Transmission of Global Financial Shocks: Which Capital Flows Matter?*

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In this paper, I study channels through which risk-appetite shocks to global investors, i.e., global financial shocks, are transmitted to emerging market economies (EMEs). I focus on how transmission channels have changed as EMEs have become able to borrow from abroad in the form of equity and local currency debt. First, I empirically show that much of the transmission of global financial shocks to EMEs is reflected in equity and local currency bond portfolio flows. I then develop a small open-economy model which, augmented with leverage-constrained banks, can replicate these empirical findings qualitatively. Finally, I calibrate the model to the Korean economy in which most of the external liabilities of the country are Korean won-denominated equities and debts. Quantitative analysis of the model suggests that global financial shocks are a dominant factor in financial market fluctuations and significantly contribute to the dynamics of the real economy in Korea. In short, all the analyses in this paper imply that, to a substantial extent, global financial shocks are transmitted to EMEs via fickle portfolio flows to equity and local currency bond markets in EMEs.

JEL Codes: E32, F36, F41, F62, G15.

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1. Introduction

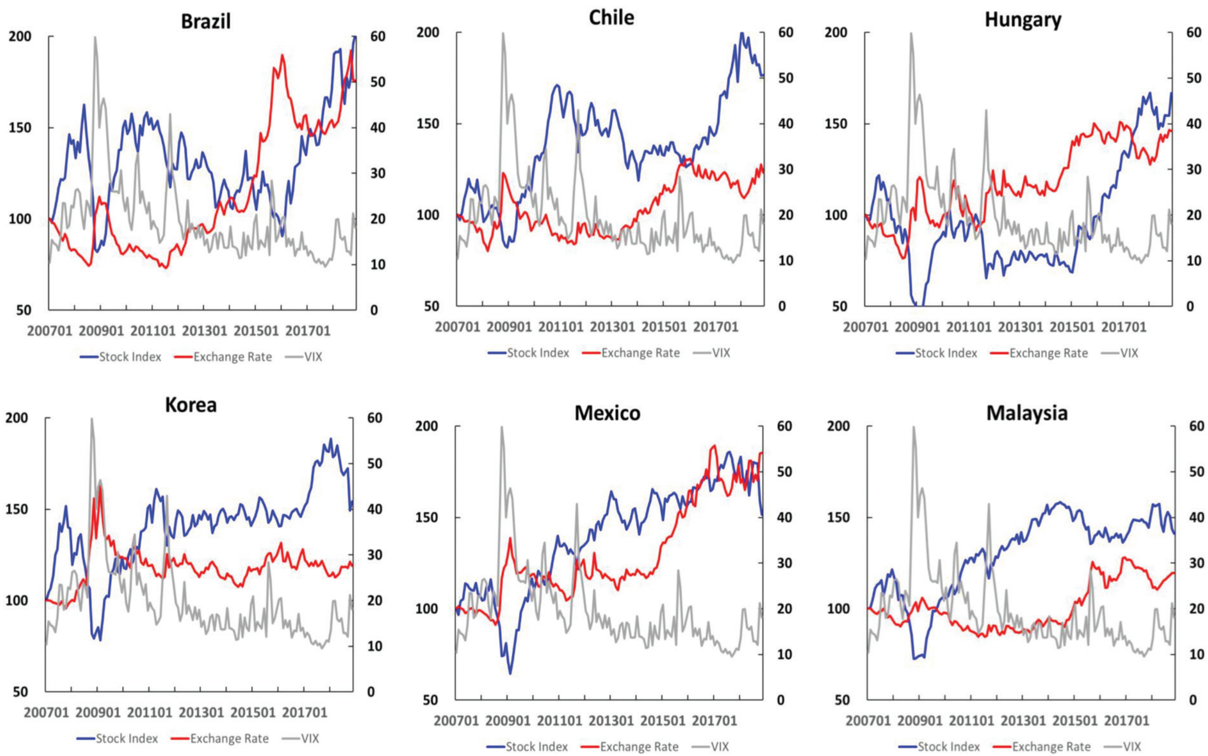
Disruptive effects of cross-border capital flows in emerging market economies (EMEs) have been thoroughly explored in recent international macroeconomic and financial research. In the seminal papers, Rey (2013, 2016) coined the term "global financial cycle," saying that shocks to the risk appetite of global investors, measured by the Chicago Board Options Exchange Volatility Index (CBOE VIX),[1] generate co-movements of risky asset prices around the world. In the context of EMEs, as is shown in Figure 1, we can see certain correlations between VIX and EME financial market variables. A higher VIX is associated with falls in EME stock indices and with EME local currency depreciation, and vice versa for a lower VIX. Furthermore, when the final draft of this paper was written (in September 2022), we clearly saw another big shock to the risk appetite of global investors, instigated by the drastic changes in the Federal Reserve's monetary policy stance and heightened geopolitical risk, resulting in large falls in stock indices and currency values across EMEs. This paper aims at improving our understanding of the mechanism by which the risk-appetite shocks, "global financial cycles,"[2] affect financial markets and the real economy in small open economies and, in particular, EMEs.

This paper focuses on the global financial shock implications for EMEs because, firstly, EMEs are usually considered more vulnerable to sudden reversals in capital flows than advanced economies (AEs) and therefore EME policymakers are more concerned about capital flows. Second, this paper reviews our understanding of the key channel through which capital flows disrupt EMEs. Traditionally, it has been thought that EMEs must borrow in foreign currencies when they borrow abroad, and the resulting currency mismatches of external liabilities with domestic assets are the source of the fragility; the "original sin" hypothesis as espoused by Eichengreen, Hausman, and Panizza (2002). However, there have been important changes in

[1]Throughout this paper, VIX indicates CBOE VIX.

[2]Throughout this paper, risk-appetite shocks refer to the shock to the risk appetite of global financial intermediaries, which drive the global financial cycle. I interchangeably use risk-on/off shocks, risk-appetite shocks, and global financial shocks.

Figure 1. VIX and Financial Markets in Selected EMEs



Note: Monthly data, January 2008 to December 2018. I normalize the stock indices and nominal exchange rates on a basis of the values at the beginning of 2007 equal to 100. Exchange rates are the price of U.S. dollars in local currencies. Hence, higher exchange rates mean a depreciation of the local currencies.

international investment positions (IIPs) of EMEs over the last 20 years, which brings into question the continued validity of the original sin hypothesis. As documented in recent papers, such as Du and Schreger (2016) and Ottonello and Perez (2019), substantial parts of the external debts in EMEs are currently local currency (LC) denominated debt. Furthermore, in a companion paper (Han 2022), I constructed a data set, which shows EMEs have increasingly borrowed from abroad in the form of equity and local currency debt, and have reduced their currency mismatches. This suggests that we may no longer rely solely on the currency mismatch channel to explain the vulnerability of EMEs to global financial shocks.

In this paper, I first empirically evaluate how different types of external liabilities are associated with different sensitivities to global financial shocks. I deploy the constructed data set in the companion paper (Han 2022), which measures the composition of external liabilities of EMEs in different instruments and currencies. Thus, the first strength of the regression analysis is the use of the data set, which makes it possible to include different types of external liability by precise amounts in the regression equations—in particular, local currency debts. Using the novel data set, I estimate how financial market variables in the EMEs—stock indices and exchange rates—respond to the risk-appetite shocks, measured by changes in VIX, conditional on different types of external liabilities in each EME. Surprisingly, it turns out that more equity external liabilities and LC external debts are associated with higher sensitivities to global financial shocks, at least in terms of financial market reactions in a short run at monthly frequency. By contrast, measures of currency mismatches, both on aggregate and at the sectoral level, turn out to be insignificant. The result is in line with a few earlier empirical studies (e.g., Dedola, Rivolta, and Stracca 2017) that document no clear relationship between country responses and likely relevant fundamentals such as U.S. dollar exposure, but countries with larger capital markets, equity and bond markets, seem to be more fragile. The empirical findings here, together with these prior results, suggest that there are alternative channels for global financial shocks to affect EME financial markets other than currency mismatches.

Motivated by these facts, I develop a small open-economy model augmented by three distinctive features. First, to model equity markets in the small open economy, firms issue claims on capital every period, and government in the economy issues sovereign bonds denominated in the local currency (LC bonds). The resulting equity-type securities and LC bonds must be purchased by leverage-constrained domestic banks or global investors. Second, following Miranda-Agrippino and Rey (2020), I assume that global investors are risk neutral but face value-at-risk (VaR) constraints so that they behave like risk-averse agents. Third, the domestic banks finance their investments through either deposits from households or foreign currency (FC) borrowing in international loan markets and they face a leverage constraint. I model the leverage constraint following Gertler and Kiyotaki (2010).

To understand the mechanisms in the model, consider a risk-off scenario in which global investors face negative shocks to their own capital. The damage to capital forces the global investors to dispose of their risky asset holdings in EMEs. Given initial conditions, the global investors sell off some of their EME equity and EME LC bonds. The other investors in EMEs, domestic banks, cannot absorb the sell-off because they are leverage constrained. The resulting insufficient asset demand lowers the price of capital, which in turn reduces the net worth of domestic banks and accordingly weakens demand from domestic banks. As a result, the sell-off by global investors generates a negative externality through the domestic capital price, weakening total demand for capital and resulting in a large fall in asset price. Hence, it is a form of fire-sale mechanism ignited by the sell-off by global investors. On the other hand, in foreign exchange markets, when the global investors sell off the assets in EMEs, they must also sell off their local currency proceeds and convert them to their own foreign currency. This depreciates the local currency. These impacts of the risk-off shock on stock prices and exchange rates propagate into the real economy, resulting in lower investment in capital and higher net exports, which is typically observed during risk-off events. This describes the theoretical "capital market channel" through which global risk-appetite shocks affect EMEs' financial markets and the real economies.

Finally, I calibrate the model to the Korean economy where corporations and the government have no significant net foreign currency debts and have mostly Korean won-denominated equities and bonds as external liabilities. The purpose of the quantitative analysis is to evaluate the importance of the capital market channel quantitatively. To put it another way, how much of the financial market fluctuations and the business cycles can be attributed to global financial shocks in an environment where the external liabilities of the small open economy are equities and local currency bonds? The results of the quantitative analysis illustrate that the global financial shock is the most important and dominant force in the financial markets in Korea. It accounts for approximately 50 percent of the volatility of capital prices, as a proxy for equity prices in reality, 30 percent of real exchange rate volatility, and 40 percent of the government bond price volatility. The importance of global financial shocks is relatively low for real macroeconomic aggregates. The global financial shock accounts for approximately 40 percent of investment volatility, 25 percent of consumption, and less than 10 percent of GDP. These numbers are close to recent estimates by Acalin and Rebucci (2020). The parts of gross domestic product (GDP) variations attributable to the risk-appetite shocks are low, but it reflects that increases in net exports largely offset the negative impacts on investments during a risk-off event and vice versa for a risk-on event.

1.1 Related Literature

This paper is related to several strands of literature. First and foremost, this paper is part of the global financial cycle literature. One important question in the literature is how risk-appetite shocks in center economies, such as U.S. monetary policy shocks, are transmitted to peripheral economies. This study shows that equity and LC bond portfolio flows are important in the transmission of global financial shock to EMEs, whereas most preceding papers instead focused on the role of foreign currency debts in EMEs. The empirical strategies in this paper are similar to Aizenman, Binchi, and Hutchison (2016) and Eichengreen and Gupta (2014), who investigated financial market reactions in EMEs during the taper tantrum in 2013. I extended their empirical framework and found that financial market reactions to global financial shocks are positively associated with external liabilities in the form of equity and local currency debt. From a different angle, the results of empirical and quantitative analyses in this paper are in line with forefront empirical studies, such as Chari, Stedman, and Forbes (2022) and Committee on the Global Financial System (2022) in that these papers show the importance of portfolio flows in the transmission of global financial shocks.

The theoretical model and the subsequent quantitative analysis in this paper are related to a group of papers that emphasized the interaction between external shocks (e.g., U.S. monetary policy shocks) and domestic banking sectors. Akinci and Queralto (2019), Aoki, Benigno, and Kiyotaki (2018), Devereux and Yu (2020), and Jiang, Krishnamurthy, and Lustig (2019) belong to this group. This paper also constructs a small open-economy model augmented with domestic banking sectors and echoes the importance of leverage-constrained financial intermediary. However, unlike the papers mentioned above, the model in this paper includes different types of capital flows, and the focus of the analysis using the model is on the cross-border spillovers through equity and LC bond portfolio flows to EMEs, although the analysis also includes the foreign currency debts. A handful of recent papers studied how external shocks can be transmitted through different types of capital flows. Cavallino and Sandri (2019) and Devereux and Yu (2020) modeled different types of capital flows. However, the model in this paper differs in that in my model, the negative impacts of the sell-off by foreign investors in domestic markets are amplified through asset price falls, whereas this mechanism is absent in their models. The core mechanism behind the model in this paper is close to Caballero and Simsek (2020). However, despite the similarity, my model in this paper identifies different channels from different types of capital flows more precisely in richer environments. Thus, the model is more suitable for quantitative studies.

This paper contributes to the emerging and growing literature on LC-denominated sovereign debts in EMEs. Among different groups of papers in the literature, this paper is related to the handful of forefront research that studied how EMEs borrowing abroad in local currency can be destabilized by global financial shocks. Bertaut, Bruno, and Shin (2021) empirically showed that local currency depreciation amplifies the sell-off of LC bonds in EMEs during a risk-off event, which suggests that the local currency depreciation dampens the balance sheet of global financial intermediaries holding the LC bonds. Based on their findings, the authors argued that external borrowing in domestic currency has not insulated EMEs from global financial shocks, which they called "original sin redux." Hofmann, Patel, and Wu (2022) constructed a quantitative model to evaluate the importance of the channel in Bertaut, Bruno, and Shin (2021). Adrian et al. (2021) and Basu et al. (2020) studied the optimal policy mix in response to capital outflows from LC bond markets in EMEs. This paper adds to the discussion by empirically and theoretically showing that a small open-economy borrowing abroad in local currency can still be vulnerable to external shocks as long as it relies on foreign capital. However, the idea in this paper is developed separately from the aforementioned papers. Moreover, this paper emphasizes the role of domestic asset prices, which is not extensively analyzed in the other papers. In this regard, this paper complements the findings in Bertaut, Bruno, and Shin (2021) and Hofmann, Patel, and Wu (2022) by providing another reason EMEs borrowing abroad in domestic currency can be vulnerable to global financial shocks.

1.2 Layout

The rest of the paper is organized as follows. Section 2 conducts a simple empirical analysis using a novel data set from a companion paper. Section 3 introduces a small open-economy model to explain the empirical findings. Section 4 illustrates the results from a quantitative approach, using the model. Section 5 concludes.

2. Empirical Analysis

In this section, I conduct a simple empirical analysis to see how the fragility of EMEs to global financial shocks is associated with different types of external liabilities—equities, LC debts, and foreign currency debts. The data used in the regressions come from a companion paper (Han 2022). I hand-collected data on the currency composition of different types of external liabilities. More precisely, by combining different national sources with the International Investment Positions (IIP) data set from the International Monetary Fund (IMF), I can identify seven different types of external liabilities of

20 EMEs[3]—equity foreign direct investments, debt foreign direct investments, local currency equities, local currency bonds, other local currency debts (deposits), foreign currency debts, and other foreign currency external liabilities. Thus, the first strength of the regression analysis below is that it uses novel data described in the companion paper, which makes it possible to include different types of external liability by precise amounts in the regression equations—in particular, local currency debts.

The empirical findings from the constructed data, relevant to the main conclusions in this paper, are as follows:

- As of 2019, significant parts of the external liabilities of the 20 EMEs are equities or local currency debts. On average, 40 percent of the external liabilities excluding foreign direct investments are local-currency-denominated equities or debts.
- As of 2019, 18 EMEs among the 20 are net long in foreign currency but net short in local currency. Even excluding official reserve assets, eight EMEs are still net long in foreign currency. For EMEs whose foreign currency positions without official reserves are net short, the net short positions (net debts) are no larger than 20 percent of GDP, except for Turkey.
- Only non-financial corporate sectors have sizable net foreign currency debts (net short in foreign currency). Households in the EMEs have positive net foreign currency assets (net long in foreign currency) and the financial corporate sectors have balanced foreign currency assets and debts (squared-off in foreign currency).

That is, EMEs borrow substantially from abroad in the form of equity and LC debt, and as a result currency mismatches in the EMEs at both the aggregate and the sectoral levels are not as severe as usually described in the literature and discussed by commentators.

Even more surprisingly, the regression analysis shows that in contrast to the usual belief, financial markets in EMEs that have more

[3]Argentina, Brazil, Bulgaria, Chile, Colombia, the Czech Republic, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, the Philippines, Poland, Romania, Russia, South Africa, Thailand, and Turkey.

equity external liabilities and LC external debts seem to be more sensitive to global financial shocks.

2.1 Empirical Strategies

Broadly speaking, the main purpose of the analysis is to identify the kind of fundamentals that are related to higher sensitivity to risk-appetite shocks so that the information can be used to deduce specific channels of the transmission to EMEs. In particular, I examine which types of external liabilities—equities, LC debts, and FC debts— are associated with higher sensitivities to the global financial shocks. For this purpose, I need a measure for sensitivity and another measure for risk-appetite shocks. For the latter, I can conveniently use VIX as a measure of it.[4] Therefore, a rise in VIX indicates a lower risk appetite (risk-off), and naturally, a fall in VIX indicates a higher risk appetite (risk-on). Henceforth, I use risk-on/off shocks for shocks to the risk appetite of global investors, as the terminology is widely used by market participants and commentators. As measures of sensitivity to those shocks, I can use different variables: financial market prices such as stock indices or exchange rates, quantities in credit markets such as credit growth, or real economy variables like GDP growth. Although none of these is perfect, I decide to use monthly percentage changes in financial market prices—stock indices and exchange rates (against the U.S. dollar)—due to the following considerations. The credit growth or real variables will adjust to global financial cycle with lags, and the lags will differ among EMEs, which forces me to avoid a simple and tractable approach. Similarly, by taking responses of financial market prices in a relatively short run (a month), the estimation suffers less from possible various endogeneities. For example, in a longer-horizon policy authorities in EMEs that experienced bigger market falls take

[4] Another alternative is the U.S. monetary policy shocks, the same as Miranda-Agrippino and Rey (2020), which are widely used in many empirical studies. Unlike Miranda-Agrippino and Rey (2020), the sample in the regression analysis in this paper only includes relatively small EMEs. That is, VIX in the sample period, 2012–18, is mostly exogeneous to EMEs, and thus it might be better to use VIX without endogeneity concerns. In unreported results, I replaced VIX with the U.S. monetary policy shocks. However, the U.S. monetary policy shocks lost their statistical significance when I put the shocks with other global factors in some of the regressions.

actions to boost the markets.[5] Hence, using monthly data is a way to decrease the possible different endogeneities and also avoid the noise of daily or weekly data.

I also need to choose the sample period in the regression analysis. I take a relatively short sample period, January 2012–December 2018, for two reasons. First, data availability obviously prevents extending the sample to a period before 2012, as the LC debt data from national sources are available only after 2012 in some EMEs, such as Chile. Second, the LC debt data has been stable since the early 2010s, while LC debt in the EMEs rapidly increased in the early 2010s and the LC equity liabilities steadily increased during the 2000s. By taking the short sample period, I can avoid possible bias caused by the trends in the data.

Another challenge is that the data on external liabilities have a low frequency. While the IIP from IMF and some of the LC debt and equity are quarterly or even monthly, LC debt data in some EMEs are annual. Furthermore, sectoral-level FC deposits and loans, which are used in the regressions in Online Appendix I, are annual in all the EMEs. (The online appendices are available at http://www.ijcb.org.) Since the main purpose of the regression is to identify different responses to a common risk-on/off shock among the EMEs, I take the value at the end of the last year of each observation for all different types of external liabilities: LC bonds, equity, net FC debts, and so on, with the exception of reserves, for which I have monthly data for all the sample EMEs. Therefore, for example, in the monthly data, FC debts from January 2012 to December 2012 are the same as the value of the FC debts at the end of 2011, as a ratio of GDP in 2011. I take the lagged values to decrease the concerns about possible endogeneity, akin to the Bartik instrument.

This is still somewhat unsatisfactory. However, if different frequencies are used for different types of external liabilities in different EMEs, that might cause a bias toward certain EMEs or certain types of external liabilities. Therefore, taking the annual data is inevitable and is the best way to exploit all the available information, while

[5]Another important benefit of monthly data is the number of observations. These data on LC external debt have a relatively short time span (from 2012 to 2018), and hence, using monthly data on stock indices and exchange rates has the advantage of providing more observations.

also avoiding arbitrary data manipulation. In addition, the external liabilities are stocks, not flows; hence they cannot change drastically in a month.

As a result, the regression is as in Equation (1).[6]

$$y_t^j = \alpha^j + \rho y_{t-1}^j + \delta_0 vix_t + \delta_1 ln\left(VIX_{t-1}\right) + \beta' \left(\Lambda_{EOY_{-1}}^j * vix_t\right) \\ + \Gamma_0' \Lambda_{EOY_{-1}}^j + \Gamma_1' \chi_t^j + \xi_0 \Delta p_t^c + \xi_1' I_G \cdot \Delta p_t^o + \epsilon_t^j, \quad (1)$$

where y_t^j represents the percentage changes in the nominal bilateral exchange rates of country j (against the U.S. dollar) for the exchange rate regression,[7] denoted by ΔEx_t^j, and the percentage changes in the stock index in country j, denoted by $\Delta Stock_t^j$, for the stock index regression. $\Lambda_{EOY_{-1}}^j$ is the key variable in this regression equation: a vector of different types of ratios of external liabilities and assets to GDP, including LC equities-to-GDP ratio, and similarly for LC debts, FC debts, official reserves, and external assets in the private sector. The subscript EOY_{-1} indicates the values at the end of the last year of each observation, as I explained above. For other terms, vix_t = log-difference of VIX, χ_t^j = the vector of controls, Δp_t^c = log-difference of commodity price index, Δp_t^o = log-difference of oil price index, and I_G = oil net export dummies. I divide the 20 EMEs into three different groups according to the amounts of net oil exports as a proportion of GDP. The list of countries in each of the groups is relegated to Online Appendix D. The global factor variables, VIX variables, and commodity price index will be dropped in regressions with time fixed effects. I used Driscoll-Kraay standard errors to handle cross-country dependence and heteroskedasticity. The results introduced below are robust to different methodologies to control heteroskedastic standard errors.[8]

[6]I also borrow some features from Aizenman, Binchi, and Hutchison (2016), Eichengreen and Gupta (2014), and Rey (2013).

[7]Hence, the higher exchange rate indicates a depreciation of the currency of country j.

[8]The set of controls includes inflation, industrial production, monetary aggregates, short-term interest rates of country j, the short-term interest rate differential between country j and the United States, and the lag of real effective exchange rate. The regression equation also includes the lagged log-level of VIX to control additional effects from the global risk appetite, which is probably not

2.2 Results

I first introduce the results of the exchange rate regressions in Table 1. For brevity, I display only the estimated coefficients of the key variables. The results for other control variables are relegated to Online Appendix D. I denote LC debts, LC bonds, LC equities, FC debts, FC assets of debt instruments, and FC assets of equities by LCD, LCB, LCE, FCD, FCA_D, and FCA_E, respectively.

Surprisingly, it turns out that LC-denominated debts are highly associated with higher sensitivities of exchange rates to the risk-appetite shocks, and results are much stronger once I replace LC debts with LC bonds; I extract LC deposits and LC loans from LC debts. On the contrary, FC debts are insignificant: there is no clear relationship between the amounts of FC debts and the measured sensitivities of a currency to the risk-appetite shocks. Regarding the asset sides, external assets in the private sector are mostly insignificant, while central bank international reserves are significant. The results of international reserves indicate that higher central bank international reserve-to-GDP ratios are associated with less sensitivity of exchange rates to global financial shocks.[9]

Next, I introduce the results of the monthly stock index regressions in Table 2. All the measures of GDP ratios—each type of liability-to-GDP ratio— turn out to be insignificant. In contrast to the GDP ratios, the LC equity external liabilities to total stock market capitalization ratios (i.e., foreign portfolio investor shares in domestic equity markets) are negative and all significant at least the 10 percent level. That is, when the share of foreign portfolio investors in the stock market is higher, the stock market is more sensitive to

fully captured by the log-difference of VIX. The inclusion of the lagged level of the global risk-appetite variable or global liquidity variable is common in exchange rate analysis such as Engel and Wu (2018) and Rey (2013). In addition, I added other global factor variables such as the log-differenced industrial production index of the U.S. and the global economy. Most of the variables turn out to be insignificant, and the inclusion/exclusion of the variables does not significantly change the results.

[9]While this can be interpreted as indicating either the more active foreign exchange intervention by central banks with more international reserves or the positive signaling effects from more international reserve holdings, the exchange rate stabilizing effects of international reserves or foreign exchange intervention are in line with the evidence from recent papers, such as Devereux and Wu (2022) or Fanelli and Straub (2021).

Table 1. Exchange Rate Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
vix_t	0.037***	0.036***	0.035***	0.034***	0.031**	0.034***		
	(0.012)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)		
$(FCD/GDP)^j_{EOY-1} \times vix_t$	0.015				0.015		0.019	
	(0.030)				(0.031)		(0.036)	
$(LCE/GDP)^j_{EOY-1} \times vix_t$		0.034						
		(0.031)						
$(LCD/GDP)^j_{EOY-1} \times vix_t$			0.075**					
			(0.030)					
$(LCB/GDP)^j_{EOY-1} \times vix_t$				0.103**	0.100**	0.102**	0.112**	0.115**
				(0.050)	(0.050)	(0.050)	(0.051)	(0.052)
$(NFCD/GDP)^j_{EOY-1} \times vix_t$						–0.004		–0.002
						(0.022)		(0.027)
$(Reserve/GDP)^j_{EOY-1} \times vix_t$	–0.052**	–0.048**	–0.057**	–0.052**	–0.058**	–0.052**	–0.052*	–0.043*
	(0.023)	(0.023)	(0.022)	(0.024)	(0.025)	(0.023)	(0.029)	(0.025)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	No	No	Yes	Yes
# of Obs.	1,660	1,660	1,615	1,615	1,615	1,615	1,615	1,615
R-squared	0.229	0.230	0.234	0.232	0.233	0.232	0.099	0.099

Note: vix_t is log-difference of VIX_t. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$, $^{\dagger}p < 0.15$. LCD: local currency debt, LCB: local currency bond, LCE: local currency equity, FCD: foreign currency debt, FCD_A: foreign currency external debt assets (debt instruments), and FEC_A: foreign currency equity assets. NFCD: net foreign currency debt assets. EOY_{-1} indicates the value at the end of last year of time t. Standard errors are Driscoll-Kraay standard errors.

Table 2. Stock Index Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
vix_t	–0.082***	–0.069***	–0.073***	–0.071***	–0.068***			
	(0.015)	(0.016)	(0.016)	(0.016)	(0.017)			
$(FCD/GDP)^j_{EOY-1} \times vix_t$	0.015		0.023	0.026		0.028	0.030	
	(0.028)		(0.028)	(0.027)		(0.029)	(0.028)	
$(LCE/Mkt\ Cap)^j_{EOY-1} \times vix_t$		–0.063**	–0.066**	–0.074*	–0.071*	–0.064*	–0.075*	–0.069*
		(0.032)	(0.032)	(0.039)	(0.039)	(0.037)	(0.041)	(0.040)
$(LCB/GDP)^j_{EOY-1} \times vix_t$				0.032	0.034		0.051	0.052
				(0.090)	(0.091)		(0.099)	(0.100)
$(NFCD/GDP)^j_{EOY-1} \times vix_t$					–0.005			0.001
					(0.032)			(0.034)
$(Reserve/GDP)^j_{t-1} \times vix_t$	0.062**	0.086***	0.076***	0.063***	0.074***	0.055**	0.044†	0.057**
	(0.025)	(0.019)	(0.022)	(0.021)	(0.018)	(0.025)	(0.027)	(0.025)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	No	Yes	Yes	Yes
# of Obs.	1,660	1,660	1,660	1,615	1,615	1,660	1,615	1,615
R-squared	0.107	0.116	0.114	0.102	0.090	0.017	0.019	0.020

Note: vix_t is log-difference of VIX_t. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$, $^\dagger p < 0.15$. LCD: local currency debt, LCB: local currency bond, LCE: local currency equity, FCD: foreign currency debt, FCD_A: foreign currency external debt assets (debt instruments), and FEC_A: foreign currency equity assets. NFCD: net foreign currency debt assets. EOY_{-1} indicates the value at the end of last year of time t. Standard errors are Driscoll-Kraay standard errors.

global financial shocks. As with the exchange rate regressions, FC debts and assets are insignificant in all the specifications. Higher international reserve-to-GDP ratios are associated with lower stock market sensitivity to global financial shocks, similar to the exchange rate regressions.

Broadly speaking, the empirical results show that LC debts and equity external liabilities are associated with higher sensitivities of financial market variables to global financial shocks. The results in the tables are highly unexpected. It is straightforward that LC-denominated bonds or equities have some risk-sharing properties. For example, if any negative shock to a small open economy results in the depreciation of the local currency, then the depreciation will reduce the real debt burden, thereby limiting the local currency depreciation. Hence, the standard model predicts that we may see even negative coefficients for LC debt (or bonds), or smaller and less significant coefficients in terms of absolute value when compared with FC debts.[10] Similar reasoning can be applied to equity external liabilities. Although the results might be opposite to the standard model, they align with some preceding papers.[11] In particular, the results of the exchange rate regressions are in line with Bertaut, Bruno, and Shin (2021) in that the paper also shows the fragility of EMEs borrowing abroad in their own local currencies.

Another noteworthy result in the regression is that the FC debts or net FC debts turn out to be insignificant factors in financial market sensitivity to global financial shocks.[12] This might be related to the fact documented at the beginning of this section: in many EMEs, the financial corporate sectors have balanced foreign

[10]For the related mechanisms, see Fanelli (2019).

[11]Eichengreen and Gupta (2014) documented that EMEs with higher ratios of stock market capitalization to GDP or more open capital markets suffered more from the taper tantrum shock, and Aizenman, Binchi, and Hutchison (2016) also reported similar results. Their results can be in line with the stock index regressions in this paper if larger capital markets and higher capital market openness are positively correlated with higher foreign investor shares in their stock markets.

[12]Many preceding papers documented no clear relation between FC external debts and fragilities to external shocks. For example, Dedola, Rivolta, and Stracca (2017) showed that there there is no clear-cut relation between country responses and likely relevant country characteristics, including U.S. dollar exposures. Aizenman, Binchi, and Hutchison (2016) and Eichengreen and Gupta (2014) reported similar results.

currency assets and debts (squared-off in foreign currency), whereas the non-financial corporate sectors have sizable net foreign currency debts (net short in foreign currency). Thus, it is desirable to investigate how the non-financial corporate sector net FC debts are related to the financial market sensitivities to global financial shocks. As noted below, I tested the relationship and found it is not statistically significant. One possible interpretation of the results is the following: obviously, many of the non-financial corporations in EMEs are exporters, and the prices of the exported goods are denominated in key currencies such as U.S. dollar, while many of their costs, like wages, are denominated in the LC. Then LC depreciation can boost the profitability of exporters since the revenues from exports in LC increase, whereas costs are given. If FC debts are positively associated with benefits to exporters from LC depreciation, higher net FC debts of non-financial corporate sectors do not necessarily lead to higher fragility.[13] I formalized the idea in a simple model in Online Appendix G.

2.2.1 Robustness Checks

All robustness check results are relegated to the online appendix. In the regressions conducted above, foreign currency assets and liabilities are measured on the aggregate level. In Online Appendix I, I replace the aggregate-level data with sectoral-level currency mismatches. I add net FC debts of the four different sectors—households, deposit-taking financial corporate sector (banks), non-financial corporate sector, and government. Overall, the results are much the same as the regressions of the aggregate currency mismatch.

I also conducted various robustness checks. I added more control variables or took the annual average of the different types of external liabilities. More importantly, I checked whether the results are robust to other measures of fragility: government debts, trade openness, financial openness, and others. All the different trials show similar results with the baseline estimation. The results can be found in Online Appendix K.

[13] Jiao, Kwon, and Roh (2021) documented that firms with higher export shares tend to have more foreign currency debts in Korea. Dalgic (2020) documented similar empirical findings from the firm-level data from Turkey.

One possible interpretation of the results is that some EMEs issue more LC-denominated securities to foreign investors because the EMEs are more sensitive to global financial shocks. The idea follows from a typical risk-sharing argument. That is, an EME whose business cycles follow the global financial cycle is incentivized to issue more equities or LC debts to global investors, as both equity and LC debt have properties that payments to foreign investors are procyclical to global financial cycle. However, the argument simply does not hold if the global investors are risk averse: global financial shocks must be their own risk to global investors. Moreover, the historical evidence does not seem to support the risk-sharing argument. For more discussion, I refer interested readers to Online Appendix H.

3. Model

Having documented that the local currency liabilities are associated with higher fragilities to the risk-appetite shocks in opposition to conventional wisdom, I now suggest a model to reveal the mechanisms by which risk-appetite shocks to global investors result in large fluctuations in financial markets and the real economy in EMEs, through equity external liabilities and LC debts. Before deploying the model for quantitative analysis in the next section, I illustrate how the model can capture the uncovered empirical regularities in the regressions, and, in addition, how the impact on the financial markets propagates into the real economy in the model.

For simplicity, I abstract from several important features relevant to the analysis of business cycles in EMEs or small open economies.

3.1 Environments

The model has three main features: (i) a capital market where producers issue securities that are claims on the capital, and the securities are purchased by other agents; (ii) leverage constraints on domestic banks; and (iii) global investors who invest in (LC-denominated) domestic capital markets and government bonds. The model is a small open-economy model in discrete time with an infinite horizon.

There are seven types of agents in the model: workers, goods producers, capital producers, domestic banks, the government, monetary authority, and global (foreign) investors. Workers supply labor to goods producers and save by making deposits in domestic banks. Goods producers produce goods to be used for consumption or investment domestically or exported abroad, and they issue securities that are claims on capital. The securities must be purchased by either domestic banks or global investors. Capital producers supply (or disinvest) capital depending on the demand from goods producers. Domestic banks finance through both deposits from workers and foreign currency debts borrowed from foreign investors, and supply funds to goods producers and the government, buying the securities issued by the producers and the government. The government provides fixed amounts of public services and, to fund the activities, collects taxes or issues government bonds. The monetary authority sets an interest rate to stabilize inflation. Global investors invest in the securities or government bonds.

For some of the specifications and notations, I follow the influential paper by Aoki, Benigno, and Kiyotaki (2018). I denote all the price variables in real term. All the prices of the securities are in the unit of domestic consumption goods.

3.1.1 Households

The representative household consists of a continuum of bankers and workers with the total population size being normalized to be unity. Each banker member manages a bank (financial intermediary) until he/she retires with a probability $1-\sigma$. Retired bankers transfer their remaining net worth as dividends to the household and are replaced by a given number of workers who become new bankers. New bankers receive ξ fraction of the total assets from the household as startup funds. Bankers will be described in detail later.

Workers in the model consume both domestic and imported goods, and supply labor. The optimization problem of the representative households is

$$\max_{\left\{C_t^d, C_t^m, L_t\right\}_{t=0}^{\infty}} \mathbb{E}_0\left[\sum_{t=0}^{\infty} \beta^t U\left(C_t^d, C_t^m, L_t\right)\right]$$

$$\textit{subject to } \; C_t^d + \varepsilon_t C_t^m + d_t + \tau_t \leq w_t L_t + R_t d_{t-1} + \pi_t,$$

where C_t^d is the domestic consumption good, C_t^m is the imported consumption good, τ_t is the tax payments, L_t is the labor supply, π_t is the profits transferred from retired banks and goods produces, and d_t is deposits made at time t. R_t are the interest rate on the deposits, from date $t-1$ to date t. w_t and ε_t are the real wage and the price of imported goods in terms of domestic goods, respectively. I find it is convenient to take ε_t as a proxy for real exchange rates, whose changes are qualitatively the same as the terms of trade, as I implicitly assume that the foreign price is fixed to 1. Moreover, it is even quantitatively similar to the true real exchange rate as long as the weight of the imported goods is relatively small. Henceforth, I call ε_t the real exchange rate.

Now the per-period utility function of the consumption is given by

$$U\left(C_t^d, C_t^m\right) = ln\left(H\left(C_t^d, C_t^m\right)\right) - \frac{1}{1+\zeta} L_t^{1+\zeta},$$

where $H\left(C_t^d, C_t^m\right)$ is the constant elasticity of substitution (CES) composite.

$$H\left(C_t^d, C_t^m\right) = \left(\omega\left(C_t^d\right)^{\frac{\mu-1}{\mu}} + (1-\omega)\left(C_t^m\right)^{\frac{\mu-1}{\mu}}\right)^{\frac{\mu}{\mu-1}}$$

ω controls the share of imports in consumption, while μ is the elasticity between domestic goods and imported goods.

The optimality conditions of the household—the labor-leisure condition, the intertemporal and intra Euler equation—follow the standards in the literature.

$$w_t U_{C_{t+1}^d} = L_t^{\zeta} \tag{2}$$

$$\mathbb{E}_t\left[\beta \frac{U_{C_{t+1}^d}}{U_{C_t^d}} R_{t+1}\right] = 1 \tag{3}$$

$$U_{C_t^d} = \varepsilon_t^{-1} U_{C_t^m}, \tag{4}$$

where V_x denotes the partial derivative of the generic function V with respect to a variable x.

3.1.2 Goods Producers

Following the standard in the literature, final goods are produced by the retailer under perfect competition, and each of the differentiated intermediate goods is produced by an exclusive producer under monopolistic competition. The producers use Cobb-Douglas technology. The producers use imported intermediated inputs. Let $k_{i,t-1}$, $m_{i,t}$, and $l_{i,t}$ be the capital, intermediate goods, and labor used by firm i at time t, respectively. Then the production function is

$$y_{i,t} = A_t \left(\frac{k_{i,t-1}}{\alpha_k} \right)^{\alpha_k} \left(\frac{m_{i,t}}{\alpha_m} \right)^{\alpha,m} \left(\frac{l_{i,t}}{1 - \alpha_k - \alpha_m} \right)^{1-\alpha_k-\alpha_m},$$

where α_k, α_m and $\alpha_k + \alpha_m \in (0, 1)$. A_t is a total factor productivity (TFP) in this economy and follows an AR(1) process.

I introduce Calvo-type nominal rigidity. In each period, a producer can adjust her price with probability $1 - \kappa$. Accordingly, each producer chooses the reset price P_t^* to maximize expected discounted profits subject to the restriction on the adjustment frequency. As is the standard in the literature, the first-order condition is given by

$$\mathbb{E}_t \left[\left\{ \sum_{j=0}^{\infty} \kappa^j \Lambda_{t,t+j} \left(\frac{P_t^*}{P_{t+j}} - \frac{\eta}{\eta - 1} mc_t \right) y_{i,t+j} \right\} \right] = 0, \tag{5}$$

where $\Lambda_{t,t+j}$ is the stochastic discount factor of the representative households, and mc_t is the real marginal cost. The real marginal cost is a result of the cost-minimization problem and is formulated as follows:

$$mc_t = \frac{1}{A_t} z_t^{\alpha_k} \varepsilon_t^{\alpha_m} w_t^{1-\alpha_k-\alpha_m},$$

where z_t is the rental cost of capital.

From the law of large numbers, the aggregate price level is characterized as follows:

$$P_t = \left[(1 - \eta) \left(P_t^* \right)^{1-\eta} + \eta \left(P_{t-1} \right)^{1-\eta} \right]^{\frac{1}{1-\eta}}. \tag{6}$$

3.1.3 Capital Producers

I used the adjustment cost by which the investment cost varies with the investment growth. Denoting the investment by I_t, the objective of the capital producer is

$$\max_{\{I_t\}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \Lambda_{0,t} \left(Q_t I_t - e^{\varsigma_t} \left(1 + \Phi \left(\frac{I_t}{I_{t-1}} \right) \right) I_t \right) \right]$$

with

$$\Phi \left(\frac{I_t}{I_{t-1}} \right) = \frac{\varphi}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2,$$

where Q_t is the price of capital, Tobin's Q, and ς_t captures the investment shock, and it follows an AR(1) process.

The optimality condition of the capital producer is as follows:

$$Q_t = 1 + e^{\varsigma_t} \Phi \left(\frac{I_t}{I_{t-1}} \right) + e^{\varsigma_t} \frac{I_t}{I_{t-1}} \Phi' \left(\frac{I_t}{I_{t-1}} \right) - \mathbb{E}_t \left[\Lambda_{t,t+1} e^{\varsigma_{t+1}} \left(\frac{I_{t+1}}{I_t} \right)^2 \Phi' \left(\frac{I_{t+1}}{I_t} \right) \right]. \tag{7}$$

3.1.4 Long-Term Bond

To account for the impact of sell-offs by global investors in bond markets in EMEs, I model the government bonds as perpetual bonds.[14] I mostly follow the specification in Gertler and Karadi (2013). The perpetual bond pays one unit of domestic consumption goods every period. Denoting the real bonds price by q_t, the return to the bonds including the capital gains/losses is

$$R^b_{t+1} = \frac{1 + q_{t+1}}{q_t}.$$

Therefore, bond investment is risky, as its return changes along with the bond price in the next period, q_{t+1}.

[14]The perpetual bond here is an inflation-adjusted bond, like TIPs (Treasury inflation-protected securities) in the United States. I can model it as nominal perpetual bonds. However, whether the bond strips are nominal or real does not meaningfully alter the quantitative results.

3.1.5 Domestic Banks

Domestic financial intermediaries purchase capital or government bonds and finance the investments through deposits from households, foreign borrowings, and their net worth. They face a leverage constraint, which is a function of profitability in the future, as in Aoki, Benigno, and Kiyotaki (2018) and Gertler and Kiyotaki (2010).[15]

Therefore, the balance sheet of a typical bank is

$$Q_t k_t^d + q_t b_t^d = d_t + \varepsilon_t d_t^* + n_t, \tag{8}$$

where k_t^d and q_t^d represent the capital and the bonds held by the domestic bank, d_t and d_t^* represent the deposit and the foreign borrowing, and n_t denotes the net worth of the bank.

Accordingly, the evolution of the net worth of a bank is

$$\begin{aligned} n_t = {} & (z_t + Q_t)\, k_{t-1}^d + R_t^b q_{t-1} b_{t-1}^d - R_t d_{t-1} \\ & - \varepsilon_t R_t^* d_{t-1}^* - \Theta\left(x_t^2, D_t\right), \end{aligned} \tag{9}$$

where $\Theta\left(x_t^2, D_t\right) = \frac{\zeta_d}{2} x_t^2 D_t$ and $x_t = \frac{\varepsilon_t d_t^*}{d_t + \varepsilon_t d_t^*}$, the ratio of FC debt to total debt and thus, $\Theta\left(x_t^2, D_t\right)$ is the management cost of the FC debt, following Aoki, Benigno, and Kiyotaki (2018).

The evolution of the net worth with the exit of incumbent bankers and the entry of new bankers is[16]

$$\begin{aligned} N_t = {} & (\sigma + \xi)\left((z_t + Q_t)\, k_{t-1}^d + R_t^b q_{t-1} b_{t-1}^d\right) \\ & - \sigma\left(R_t d_{t-1} + \varepsilon_t R_t^* d_{t-1}^* + \Theta\left(x_t^2, D_t\right)\right). \end{aligned}$$

[15] I adopt the leverage constraint in Gertler and Kiyotaki (2010) which is widely used in the literature. However, regardless of the specification of leverage constraint, as long as the banks in the model are leverage constrained, the qualitative results should be the same. Another possible approach is to impose a value-at-risk (VaR) constraint on financial intermediaries, as the global investors in this paper. Adrian and Shin (2014) and Nuño and Thomas (2017) model the banks facing a form of VaR constraint.

[16] For convenience, I include the bonds, $R_t^b q_{t-1} b_{t-1}^d$, in the startup funds. We can think of the startup funds as a fraction of the total amount of financial assets held by domestic agents.

The key idea in Gertler and Kiyotaki (2010) is that the continuation value should be larger than the fraction of the total assets that the banks can divert. The continuation value is defined as the sum of present values of future dividends as

$$V_t = \mathbb{E}_t \left[\sum_{j=1}^{\infty} \Lambda_{t,t+j} (1-\sigma) \sigma^{j-1} n_{t+j} \right].$$

The continuation value can be reformulated in a recursive form as

$$V_t = \mathbb{E}_t \left[\Lambda_{t,t+1} \left[(1-\sigma) n_{t+1} + \sigma V_{t+1} \right] \right]. \tag{10}$$

The leverage constraint arises due to the following moral hazard problem. After raising funds, the banks can decide whether to operate honestly or divert assets for personal use. Specifically, the banker can divert a θ fraction of the total capital and a fraction $\triangle\theta$ of the government bonds. Government bonds are more transparent and have better legal protections, and hence harder to divert. Thus, $\triangle \in (0, 1)$.

The continuation value, V_t, must be no less than the gains from diverting the funds for the banks to raise outside financing. If the continuation value is less than the gain from diverting funds, the banks are incentivized to divert the funds and, accordingly, no investors are willing to lend to the banks. Therefore, the following incentive constraint must be satisfied:

$$V_t \geq \theta Q_t k_t^d + \Delta \theta b_t^d. \tag{11}$$

The optimization of the banks is to maximize (10) subject to (9) and (11). Since the solution to the maximization problem is well known, I introduce the solutions of the banks as follows. Let ϕ_t be the leverage ratio of domestic banks for the capital investments, and assume that the incentive constraint always binds.

$$\phi_t = \frac{E_t \Lambda_{t,t+1} \Omega_{t,t+1} R_{t+1}}{\theta - E_t \Lambda_{t,t+1} \Omega_{t,t+1} \left(R_{t+1}^k - R_{t+1} \right)} \tag{12}$$

$$E_t \Lambda_{t,t+1} \Omega_{t,t+1} \left(R_{t+1}^k - R_{t+1} \right) \Delta = E_t \Lambda_{t,t+1} \Omega_{t,t+1} \left(R_{t+1}^b - R_{t+1} \right), \tag{13}$$

where $R^k_{t+1} = \frac{z_{t+1}+(1-\delta)Q_{t+1}}{Q_t}$ and $\Omega_{t,t+1}$ reflects the shadow value of one unit of net worth to the bank in each state at time $t+1$. Hence, $\Lambda_{t,t+1}\Omega_{t,t+1}$ is the stochastic discount factor of the banks.

In the equilibrium, the marginal cost of the FC debt, the expected interest rates on FC debts in the unit of LC, and the adjustment cost, discounted by the stochastic discount factors of the banks, must be the same as the interest rates on the deposits. The optimization of the bank characterizes the FC debt as follows:

$$d^*_t = D_t \frac{\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t,t+1}\left(R_{t+1} - \frac{\varepsilon_{t+1}}{\varepsilon_t} R^*_{t+1}(v_t)\right)\right]}{\psi\varepsilon_t}. \tag{14}$$

$R^*_{t+1}(v_t)$ is the borrowing rate on the FC debts of the domestic banks and D_t indicates the total amount of the borrowing of the bank. Rather than modeling the determination of the interest rate R^*_{t+1}, I assume that the interest rate will react to the risk appetite v_t. More specifically,

$$R^*_{t+1}(v_t) = 1 + r^* e^{\chi_d v_t}, \tag{15}$$

where $r^* e^{\chi_d v_t}$ is the time-varying net interest rate and $\chi_d \in (0, \infty)$. v_t follows an AR (1) process, and more description of v_t is provided below. We can think of the interest rate as the JP Morgan Emerging Market Bond Index (EMBI) spread in reality, which is strongly correlated with the VIX index; higher VIX is correlated with higher EMBI spreads.

The spread is of course endogenously determined in equilibrium. However, the endogenous determination of the interest rate is beyond the scope of this paper, and moreover, recent studies such as Morelli, Ottonello, and Perez (2022) showed that the interest rates on FC sovereign bonds of EMEs are heavily affected by bond demands from global banks. Thus, such a reduced-form approach is a way to include the necessary ingredients without setting up another optimization problem.

3.1.6 Global Investors

Global investors are international financial intermediaries who purchase LC-denominated equities and bonds in the small open economy. Like other components in the model, I model the global investors in a simple way but also aim to capture key features in reality. Since this paper studies the impacts of risk-appetite shocks on global investors, the global investors in the model need to be risk averse. While there are different ways to do this, I model global investors as international financial intermediaries under a "value-at-risk" (VaR) constraint, following Miranda-Agrippino and Rey (2020). The key idea in their model is that financial intermediaries are risk neutral in terms of their preference but act as if they are risk averse as they face a VaR constraint.

For the detailed steps of the derivation, I refer readers to Online Appendix B. Let k_t^f and b_t^f be the quantities of the capital and the local currency bonds held by global investors, and then p_t^k and p_t^b are the investments in the capital and local currency bond markets in EMEs, in the unit of FC. The investments of global investors in equities and LC bonds in the small open economy are characterized by the following equations:

$$p_t^k = Q_t k_t^f \varepsilon_t^{-1} = \frac{1}{\Gamma^k e^{v_t}} \left[\chi_k^0 + \chi_k^1 \mathbb{E}_{\mathrm{t}} \left[\frac{\varepsilon_t}{\varepsilon_{t+1}} R_{t+1}^k - R_{t+1}^m (v_t)\right]\right] \quad (16)$$

$$p_t^b = b_t^f \varepsilon_t^{-1} = \frac{1}{\Gamma^b e^{v_t}} \left[\chi_b^0 + \chi_{\mathrm{b}}^1 \mathbb{E}_{\mathrm{t}} \left[\frac{\varepsilon_t}{\varepsilon_{t+1}} R_{t+1}^b - R_{t+1}^m (v_t)\right]\right] \quad (17)$$

$$R_{t+1}^m (v_t) = 1 + r^m e^{\chi_{,m} v_t}, \quad (18)$$

where both χ_k^0 and $\chi_b^0 \in (0,1)$.[17] The terms in brackets, $\mathbb{E}_{\mathrm{t}} \left[\frac{\varepsilon_t}{\varepsilon_{t+1}} R_{t+1}^k - R_{t+1}^m (v_t)\right]$, are the expected excess returns to the investment in the assets in the small open economy, in which R_{t+1}^m is the return to the global market portfolio denominated in FC,[18] such as yields on BAA-grade corporate bonds in the United States,

[17]This is because χ_i^0 measures the share of the asset i in the portfolio of global investors.

[18]The characterizations in Equations (16) and (17) are identical to Gabaix and Maggiori (2015) if I let $\chi_i = 0$ and replace R^* with R^f, the return to the safe asset like the U.S. Treasury bills. Gabaix and Maggiori (2015) posit an investor who arbitrages between Japanese yen-denominated government bonds and U.S. dollar government bonds, while the investor in this model is arbitraging between different risky assets. Since the benchmark for the investors is a risky asset, the asset that the global investors in the model compare to the assets in the small open economy should be a risky asset.

and $\mathbb{E}_t\left[\frac{\varepsilon_t}{\varepsilon_{t+1}}R^k_{t+1}\right]$ and $\mathbb{E}_t\left[\frac{\varepsilon_t}{\varepsilon_{t+1}}R^b_{t+1}\right]$ are expected returns in FC to capital and LC bonds in the small open economy. The return to the global market portfolio R^m_{t+1} can, of course, react to the risk-appetite shocks, and thus, I let it be a function of the risk-appetite shocks. χ^0_i measures the stickiness in the global investors' portfolio: the amount that the global investors allocate to asset i, regardless of the changes in the return, due to risk management.[19]

The ratio $\frac{1}{\Gamma e^{v_t}}$ is a measure of the risk appetite of the investors. As expected, a lower $\frac{1}{\Gamma e^{v_t}}$ indicates lower risk appetite; i.e., higher Γe^{v_t} indicates a lower risk appetite. e^{v_t} captures the time-varying risk appetites of the investors. Thus, a positive shock to v_t means shrinking of the risk appetite, as VIX does so in reality. Therefore, v_t is an analogy to VIX. I assume v_t follows an AR(1) process:

$$v_t = \rho_v v_{t-1} + \nu_t, \tag{19}$$

where $\nu_t \sim N\left(0, \sigma^2_\nu\right)$ and $\rho_v \in (0, 1)$. Henceforth, I call $\nu_t > 0$ "risk-off" shock and $\nu_t < 0$ "risk-on" shock.

Adopting the interpretation in Miranda-Agrippino and Rey (2020), ν_t is modeled as shocks to the net worth of global investors, who are large international financial intermediaries. Of course, the driving force behind the changes in the risk appetite is not necessarily a shock to the capital of the global investors. For example, it can be some abrupt change in the beliefs of the investors. In the context of this paper, adopting a different microfoundation does not alter the specifications in this paper or any of the following economic interpretations.

To summarize the discussion, investments by global investors—equity and local currency bond capital flows into the small open economy—are determined by two factors: the expected excess return and the risk appetite.

[19]The forms in Equations (16) and (17) are approximations of the result of the optimal portfolio of global investors who want to maximize the Sharpe ratio of their portfolios. Then, it is intuitive that the investors allocate some of their funds to some assets despite low returns if the assets have good risk-hedging properties. Another possible interpretation is the constant term reflects some stickiness in the portfolio, due to some informational friction or gravity in capital flows.

3.1.7 Government

I abstract from the problem of the government and fiscal policy. The budget constraint of the government is

$$G = \tau_t + q_t B_t - R_t^b q_{t-1} B_{t-1}.$$

The government expenditure and the supply of government bonds are fixed at G and $\overline{B}$, respectively. Hence $B_t = \overline{B}$.

3.1.8 Exports

The trade literature comes to a consensus that exporters can set a different price in foreign markets (LCP) or the price of tradable goods are in general priced in key currencies like U.S. dollars (DCP).[20] Since the risk-on (off) shocks in this model cause LC appreciations (depreciations), it is important to model the export pricing in a realistic way to assess the quantitative impacts of the shocks on the small open economy.

For this purpose, I make an assumption about export pricing, following Wang (2018). I denote the export price in the foreign market by p_t^{ex}. Then p_t^{ex} is

$$p_t^{ex} = \left(\varepsilon_t^{-1}\right)^{\lambda} \left(p_t^{ex^*}\right)^{1-\lambda},$$

where $\lambda \in (0,1)$. If $\lambda = 1$, the export pricing follows a perfect producer currency pricing (PCP). In contrast, if $\lambda = 0$, it indicates a perfect DCP. Let $p_t^{ex^*}$ be the exogenously given price of the exports—for example, the price of competitors in foreign markets. Such a "reduced-form" approach to export pricing makes the model simple but also allows tractability. I can set a reasonable parameter value for λ reflecting empirical evidence.[21]

[20]See Betts and Devereux (2000) for LCP and Gopinath and Stein (2021) for DCP.

[21]A more sophisticated way of modeling the incomplete exchange rate pass-through is to assume the exporters can set up prices in foreign markets in FC, facing some nominal rigidity: just add another Phillips curve for exporters. This is obviously better microfounded, but I found that the more microfounded way shows worse performance than the "reduced form" used in this paper. More

Following Aoki, Benigno, and Kiyotaki (2018), exports are

$$EX_t = \left(p_t^{ex}\right)^{1-\gamma} Y_t^*, \tag{20}$$

where $\gamma > 1$ and $Y_t^* = \overline{Y}^* e^{T_t}$. T_t is an AR(1) process, which captures trade shocks, i.e., shocks to the demand for exported goods from the small open economy.

3.1.9 Monetary Authority

The monetary authority conducts policy using a nominal interest rates rule. The nominal rate i responds to the deviation of inflation from target, π_t relative to $\overline{\pi}$. In addition, I assume that the authority tends to avoid drastic changes in the nominal interest rate. As a result, the interest rate rule is

$$i_t = \overline{i} + (1 - \rho_i)\,\omega_\pi\,(\pi_t - 1) + \rho_i\left(i_{t-1} - \overline{i}\right) + m_t, \tag{21}$$

where $\rho_i \in (0, 1)$ and $\omega_\pi > 1$, and m_t is the monetary policy shock in this model.

3.1.10 Resource Constraint

Output is divided between consumption, investment, government consumption, exports, and FC debt management costs. The economy-wide resource constraint is thus given by

$$Y_t = C_t^d + e^{\varsigma_t}\left[1 + \Phi\left(\frac{I_t}{I_{t-1}}\right)\right] I_t + G + EX_t + \Theta\left(x_t^2, D_t\right), \tag{22}$$

where $Y_t = \left(\int_0^1 y_{i,t}^{\frac{\eta-1}{\eta}}\,di\right)^{\frac{\eta}{\eta-1}}$.

specifically, I let exporters have pricing power (in FC) in foreign markets here, facing Calvo-type nominal rigidity, and the calibrated model seems to underestimate the correlation between exports and export demand shocks. However, of course, the overall and the core quantitative results are mostly the same as the reduced-form approach, as reported in this section. I report the other results in Online Appendix J.

The GDP of this economy is the total output minus the imported intermediate inputs.

$$Y_t^{net} = Y_t - \varepsilon_t M_t, \tag{23}$$

where $M_t = \left(\int_0^1 m_{i,t}^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}}$.

3.2 Inspecting the Mechanism

In this subsection, I briefly describe the core mechanism in the model. I reveal the transmission channel, through which equity and local currency bond portfolio flows generate large fluctuations in financial markets and the real economy. The illustration of the transmission channel also shows how the model can generate comparative statics consistent with the regression coefficients in the empirical analysis. More formal propositions and the proofs of the propositions can be found in Online Appendix E.

For illustrative purposes, I abstract from the labor supply, imported intermediate goods, foreign currency debt, and nominal rigidity. In addition, the government bond is a one-period short-term bond and there is no friction when the domestic banks purchase the government bonds.[22] As a result, the government bond price is one ($q_t = 1$) and the return to the bonds are equivalent to the deposit rate ($R_t^b = R_t$). For tractability, I let λ be 0: hence, PCP in export pricing.

I make further simplifications regarding the capital market equilibrium. First, I use the simple quadratic form of the adjustment cost and set the capital depreciation rate δ to zero. Then the adjustment cost is

$$\Phi(I_t) = \frac{\varphi}{2} \left(\frac{I_t}{K_{t-1}} \right)^2 K_{t-1}.$$

Second, assume that the leverage ratio is constant. That is,

$$N_t \phi \geq Q_t k_t^d, \tag{24}$$

where $\phi \in (1, \infty)$.

[22] This is the case when Δ in Equation (13) converges to zero.

3.2.1 Impacts on the Capital Market (Capital Market Channel)

I illustrate the mechanism using an example of a risk-off shock.[23] I exclude FC debts from the model so that I can separately describe the channel by which capital flows disrupt the economy without currency mismatches.[24] I call this the "capital market channel."

Plugging the first-order condition of the capital producer into the market-clearing condition, I can solve for the equilibrium price of capital.

$$Q_t = \frac{(1-\varphi) + \sqrt{(1-\varphi)^2 + 4\varphi \frac{N_t \phi + p_t^k \varepsilon_t}{K_{t-1}}}}{2}, \tag{25}$$

where $N_t = \sigma\left((z_t + Q_t)\, k_{t-1}^d - R_t d_{t-1}\right) + \xi\,(z_t + Q_t)\, k_{t-1}^d$. Since the right-hand side (RHS) includes Q_t, the equilibrium capital price is the fixed point of Equation (25). Taking the derivative of Q_t with respect to ν_t, the risk-off shocks, give

$$\frac{\partial Q_t}{\partial \nu_t}\,|_{\varepsilon_t} = \underbrace{\left(\frac{\varepsilon_t}{\sqrt{\left(\frac{1-\varphi^{-1}}{K_{t-1}^{-1}}\right)^2 + 4\varphi \frac{N_t\phi + p_t^k \varepsilon_t}{K_{t-1}^{-1}}}} \frac{dp_t^k}{d\nu_t}\right)}_{\text{First Foreign Demand Shock}} \underbrace{\left(1 - \frac{(\sigma+\xi)\, k_{t-1}^d \phi}{\sqrt{\left(\frac{1-\varphi^{-1}}{K_{t-1}^{-1}}\right)^2 + 4\varphi \frac{N_t\phi + p_t^k \varepsilon_t}{K_{t-1}^{-1}}}}\right)^{-1}}_{\text{Second Fire Sale}} < 0 \tag{26}$$

when $\frac{dp_t^k}{d\nu_t} < 0$, as it commonly is.

To understand the mechanism, notice that there are two types of investors: domestic banks and global investors. Given other states,

[23] Qualitatively, the impacts of risk-on shocks are identical to risk-off shocks in the opposite direction since I assume the leverage constraint always binds. However, there could be significant differences between risk-off shocks and risk-on shocks in terms of quantitative effect due to the non-linearity of the leverage constraint. However, this paper does not aim at capturing such quantitative differences.

[24] Theoretical analysis of the transmission through foreign currency debt is introduced in Online Appendix F.

risk-off shocks drive down the demand for capital from global investors. For the price to be maintained, the other investor—domestic banks—should increase their demands, but that is not possible due to the leverage constraint. Hence, for the capital market to be cleared, the capital price must fall. This is the foreign demand shock in the first term in the RHS in Equation (26).

The lower capital price in turn hurts the balance sheet of the domestic banks. To see this, notice the numerator in the second term in the RHS of Equation (26) is

$$(\sigma + \xi)\, k^d_{t-1} = \frac{dN_t}{dQ_t}.$$

Thus, the term is the marginal impact of capital price changes on the net worth of the bank. The banks whose net worth is damaged are forced to deleverage, and therefore, the capital price falls even more, as revealed in the second term in the RHS of Equation (26). The negative effects of the risk-off shock are amplified through a form of fire-sale mechanism.[25]

The stock index regressions in the last sections showed that the marginal impacts of risk-on/off shocks on equity markets increase with the shares of foreign investors in the markets. This can be well understood in the context of the mechanism described here. Intuitively, risk-appetite shocks are the shocks to demand from global investors, and then, it is straightforward that the magnitude of the shocks depends on how large the demands from foreign parties are compared with those of domestic investors. When there are more domestic investors than foreign investors in the same market, it must be easier for domestic investors to absorb the sell-off from global investors. For more analytical analysis, I refer readers to Online Appendix E.

[25]The results are from the simplest form of leverage constraints. In Online Appendix E, I show that in the environment where the leverage ratio is a function of the profitability of the investments, risk-off shocks raise the leverage ratio, but the capital prices still fall during a risk-off event. Furthermore, if the shock is persistent enough—that is, ρ is large enough—then the fire-sale mechanism is preserved in the sense that the risk-off shocks lower the capital demands from domestic banks as well. I refer interested readers to the appendix for more details.

3.2.2 Impacts on the Foreign Exchange Market

Once global investors disposed of part of their positions in the capital market, the investors converted the proceeds to foreign currency and moved out the capital from the small open economy. Capital outflows from the small open economy depreciate the local currency. Below, the mechanism of the impacts on the exchange rate is more explicitly explained.

In the analysis of exchange rate, assume $\chi_i^0 = 0$ for simplicity. Of course, the qualitative results and the underlying intuition are not altered by the different assumptions. Recall $p_t^k = \frac{1}{\Gamma(\theta^i)e^{v_t}}\left[\mathbb{E}_{\mathrm{t}}\left[\frac{\varepsilon_t}{\varepsilon_{t+1}}R_{t+1}^k\right] - R_{t+1}^m\left(v_t\right)\right]$, as I assumed $\chi_k^0 = \chi_b^0 = 0$. I find it convenient to formulate p_t^k and p_t^b as follows:

$$p_t^i = \frac{1}{\Gamma^i e^{v_t}} S_t^i,$$

where $i \in (k, b)$ and $S_t^i = \mathbb{E}_{\mathrm{t}}\left[\frac{\varepsilon_t}{\varepsilon_{t+1}}R_{t+1}^i - R_{t+1}^m\right]$. Then $\frac{dp_t^k}{d\nu_t}$ is as follows:

$$\frac{dp_t^k}{d\nu_t} = -p_t^k + \frac{1}{\Gamma^k e^{v_t}}\left(\frac{dR_t^{k^*}}{d\nu_t} - \frac{dR_{t+1}^m}{d\nu_t}\right),$$

where $R_t^{k^*} = \frac{\varepsilon_t}{\varepsilon_{t+1}}R_{t+1}^k$ and see $\frac{dS_t^k}{d\nu_t} = \frac{dR_t^{k^*}}{d\nu_t} - \frac{dR_{t+1}^m}{d\nu_t}$.

From the foreign exchange market-clearing condition, I can derive the equilibrium exchange rate as follows:

$$\varepsilon_t = \left(\frac{\varepsilon_t C_t^m + R_t^k k_{t-1}^f + R_t^b b_{t-1}^f - \varepsilon_t\left[p_t^k + p_t^b\right]}{Y_t^*}\right)^{\frac{1}{\gamma}}. \quad (27)$$

Let $\eta_t^k = \frac{p_t^k}{Y_t^*}$, $\eta_t^b = \frac{p_t^b}{Y_t^*}$ and assume $\eta_{t-1}^k \approx \eta_t^k$. Then, taking a derivative of ε_t with respect to ν_t and a manipulation gives

$$\frac{d\varepsilon_t/d\nu_t}{\varepsilon_t} \approx \frac{Y_t^*\left[\left(1 - \frac{dS_t^b/d\nu_t}{S_t^b}\right)\eta_t^b + \left(1 - \frac{dS_t^k/d\nu_t}{S_t^k} + \frac{\varepsilon_{t-1}}{\varepsilon_t}\frac{dR_t^k}{d\nu_t}\right)\eta_t^k\right] + \frac{dC_t^m}{d\nu_t}}{Y_t^*\left(\gamma\varepsilon_t^{\gamma-1} + \eta_t^k + \eta_t^b\right) - C_t^m} > 0. \quad (28)$$

Note that here I take Q_t as a function of ν_t on purpose.[26] As explained, the mechanism behind this is straightforward. For the risk-off shock, capital outflows driven by the shock reduce FC liquidity in the foreign exchange market so that the price of the FC, the exchange rate, rises; the LC depreciates.

In Equation (28), Y_t^* is the base of foreign demands for exported goods from the small open economy. Given the same trade openness, Y_t^* proxies the size of the economy, GDP. η_t^k and η_t^b measure (or proxy) the equity external-liability-to-GDP ratio and the LC debts-to-GDP ratio, respectively. Now the equation shows why the coefficients of the LC debt-to-GDP ratio interaction terms are larger than the coefficients of the equity-to-GDP ratio interaction terms and the equity-to-GDP ratio interaction terms are not significant in the exchange rate regressions.

Notice that the "coefficient" in front of η_t^b, $1 - \frac{dS_t^b/d\nu_t}{S_t^b}$, is probably larger than the coefficient of η_t^k, $1 - \frac{dS_t^k/d\nu_t}{S_t^k} + \frac{\varepsilon_{t-1}}{\varepsilon_t}\frac{dR_t^k}{d\nu_t}$. First, capital price falls reduce capital outflows ($\frac{dR_t^k}{d\nu_t} < 0$). A lower capital price lowers the amount of capital outflows, reducing the LC depreciation due to the risk-off shock. Second, it is very likely to see $\frac{dS_t^k/d\nu_t}{S_t^k} > \frac{dS_t^b/d\nu_t}{S_t^b}$, as the increases in the return to the investments in the LC bond only come from LC depreciation, whereas the increases in the return to the capital come from both capital price falls and LC depreciation. This makes equity flows less sensitive to the risk-off shocks than LC bond flows. In other words, during a risk-off event, the LC bond portfolio investments outflow more than the equity (capital) portfolio investments.[27] Intuitively, capital price falls following the risk-off shocks gift the global investors a higher expected return on the investments in the capital, which incentivizes capital investors to stay in the market.[28]

[26] I can solve for $\frac{d\varepsilon_t}{d\nu_t}$ more explicitly and then I can easily show $\frac{d\varepsilon_t}{d\nu_t} > 0$ under some assumptions that I explicitly spell out in Online Appendix E. See the appendix for details.

[27] $\frac{dS_t^k/d\nu_t}{S_t^k}$ measures the marginal percentage changes in the excess return of the capital investment and equivalently for $\frac{dS_t^b/d\nu_t}{S_t^b}$.

[28] As a result, the "coefficient" in front of η_t^k is much smaller than η_t^b, and it can even be a negative number. Online Appendix E discusses the strict conditions to have the properties.

3.2.3 Impacts on the Real Economy

Of course, the impacts on financial markets propagate into the real economy. Thanks to the simple structure of the model, we can easily characterize the impacts on the real economy as follows:

$$\frac{dI_t}{d\nu_t} < 0 \quad \text{and} \quad \frac{d\,(NX_t)}{d\nu_t} > 0.$$

I_t and NX_t denote the capital investments and net exports, respectively. Thus, risk-off shocks lower investments and raise net exports.

The comparative statics captures typical reactions of small open economies to risk-appetite shocks: risk-off shocks result in falls in investments while raising net exports. In the case of risk-off shocks, weaker demand from global investors and idle financial intermediations by domestic banks due to lower asset prices altogether induce less funding from households and foreign investors to the domestic corporate sector, which subsequently diminishes investment by the corporations. The higher exchange rates elevate exports, while reducing imports through the "expenditure-switching effects."[29]

Another important observation in the comparative statics is that the risk-off shocks cause two opposing effects on GDP: it decreases investments (lower aggregate demand) and, at the same time, increases net exports (higher aggregate demand), limiting the impacts of risk-off shocks on GDP. GDP in this simple model is invariant to the risk-off shock because of the absence of nominal rigidity, but the two opposing effects become clearer in a model with nominal rigidity, as I will show in the next section. This mechanism echoes the findings in Blanchard et al. (2016) of two opposing effects from capital flows on a small open economy.[30]

[29] The relationship between exchange rates and net exports here is based on the assumption of producer currency pricing (PCP). However, the impact on net export above is driven by the equality between the capital account balance and the current account balance, $NX_t + CF_t = 0$. Fewer net capital inflows must be offset by more net exports.

[30] In fact, the model mechanism itself is similar to Blanchard et al. (2016) in that both my model and theirs assume imperfect substitutability between different assets and constrained foreign investors.

4. Quantitative Results

This section illustrates quantitative analysis using the dynamic stochastic general equilibrium (DSGE) model. The analysis provides the answer to the question, How much variation do global financial shocks generate in the financial markets and the real sector of the economy?

4.1 Calibration

I calibrate the model to the Korean economy because it is an ideal example in the context of the analysis in this paper, as most of the external liabilities in Korea are equities and LC bond portfolio investments.[31] To capture the short-run dynamics, I set one period to a quarter.

For most of the parameters in the model, I use standard values in the literature. For some parameters regarding trade openness or output-to-capital ratio, I calibrate the parameters to match the observed ratios in Korea during the sample period, from 2005 to 2019. The parameters I newly calibrated are the parameters about the global investors and global financial shocks, which are new components in this model.

4.1.1 Assigned Parameters

First, I explain the parameters I set externally. For those parameters, I mostly followed Akinci and Queralto (2019), Aoki, Benigno, and Kiyotaki (2018), Gertler and Karadi (2013), and a few others.

[31]The ratio of FC debt to GDP in Korea had been around 0.2 during the sample period. However, as I emphasized in the companion paper, Han (2022), the private sectors in Korea, similarly with many EMEs, have held substantial FC assets. The FC assets in the form of debt instruments, i.e., FC debt claims, except for the international reserves of Bank of Korea, have been more than the FC debts since 2015 and the net FC debt claims have been above –5 percent since 2013. Liquid FC assets, foreign currency debt claims and FC equities, have been more than FC debts since 2013. More importantly, I confirmed that most of large financial corporations and non-financial corporations in Korea have positive FC net debt claims or even in FC in the sense that their FC debts are matched with FC assets. Thus, there is no significant balance sheet effect of Korean won depreciation in Korea.

I set the discount factor, β, to be 0.9925 so that the annual interest rate is 3 percent. This corresponds to the discount rate used in Akinci and Queralto (2019) for their emerging market bloc in their two-country model. It also approximately matches the real interest rate in Korea before the global financial crisis in 2008. For the labor supply parameters, I set the Frisch elasticity to be 0.33 following Galí and Monacelli (2005); therefore, the inverse of the Frisch elasticity ζ is 3. The elasticity between domestic goods and imported goods is 2 ($\mu = 2$), as in Akinci and Queralto (2019). This is in the range of standard values in the literature. I set the parameter of imported goods $1 - \omega$ to 0.225. This value corresponds to the ratio of foreign goods and services consumption to GDP in Korea.[32]

On the production side, the capital share α_K and imported goods share α_M are 0.25 and 0.25, respectively. The elasticity of demand from the aggregator, η, is 9 following Aoki, Benigno, and Kiyotaki (2018). For the inverse elasticity of net investment to the capital price, capital depreciation rate, and Calvo parameter, I followed the standard values in the parameters. I set the investment adjustment cost parameter to be 2.85, following Akinci and Queralto (2019), which followed Justiniano, Primiceri, and Tambalotti (2010). This value is in the range of conventional values in the literature.

I set the elasticity of export demand, γ, to be 3. An important parameter is the exchange rate pass-through, λ. I use the value reported in Burstein and Gopinath (2014). The exchange rate pass-through from LC to U.S. dollar is 0.2. Reflecting the consensus that most tradable goods are denominated in U.S. dollars, I set λ to be 0.2.

For the parameters of the domestic bank, I mostly followed Aoki, Benigno, and Kiyotaki (2018) and Gertler and Karadi (2013). The bank survival rate σ and the fraction of total financial assets to new bankers ξ are set to 0.94 and 0.046, respectively, following Aoki, Benigno, and Kiyotaki (2018). The proportion of divertible capital to total capital, θ, is set to 0.34. This value is close to that

[32]The consumption of imported goods and services includes expenditures made abroad by residents in Korea, such as traveling abroad or tuition for students studying abroad.

of Gertler and Karadi (2013).[33] With those parameter values, the spread between the return to the capital and deposit rates in the deterministic steady state is very close to 0.02 annually. This is the target used in the calibration in Gertler and Karadi (2013) and Gertler and Kiyotaki (2010). In this paper, it is important to have realistic capital-to-GDP ratios in the model, as the impact of risk-on/off shocks depends on the foreign investors' share in the capital market. The capital-to-GDP (annual GDP) ratio in the steady state is close to 2 and that is close to the tangible-assets-to-GDP ratio in Korea, after excluding residential real estate. The parameter of the advantage of government bonds in terms of leverage, Δ, is set to 0.5, following Gertler and Karadi (2013). Marginal management cost for FC debt borrowing, ψ, is set to 0.110 to keep the FC debt-to-GDP ratio below 5 percent.[34]

Besides the global financial shocks, there are four exogenous shocks in the model: TFP shock, export shock, monetary policy shock, and investment shock. For both TFP and export shock, the autocorrelation parameter is set to 0.9, which lies in the range of the values used in the literature. I set the standard deviation of the TFP shock to be 0.002 and 0.0175 for the export shock. These volatilities of the TFP shock and export shock are calibrated to match the volatilities of GDP and exports of Korea in the sample period 2005–19. I choose the sample period 2005–19, as the foreign portfolio investment in domestic stock markets in Korea has been in the range of 25–28 percent of GDP since 2005. The standard deviation of monetary policy shock is 0.0005, so that the unexpected change in the policy rate is 0.2 percent annualized rate. The monetary policy shock is serially uncorrelated, as the shock will be persistent by the Taylor rule in Equation (21). The standard deviation of investment shock is 0.0105, which is set to capture the volatility of investment in Korea. The autocorrelation of the investment shocks is set to 0.72, following Justiniano, Primiceri, and Tambalotti (2010).

[33]In Aoki, Benigno, and Kiyotaki (2018), the proportion of divertable assets depends on the ratio of FC debts to total assets. However, I have no reasoning or empirical evidence to support it.

[34]Of course, it is to prevent the model Korean economy from having significant currency mismatches.

Table 3. Assigned Parameters

Parameter	Symbol	Value
Discount Factor	β	0.9925
Inverse Frisch Elasticity of Labor Supply	ζ	3.000
Trade Elasticity	μ	2.000
Share of Imported Goods	$1-\omega$	0.225
Capital Share	α_K	0.250
Imported Intermediate Goods Share	α_M	0.250
Elasticity of Demand from the Aggregator	η	9.000
Capital Depreciation Rate	δ	0.025
Inverse Elasticity of Net Investment to the Capital Price	φ	2.850
Probability of Keeping the Price Constant	κ	0.779
Government-Expenditure-to-GDP Ratio in Steady State	G/Y_{net}	0.200
Government-Bond-to-GDP Ratio in Steady State	qB/Y_{net}	0.450
Inflation Coefficient in the Taylor Rule	ω_π	1.500
Persistence Coefficient in the Taylor Rule	ρ_i	0.800
Elasticity of Export Demand	γ	3.000
Exchange Rate Pass-Through	λ	0.200
Fraction of Capital That Can Be Diverted	θ	0.340
Leverage Advantage in Seizure Rate of Government Bonds	Δ	0.500
Transfer to the Entering Bankers	ξ	0.046
Survival Rate of Bankers	σ	0.940
Management Cost for FC Debt	ψ	0.110
Autocorrelation of TFP Shock	ρ_a	0.900
Autocorrelation of Export Shock	ρ_{ex}	0.900
Autocorrelation of Investment Shock	ρ_I	0.720
Standard Deviation of TFP Shock	σ_a	0.002
Standard Deviation of Export Shock	σ_{ex}	0.0175
Standard Deviation of Monetary Policy Shock	σ_i	0.0005
Standard Deviation of Investment Shock	σ_I	0.0105

I set the parameters in the Taylor rule, following Aoki, Benigno, and Kiyotaki (2018). Regarding the government, I set the ratio of government expenditure to GDP and the ratio of government debt to GDP to be 0.20 and 0.45, respectively, the same as in Gertler and Karadi (2013). These ratios are also close to the observed ratios in Korea.[35] I summarize the assigned parameters in Table 3.

[35]The government debt-to-GDP ratios are higher than government debt-to-GDP ratios in Korea but are close once the monetary stabilization bonds issued by the central bank in Korea, Bank of Korea, are included.

Table 4. Estimated Parameters

Parameter	Symbol	Value	Target
Stickiness of Equity Portfolio Investments	$\frac{\chi_k^1}{\chi_k^0}$	4.621	g_{pk}
Stickiness of LC Bond Portfolio Investments	$\frac{\chi_b^1}{\chi_b^0}$	9.785	g_{pb}
Inverse of Funds Allocated to the Capital Market	Γ_k	0.033	LCE/Y_{net}
Inverse of Funds Allocated to the Bond Market	Γ_b	0.120	LCB/Y_{net}
Elasticity of Global Portfolio Return to Risk-on/off Shock	χ_m	2.010	BAA
Elasticity of Foreign Borrowing Rates to Risk-on/off Shock	χ_*	2.636	EMBI
Standard Deviation of Risk-on/off Shock	σ_v	0.055	σ_{K_f}
Autocorrelation of the Risk Appetite	ρ_v	0.880	ρ_{p_k}

4.1.2 Estimated Parameters

I need to estimate the parameters of the global investors and the related global financial shock. I need to calibrate the parameters in Equations (15), (16), (17), (18), and (19), and the results are reported in Table 4.

I let R^m and R^* be the five-year BAA corporate bond yields in the United States and the EMBI spreads. I estimate $\chi_{,m}$ and χ_d by regressing those interest rates on the CBOE VIX. I relegate details of the estimations to Online Appendix C. The estimated values of χ_m and χ_* are 2.010 and 2.636, respectively.[36] I use the values in quarterly data and also consider the standard deviations of VIX and global financial shock process in my model, which I describe below.

I estimate the parameters in Equations (16) and (17), using generalized method of moments (GMM). Notice that once I get the ratio of χ_j^0 to χ_j^1, I can easily compute Γ_j based on the observed ratios of equity liability to GDP and LC bond to GDP. The target moment in the GMM estimation is the growth of the portfolio investments. Estimated $\frac{\chi_k^1}{\chi_k^0}$ and $\frac{\chi_b^1}{\chi_b^0}$ are 4.621 and 9.785. These values reflect the

[36] The regression might suffer from autocorrelation in R_t and v_t. I discuss this issue in Online Appendix C and show that the results do not change much in another empirical identification, which is relatively free from the concern of autocorrelation.

fact that global investors do not strongly respond to the arbitrage opportunity; that is, they slowly adjust their portfolios.[37] Then, it is easy to compute Γ_k and Γ_b from the data. I set Γ_k and Γ_b to match the equity portfolio investment-to-GDP ratio (0.27, on average in 2012–18) and Korean won bond portfolio investment-to-GDP ratio (0.08, on average in 2012–18).[38]

In Miranda-Agrippino and Rey (2020), the autocorrelation of the estimated global financial cycle is 0.88. I followed them and set $\rho_v =$ 0.88. With $\rho_v =$ 0.88, the autocorrelation of the simulated equity portfolio investment p_k is 0.86, which is close to the data, 0.84. I set the standard deviation of the global financial shock σ_ν to be 0.055 so that the standard deviation of foreign portfolio capital holdings in the model roughly matches the standard deviation of equity holdings of foreign investors in the data, 0.075.

Except for the monetary policy shock, all the shocks are certainly correlated in reality. In particular, the risk-on/off shocks must be correlated with the export shocks, as the negative (positive) risk-appetite shocks are highly likely to negatively (positively) affect the global economy. Although the correlation between the risk-on/off shocks and the export shocks is not crucial in my analysis, I let the shocks be correlated, depending on the purpose of the model simulation. If the shocks are correlated, I set the correlation between global financial shocks and export demand shocks to be 0.50.

4.1.3 Selected Second Moments

Table 5 shows the comparison between the moments computed from the simulated data and the true data. When computing the correlations between the global financial cycle and the macroeconomic

[37] One interpretation of this result is that most of the non-resident portfolio investors are noisy traders in the sense that their investments are rather irrational, and rational investors under leverage constraints, such as global bankers in Gabaix and Maggiori (2015), are a minority in the market. Basu et al. (2020) introduced a model in which there are these two different types of investors, and the irrational investors strongly react to global financial shocks.

[38] This includes LC deposits, as the deposits are mostly held by foreign investors in the Korean won bond market. The reason I excluded them from the regressions is that in some countries, such as India, the deposits are mostly held by residents abroad who are actually citizens of the emerging market country.

Table 5. Selected Second Moments

	σ_C	σ_I	σ_{Ex}	σ_Y	$\rho_{V,C}$	$\rho_{V,I}$	$\rho_{V,Ex}$	$\rho_{V,Y}$	$\rho_{\Delta V,\Delta Q}$	$\rho_{\Delta V,\Delta e}$
Data	0.012	0.037	0.033	0.011	–0.308	–0.388	–0.478	–0.527	–0.620	0.665
Model	0.009	0.036	0.033	0.012	–0.300	–0.423	–0.418	–0.535	–0.780	0.905

Note: All variables are detrended using HP filter. The sample period is 2000:Q1–2019:Q4. I do not extend the sample period back to the 1990s, as the East Asian crisis in 1997 seriously changed the business cycle properties in Korea; in other words, there was a structural break during the crisis. The correlation is computed in the sample period 2004:Q1–2019:Q1. Since 2004, the Korean won-denominated equity external-liabilities-to-GDP ratio of Korea has been around 0.25–27. The sample period ends at 2019:Q1, as the global factor series ends at 2019:Q1. The consumption is the total consumption expenditure, including both the government and private consumption, and the investment is the gross capital formation by private sectors. The correlation between risk-on/off shock and the export shock is −0.50; thus the foreign demand for exported goods falls during a risk-off event.

aggregates, I used the global financial cycle factor data (GFC) constructed in Miranda-Agrippino, Nenova, and Rey (2020). Meanwhile, I set global financial shock to be negatively correlated with export shock, and the correlation is –0.50. Thus, risk-off (on) shocks are associated with falls (rises) in exports.

The calibrated model generates volatilities of GDP and exports, as the standard deviations of TFP shock and export shock are calibrated to match the standard deviations of GDP and exports, respectively. The standard deviations of investment and consumption from the calibrated model are 0.009 and 0.036, while they are 0.012 and 0.037, respectively, in the data; here, the investment refers to the gross fixed capital formation by the private sectors. Thus, the quantitative model misses some of the volatility of consumption in reality.[39]

More important business cycle properties than the standard deviations are the correlations between the global financial cycle and the macroeconomic aggregates, as the purpose of the quantitative study in this paper is to capture the impacts of global financial shocks on small open economies. The calibrated moments are very close to the data. The calibrated model also generates realistic correlations between the real macroeconomic aggregates and GFC for GDP, consumption, and exports. However, the model also overestimates the co-movements between investments and GFC, although the differences are reasonable considering the simplicity of the model. The discrepancy between the calibrated moments and the data may reflect that some parts of the investments in reality are not financed by financial intermediaries.[40]

[39] Higher volatility of consumption than GDP is commonly observed in many EMEs, and it has been an important research topic in international macroeconomics. Several revisions to the standard model have been suggested to explain the excess consumption volatilities. This paper does not aim at explaining the excess consumption volatility.

[40] Some readers may wonder how different the generated moments will be if the correlation between global financial shock and export shock is set to be zero. The generated second moments under the assumption of uncorrelated global financial shock with export shock are introduced in Online Appendix K. As one might envision, simulated data of export and GDP exhibit low correlations with global financial shock once export shock becomes uncorrelated with global financial shock. On the contrary, other second moments marginally change even if the correlation is set to be zero. This implies that global financial shocks initially

Other important moments are the correlations between the global financial cycle and the financial variables, stock index and exchange rate. Because of the simplicity, the model cannot replicate the large volatilities of the stock index and the exchange rate. Despite the limitation, the model successfully resembles the tight co-movements between the financial market variables and GFC. The correlations from the model are –0.78 and 0.90 for the capital price and the exchange rate, respectively, while they are –0.62 and 0.67 in the data. The correlations computed from the model are slightly higher than those computed from the data, but such differences are reasonable, considering the simplicity of the model.

4.2 Results

4.2.1 Transmission of Global Financial Shocks in Korea

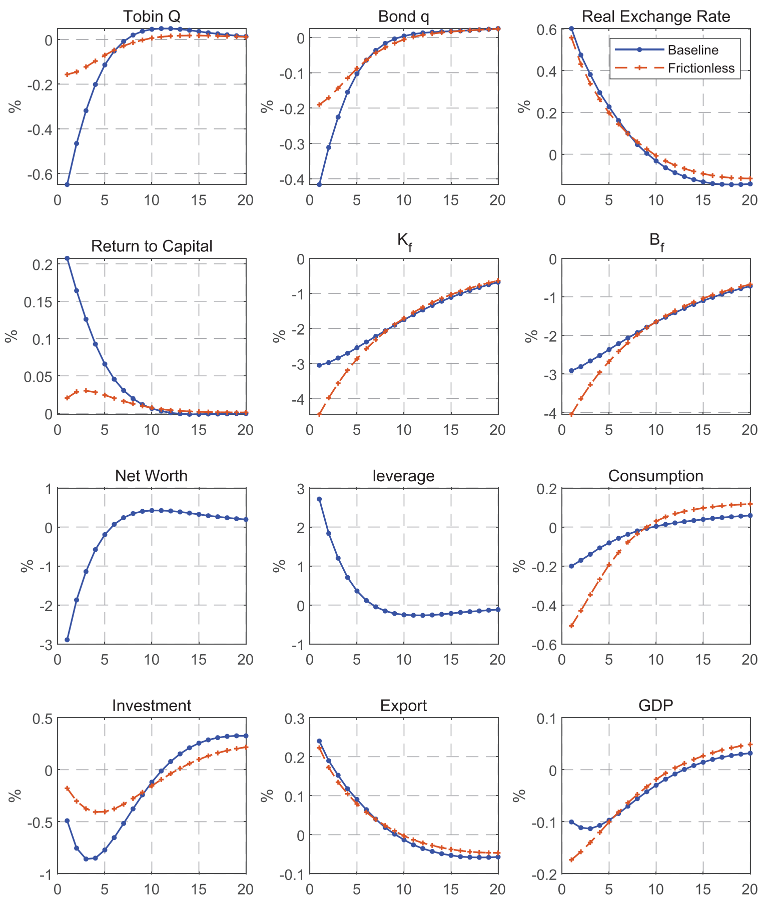
I simulated the model, using standard techniques.[41] Below, I illustrate the extent to which fluctuations in financial markets and the real economy can be generated by global financial shocks in the model economy calibrated to Korea, where most of the external liabilities are equities and Korean won-denominated debts.

Impulse Response Functions. Next, I examine how the key macrovariables react to a risk-off shock. I give a risk-off shock of one standard deviation to the model economy. In Figure 2, I show the response of the key financial variables, such as capital prices (Tobin's Q), bond prices, and the real exchange rate, and the key real variables, such as consumption, investment, exports, and GDP. I also show responses of important endogenous variables, which help to understand the mechanism. Those variables are capital and bonds held by global investors, and the net worth and leverage of the domestic banks. To highlight the importance of the leverage-constrained banks in the model, I also simulate another model in

affect financial market variables and then affect the real economy mainly through investments, as discussed.

[41] I solved the model using Dynare in the third-order approximation in Dynare. As discussed in Brunnermeier and Sannikov (2014), such perturbation techniques miss some of the non-linear dynamics in a model of financial amplification mechanisms. However, I limit my attention to a normal business cycle, not a big crisis event.

Figure 2. Impulse Response Functions



which there is no domestic financial friction, but the model is otherwise identical to the baseline model. In Figure 2, "baseline" indicates the results from the model with the leverage-constrained domestic banks and "frictionless" indicates the results from the model without banking sectors.

First, I describe the impulse response functions from the baseline model. The responses of the variables are all as expected. Tobin's Q (i.e., the capital price) falls by nearly 0.6 percent, and the bond price fall is slightly lower (0.4 percent). The capital outflows obviously depreciate the LC, and the depreciation rate is close to 0.6 percent.

The impulse response of other variables illustrates the mechanism behind the falls in the capital and bond prices. The risk-off shocks induce sell-off by the global investors in domestic financial markets, as shown in the impulse response functions of capital and bonds held by global investors. The sell-off lowers the capital price, which in turn lowers the net worth of the domestic banks and raises the return on the capital investment. The gross return increases by slightly more than 0.2 percent. The higher expected return raises leverage, but it is not enough because of the leverage constraint rooted in the agency problem of the bankers. As a result, the demand from domestic banks cannot increase enough so that the capital and bond prices fall significantly.

The fall in the capital price and the fall in investment occur simultaneously; investment falls by nearly 0.5 percent. Because of the technological features in the adjustment cost, the fall in the investment peaks one period after the shock.[42] Consumption falls, and it is mainly due to the falls in the consumption of imported goods. On the other hand, LC depreciation increases exports despite the low exchange rate pass-through, and accordingly, the fall in GDP is relatively mild. It falls by 0.1 percent.

A comparison of the results from the baseline model to the frictionless model highlights the importance of leverage constraints on domestic banks. First, one can easily notice that the negative impacts on domestic financial markets, and falls in the capital and bond prices, are much smaller than in the baseline model. Accordingly, falls in investment are much smaller as well. This is because, in a frictionless environment, the expected returns to capital and government bonds are dictated by the household Euler equations. That is, if capital prices and bond prices fall and thus the expected return on the investments rises, then it immediately results in more savings from households, as they expect higher returns. Despite higher borrowing rates on the FC debts, the households are incentivized to borrow more in FC to invest in domestic assets, as the LC is expected to appreciate. As a result, increased investments by households significantly offset the decrease in investments by global investors, preventing large falls in the asset prices and investments. In contrast,

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[42] It is a typical observation in a DSGE model with the "investment" adjustment cost.

the impact on the FX market is almost the same in the two models, and similarly for exports. Falls in consumption are higher for the frictionless model since the households in the model are incentivized to save and invest more. As a result, falls in GDP are slightly higher for the frictionless model.

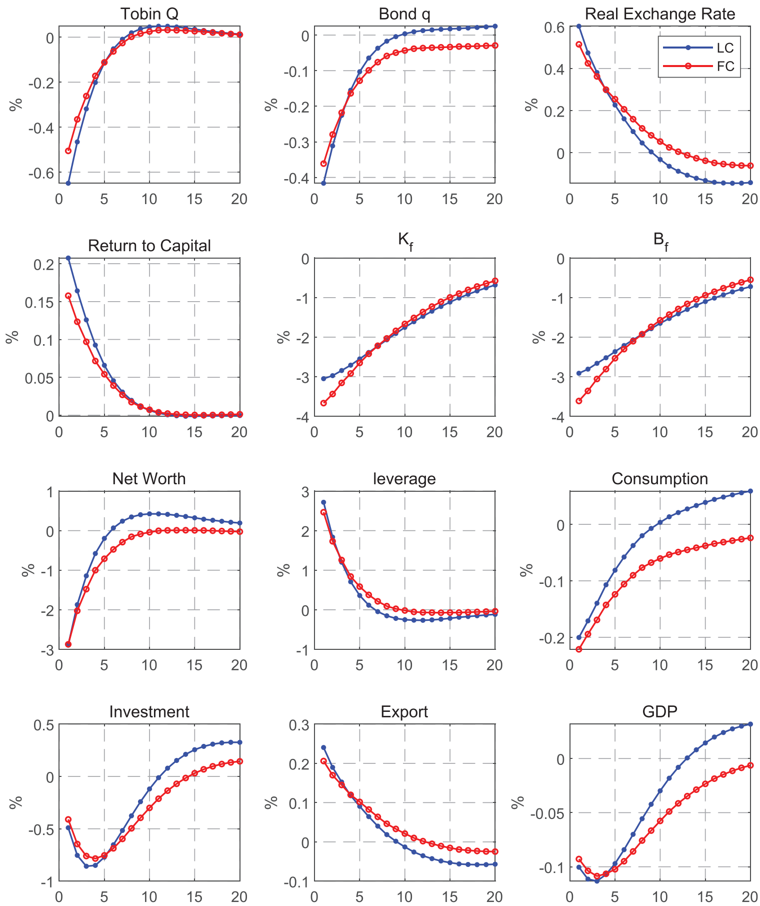
The purpose of the quantitative analysis is to evaluate the quantitative importance of the capital market channel. To quantify the importance in a different way, I compare the impulse response functions above to another small open economy, in which everything is identical but most of the external liabilities are FC debts.[43] Suppose there is another economy where the FC debt-to-GDP ratio is 28 percent and the equity liability-to-GDP and LC bond-to-GDP ratios are both 5 percent.[44] Again, the two economies are almost identical, except for the composition of external liabilities. For notational convenience, we call the economy of equity and LC bond external liabilities the "LC" economy and call the other economy the "FC" economy. The different responses of the two different economies are introduced in Figure 3.

Surprisingly, it turns out that the two economies show quite similar responses to the one-standard-deviation risk-off shock. My model is designed to evaluate the impacts of different types of capital flows on the small open economy, and therefore I abstracted from several features of EMEs, which can amplify potential risks from FC debt, such as sovereign default risk or country-level collateral constraint, as in Bianchi (2011). Despite the limit, Figure 3 shows that a large sell-off of global investors in the domestic financial market can generate sizable falls in small open economies. To understand the similarity, notice that the financial amplification mechanisms in the two different economies are similar. In both economies, the negative impacts of the risk-off shock are amplified through the negative balance sheet effects (i.e., negative pecuniary externality on

[43]The size of FC debts is affected by ϕ. Changing the parameter value makes it hard to compare the results from the two different model economies. To avoid confusion, I adjust the management cost. In the "FC-debt-denominated economy," I change the management cost to $\Theta\left(\varepsilon_t d_t^*, D_t\right) = \frac{\psi}{2}\left(x - c\right)_t^2 D_t$. I adjust c so that the marginal management costs in the two different economies are almost identical.

[44]In the LC economy, the FC debt-to-GDP, equity liability-to-GDP, and LC bond-to-GDP ratios are 3 percent, 27 percent, and 8 percent, respectively.

Figure 3. Impulse Responses Functions, LC vs. FC



the net worth of domestic banks). In the LC economy, the sell-off of global investors directly causes the capital price fall and, of course, it reduces the net worth accordingly. In the FC economy, the higher exchange rate caused by capital outflows raises the real debt burden and reduces the net worth. The lower net worth, again, puts downward pressure on capital prices. Regardless of whether the negative impacts are on the asset side or the liability side, in both economies, financial market prices (capital prices or the real exchange rate) hurt the net worth of the domestic banks.

Despite the similarity, one can notice that the falls in the real economy are larger in the FC economy. This reflects the positive income effects of risk-off shocks in the LC economy. Falls in the prices of capital and bond held by foreign (global) investors create positive income effects for the residents in the LC economy. The lower asset prices hurt the balance sheets of domestic banks, but at the same time, the lower asset prices (in LC) and the LC depreciation "inflate away" the liabilities in the sense that the values of the liabilities decline, when measuring the values in terms of export price or imported goods price.[45] This positive income effect upholds the aggregate consumption during a recession caused by the risk-off shock.

4.2.2 Quantitative Evaluation of the Importance of the Capital Market Channel

One of the important questions in the literature of the global financial cycle is, "How important is the global financial cycle to peripheral economies, small open economies with flexible exchange rate regimes?" The answer to the question should vary across countries. Different countries have different features in their financial markets and the real economies, and thus, the transmission and propagation mechanisms in each of the economies should differ as well. Because of the difficulty, I limit my focus to the model economy calibrated to the Korean economy and then evaluate the quantitative importance of global financial shock in financial and business cycles in Korea. I gave five different shocks to the model economy, as I described in the calibration section. I set all shocks to be independent of each other for an accurate assessment. I simulated the model for 20,000 periods and dropped the first 2,000 periods. The results of the variance decomposition are presented in Table 6.

The first observation from the variance decomposition is that risk-on/off shocks account for large parts of the fluctuations in financial markets in the model economy. The risk-on/off shocks account for more than half of the variations in Tobin's Q (53.9 percent) and

[45] More precisely, the values of the liabilities decline in terms of tradable goods. If all the tradable goods are denominated in U.S. dollars, as in the DCP hypothesis, LC depreciation devalues the LC-denominated assets in terms of tradable goods. See Fanelli (2019) for a more sophisticated analysis.

Table 6. Variance Decomposition

	Q_t	q_t	ε_t	R_t^k	R_t^b	C_t	I_t	E_{xt}	Y_t^{net}
Global Financial Shock	**53.9**	**38.3**	**27.9**	**69.1**	**56.2**	**28.3**	**38.3**	**1.7**	**8.6**
Export Shock	1.2	11.2	67.4	2.5	6.9	26.0	2.4	98.1	60.1
TFP Shock	6.8	31.0	2.3	3.3	3.1	40.1	20.9	0.1	27.4
Monetary Policy Shock	15.4	9.2	1.2	21.8	29.1	1.5	7.7	0.1	0.8
Investment Shock	22.7	10.4	1.1	3.3	4.6	4.1	30.7	0.1	3.1

Note: All shocks are independent of each other.

in the return on capital (69.1 percent). Similar to the capital price, the risk-appetite shocks explain 38.3 percent of bond price variations, 56.2 percent of the variations in return on the bonds, and 27.9 percent of the real exchange rate variations. Compared with the financial variables, relatively small parts of the variations in real-sector variables are attributable to the risk-on/off shocks. For investment and consumption (including both domestic and imported goods), 38.3 percent and 28.3 percent are attributable to the risk-on/off shock, respectively. For exports and GDP, only 1.7 percent of export variations and 8.6 percent of GDP variations are attributable to the risk-on/off shocks. To summarize, the risk-on/off shocks are important in fluctuations of both the financial markets and the real economy in Korea, but the influence of the shocks is much higher in financial market variables than in real economy variables.

The variance decomposition results reported above are from the relatively simple DSGE model. I abstracted from many important features in reality. Nevertheless, the variance decomposition analysis provides reasonable results consistent with the analyses in preceding papers and the usual beliefs held by financial market practitioners. Among the traders and commentators in Korean financial markets, a pervasive view is that a dominant factor in the market is the movements of global financial markets, especially the markets in the United States. In a recent paper, Acalin and Rebucci (2020), the authors empirically analyzed the importance of global financial shocks in explaining the stock market movements and business cycles in Korea. They showed that approximately 50 percent of stock market variations are attributable to the global financial cycle and less than 10 percent of GDP variations are attributable to the global financial cycle.[46] Though not an analysis of the Korean economy, Miranda-Agrippino, Nenova, and Rey (2020) also documented that the U.S. monetary policy shocks, as a proxy for the global financial cycle, cause large fluctuations in the global financial conditions, while the growth of the world economy seems to not be significantly affected by the shocks. Broadly speaking, the quantitative exercise in this paper replicated the results in the aforementioned papers in that global financial shocks are a dominant factor in financial market movements and the quantitative importance of global financial shocks in GDP fluctuations is lower, compared with financial market movements.

5. Concluding Remarks

In this paper, I explored the channel through which global financial shocks—risk-appetite shocks to global investors—are transmitted to small open economies—in particular, EMEs. Motivated by the fact that, nowadays, substantial parts of the external liabilities of many EMEs are actually equities or LC bonds, I explored a capital market channel. In an environment where domestic financial intermediaries are leverage constrained, shifts in demand for domestic financial assets from global investors can cause drastic changes in asset prices, which in turn affect domestic financial intermediaries through the changes in their net worth. Risk-off (on) shocks lower (raise) asset prices: the lower (higher) the asset prices, the weaker (stronger) the intermediations of the domestic financial intermediaries.

The importance of the capital market channel is supported by evidence. The cross-country panel regressions indicate that financial variables in an EME, namely, stock indices and exchange rates, tend to be more affected by the global financial shocks when the EME receives more equity and LC bond portfolio flows. Using the model calibrated to the Korean economy, the quantitative exercises show

[46] I note that their approach is much different from this paper. Besides the different methodologies, they computed how much of the forecast errors can be attributable to each different shock. Hence, their results are not directly comparable to the variance decomposition.

that global financial shocks are a dominant factor in the financial markets and also important for business cycles in Korea.

To conclude, all theoretical and empirical findings in this paper reveal that to a substantial extent, the risk-appetite shocks to global investors are transmitted to EMEs via fickle portfolio flows to equity and local currency bond markets in EMEs. More broadly, EMEs have a lesser concern about foreign currency debts, the previous cause of crises, as their borrowing ability in equities and LC debts has improved. However, they simultaneously face a new risk from the new sources of external financing.

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