond spread – the difference between the long-term interest rate (usually 10 year government bond) and the policy short-term interest rate – i.e., the slope of the yield curve, *IFS*.

Real effective exchange rate (*REER*) – REER index from the *IFS*. An increase indicates appreciation.

Global interest rate – the first principal component of U.S. FRB, ECB, and Bank of Japan's policy interest rates.

Commodity prices – the first principal component of oil prices and commodity prices, both from the *IFS*.

VIX index – It is available in http://www.cboe.com/micro/VIX/vixintro.aspx and measures the implied volatility of S&P 500 index options.

"Ted spread" – It is the difference between the 3-month Eurodollar Deposit Rate in London and the 3-month U.S. Treasury Bill yield.

Industrial production (IP) – It is based on the industrial production index from the IFS.

Exchange rate stability (*ERS*) and financial openness (*KAOPEN*) indexes – From the trilemma indexes by Aizenman et al. (2013).

International reserves (IR) – international reserves minus gold divided by nominal GDP. The data are extracted from the IFS.

Gross national debt and general budget balance – both are included as shares of GDP and obtained from the World Economic Outlook (WEO) database.

Trade demand by the center economies (TR_LINK_{ip}) – $TR\_LINK_{ip} = IMP_{ip}^{C}/GDP_{ip}$ where IMP_{i}^{C} is total imports into center economy *C* from country *i*, that is normalized by country *i*'s GDP based on the data from the IMF *Direction of Trade* database.

FDI provided by the center economies ($FDINV_{i}^{C}$) – It is the ratio of the total stock of foreign direct investment from country *C* in country *i* as a share of country *i*'s GDP. We use the *OECD International Direct Investment* database. Due to possible nonstationarity of the data series, we include the first-difference of the FDI data series.

Trade competition (*Trade_Comp*) – It is constructed as follows.

$$Trade\_Comp_{i}^{C} = \frac{100}{Max(Trade\_Comp)} \sum_{k} \left[\frac{Exp_{W,k}^{C}}{Exp_{W,k}^{W}} * \frac{Exp_{W,k}^{i}}{GDP_{i}} \right]$$

$Exp_{W,k}^{C}$ is exports from large-country *c* to every other country in the world (*W*) in industrial sector *k*, whereas $Exp_{W,k}^{W}$ is exports from every country in the world to every other country in the world (i.e. total global exports) in industrial sector *k*. $Exp_{W,k}^{i}$ is exports from country *i* to every other country in the world in industrial sector *k*, and GDP_i is GDP for country *i*. We assume that merchandise exports are composed of five industrial sectors (*K*), that is, manufacturing, agricultural products, metals, fuel, and food.

This index is normalized using the maximum value of the product in parentheses for every country pair in the sample. Thus, it ranges between zero and one.[28] A higher value of this variable means that country *i*'s has more comparable trade structure to the center economies.

Financial development (*FD*) – It is the first principal component of private credit creation, stock market capitalization, stock market total value, and private bond market capitalization all as shares of GDP.[29]

Legal development (*LEGAL*) – It is the first principal component of law and order (*LAO*), bureaucratic quality (*BQ*), and anti-corruption measures (*CORRUPT*), all from the ICRG database. Higher values of these variables indicate better conditions.

Currency crisis (*CURRENCY*) – It is from Aizenman and Ito (2014) who use the exchange market pressure (EMP) index using the exchange rate against the currency of the base country. We use two standard deviations of the EMP as the threshold to identify a currency crisis.

Banking crisis (*BANKCRISIS*) – It is from Aizenman and Ito (2014) who follow the methodology of Laeven and Valencia (2008, 2010, 2012). For more details, see appendix 1 of Aizenman and Ito (2014).

Exchange market pressure (EMP) index –It is defined as a weighted average of monthly changes in the nominal exchange rate, the international reserve loss in percentage, and the nominal interest rate. The nominal exchange rate is calculated against the base country that we use to construct the trilemma indexes (see Aizenman et al., 2008). The weights are inversely related to each country's variances of each of the changes in the three components over the sample countries.

$$EMP_{i,t} = \alpha(\%\Delta e_{i,t}) + \beta[\Delta(i_{i,t} - i_{b,t}) - \gamma(\%\Delta r_{i,t} - \%\Delta r_{b})$$

[28] This variable is an aggregated version of the trade competitiveness variable in Forbes and Chinn (2004). Their index is based on more disaggregated 14 industrial sectors.

[29] Because the private bond market capitalization data go back only to 1990, the FD series before 1990 are extrapolated using the principal component of private credit creation, stock market capitalization, and stock market total values, which go back to 1976. These two FD measures are highly correlated with each other.

where $\alpha = \frac{(1/\sigma_{\%\Delta e_{i,t}})}{(1/\sigma_{\%\Delta e_{i,t}})+(1/\sigma_{\Delta(i_{i,t}-ib_{,t})})+(1/\sigma_{\%\Delta \pi_{i,t}-\%\Delta r})}$, $\beta = \frac{(1/\sigma_{\Delta(i_{i,t}-ib_{,t})})}{(1/\sigma_{\%\Delta e})+(1/\sigma_{\Delta(i_{i,t}-ib_{,t})})+(1/\sigma_{\%\Delta \pi_{i,t}-\%\Delta r})}$, $\gamma = \frac{(1/\sigma_{\%\Delta \pi_{i,t}-\%\Delta r})}{(1/\sigma_{\%\Delta e_{i,t}})+(1/\sigma_{\Delta(i_{i,t}-ib_{,t})})+(1/\sigma_{\%\Delta \pi_{i,t}-\%\Delta r})}$

b stands for the "base country," which is defined as the country that a home country's monetary policy is most closely linked with as in Shambaugh (2004) and Aizenman et al. (2013). The base countries are Australia, Belgium, France, Germany, India, Malaysia, South Africa, the U.K., and the U.S. The base country can change as it has happened to Ireland, for example. Its base country was the U.K. until the mid-1970s, and changed to Germany since Ireland joined the European Monetary System (EMS).

To construct the crisis dummies in three-year panels, we assign the value of one if a crisis occurs in any year within the three-year period.

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