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External financial liabilities and real exchange rate jumps

Jiaqing Zhu[a,b,*]

[a] School of Finance, Guangdong University of Foreign Studies, Guangzhou, China
[b] Southern China Institute of Fortune Management Research, Guangzhou, China

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ABSTRACT

I apply the autoregressive conditional jump intensity (ARJI) model to weekly bilateral real exchange rate (RER) returns of 31 countries over the period 2001–2013 and investigate the causal link between external financial liabilities and bilateral RER jumps. I find that both external debt and equity liabilities significantly reduce RER jumps, above and beyond the standard optimum currency area (OCA) factors, but through different transmission mechanisms. Specifically, I find that while external debt liabilities reduce RER jumps through both a balance-sheet and a risk-sharing channel, external equity liabilities reduce RER jumps only through a risk-sharing channel. Finally, domestic financial development can help attenuate the negative effect of external debt liabilities on RER jumps.

1. Introduction

Extreme risk in the foreign exchange market has recently emerged at the forefront of international economic and financial studies, primarily as a result of the global imbalances and financial fragility caused by the recent financial crisis (see, for example, Carr & Wu, 2007; Dobrynskaya, 2014; Chernov et al., 2018). Some suggest that financial globalization (external financial linkage) is a key driving force behind large asset price spillovers across countries during the financial crises (e.g., Mendoza & Quadrini, 2010; Dedola & Lombardo, 2012). In recent decades, financial globalization has been one of the most important trends in the world economy. This process has involved the accumulation of large gross international investment positions (Lane & Milesi-Ferretti, 2003, Obstfeld & Taylor, 2004, Milesi-Ferretti & Lane, 2005). After Lehmann Brothers' bankruptcy filing in September 2008, the entire global financial system was at the risk of collapse because of the integrated and interconnected nature of the global financial market. As a result, understanding whether and how external financial linkage affects extreme risk in the foreign exchange market is of the utmost importance not only for investors who may demand a large premia to carry this risk, but also vital for policy makers who must make decisions in real time during times of chaotic conditions in foreign exchange market.

Broadly speaking, external financial linkage may either amplify or mitigate the extreme risk in exchange rates. On the one hand, a country highly integrated into world financial markets is more exposed to exchange rate shocks coming from abroad (Catão & Milesi-Ferretti, 2014). On the other hand, external finance makes it possible for domestic investors to share risk with foreign investors, thereby helping stabilize exchange rate fluctuations (Calderón & Kubota, 2018). Thus, the effect of external financial linkage on the extreme risk in exchange rates is ultimately an empirical question.

The aim of this paper is to examine the causal impact of external financial liabilities on bilateral real exchange rate (RER) jump intensities of 31 developing and developed economies over the period 2001–2013 and explore the underlying transmission mechanisms. In the spirit of the recent development of jump risk literature (Chan & Maheu, 2002; Pan, 2002; Maheu & McCurdy, 2004;

* Address: School of Finance, Guangdong University of Foreign Studies, Guangzhou, China.
E-mail address: zhujiaqing@gdufs.edu.cn.

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Bollerslev et al., 2008; Jiang et al., 2011), I use RER jumps as a proxy for extreme RER risk. Compared to continuous price changes, jumps in financial assets with occasional large price changes and extreme volatility represent a significant source of non-diversifiable risk (Eraker et al., 2003; Bollerslev et al., 2008; Bollerslev et al., 2016). To estimate bilateral RER jumps for each country pair, I use the autoregressive jump intensity (ARJI) model developed by Chan and Maheu (2002) and further augmented by Maheu and McCurdy (2004). The model allows the conditional jump intensity to be time-varying and follows an approximate autoregressive moving average (ARMA) form. The estimation results show that the model can provide a good measure of the bilateral RER jump dynamics for the sample countries.

I next examine the causal relation between different types of external financial liabilities and bilateral RER jump risk by adopting a two-stage least squares (2SLS) approach. After controlling for the endogeneity of the bilateral trade flows and external financial liabilities, the empirical results show that both external debt and equity liabilities significantly reduce RER jump intensities, and domestic financial development will attenuate the negative effect of external debt liabilities. However, the transmission channels through which external debt and equity liabilities negatively affect RER jumps are different. Specifically, while external debt liabilities reduce RER jumps through both a balance-sheet and a risk-sharing channel, external equity liabilities reduce RER jumps only through a risk-sharing channel. There is also evidence suggesting that a country's openness to trade will eliminate the negative impact of external financial liabilities on bilateral RER jump risk.

The paper contributes to the existing literature in two aspects. First, to the best of my knowledge, this is the first comprehensive study to investigate the determinants of RER jump risk in foreign exchange markets. Different from the existing studies that use some measure of variance as the proxy for RER volatility (e.g., Calderón & Kubota, 2018), which only reflects the continuous part of RER volatility, the measurement of RER jump intensities provides a different dimension of RER risk. In this regard, this study establishes relationship between external financial linkage and RER risks based on channels not identified in previous literature.

Second, this study contributes to the emerging empirical literature that highlights the importance of the composition of capital flows in understanding exchange rate fluctuations (e.g., Al-Abri, 2013; Catão & Milesi-Ferretti, 2014; Calderón & Kubota, 2018). In theory, external financial liabilities can help stabilize exchange rate fluctuations through different channels. Extending the balance sheet effects to the open economy, Devereux and Lane (2003) build up a theoretical model to demonstrate the important role of external financial linkages in affecting the efficiency of the exchange rate in responding to external shocks. They suggest that the presence of external debt makes countries more reluctant to tolerate high exchange rate volatility, which may cause tremendous damage to corporate balance sheets. This point of view is in accordance with previous studies that highlight the importance of balance-sheet effects in understanding exchange rate fluctuations. As is suggested by Hausmann et al. (2001) and Calvo and Reinhart (2002), balance-sheet effects have become a prime reason for many central banks' reluctance to allow their currencies to devalue in response to external shocks. Extending the seminal work of Devereux and Lane (2003), Li et al. (2016) find that bilateral nominal exchange rate jump risk is significantly reduced by external debt liabilities through the balance-sheet channel.

Another strand of literature points to the benefits of financial globalization in allowing for more efficient international risk sharing.[1] Rogoff (1999) suggests that a high share of equity in total external liabilities is generally viewed as desirable for improving a country's ability to share risk with international investors and its resilience to external shocks. Coeurdacier and Rey (2013) examine a series of 2-country, 2-good DSGE models with endogenous portfolio choice that demonstrate the ability of domestic and cross-border asset (equity and bond) trading to lower RER volatility. They also find that a reduction of exchange rate volatility across countries may take place through cross-border bond holdings.

Different from Li et al. (2016) which only exploits the balance-sheet channel through which external debt liabilities negatively affect bilateral exchange rate jump risk, this study emphasizes different transmission channels of the causal impact of both debt- and equity-based external financial liabilities on bilateral RER jump intensities. This also makes the study quite different from previous empirical studies that only focus on testing whether the composition of capital flows would smooth exchange rate volatilities (e.g., Al-Abri, 2013; Calderón & Kubota, 2018). Thus the findings in this study lend further support to both strands of the theoretical literature.

The paper proceeds as follows. The next section formulates the empirical hypotheses; Section 3 outlines the empirical strategy and data used in the paper; Section 4 presents the empirical results; conclusions then follow in Section 5.

2. Hypotheses development

The main goal of the paper is to explore whether and how different types of external financial liabilities affect bilateral RER jump risk. I focus on two types of external financial liabilities, i.e., external debt and equity liabilities.

The net impact of external debt liabilities on RER jump risk depends on three forces. First, external debt liabilities may tighten financial constraints and reduces the efficiency of the exchange rate in responding to external shocks (i.e., the balance-sheet channel). This is derived from the current literature that points to the important effect of corporate balance sheets on macroeconomic outcomes, especially exchange rates. For example, Aghion et al. (2001, 2004) show that corporate balance sheets play a role in the onset of currency crisis. By developing a small open economy model, Devereux and Lane (2003) show that the presence of credit constraints, in combination with external debt, leads to significant decline in the optimal response of exchange rates to shocks.

Second, as an important component of financial integration, external debt liabilities may help stabilize exchange rate fluctuations through an international risk-sharing channel. A substantial body of theoretical literature suggests that financial integration allows for more efficient international risk sharing by providing better opportunities for countries to smooth consumption growth in the face

[1] See Terrones et al. (2007) for a summary of findings of related papers.

of country-specific fluctuations in output growth (Kose et al., 2009). Using a simple welfare-based measure of risk sharing, Flood et al. (2012) show that international risk sharing has been improving over time. Balli et al. (2013) examine the impact of the recent global financial crisis on the degree of international income and consumption risk-sharing among industrial economies and find that debt delivered better risk-sharing than equity during the post-crisis period. By examining a series of 2-country, 2-good DSGE models with endogenous portfolio choice, Coeurdacier and Rey (2013) demonstrate the ability of domestic and cross-border asset (equity and bond) trading to lower RER volatility. They also find that a reduction of exchange rate volatility across countries may take place through cross-border bond holdings.

Third, since a country highly integrated into world financial markets is more exposed to exchange rate shocks coming from abroad, external debt liabilities may contribute to more exchange rate fluctuations (i.e., the risk-amplifying channel). Frankel and Saravelos (2012) find that external debt is a useful indicator of the cross-country incidence of the 2008–09 financial crisis. Using comprehensive data spanning 1970–2011, Catão and Milesi-Ferretti (2014) find that the ratio of net external liabilities (both debt and equity) to GDP is a significant crisis predictor.

Together, these suggest an ambiguous effect of external debt liabilities on bilateral RER jump risk, thus the following null hypothesis is developed:

Hypothesis 1. External debt liabilities are not related to bilateral RER jump risk.

To explore the transmission channels through which external debt liabilities have an impact on bilateral RER jump risk, the following hypotheses are developed.

Hypothesis 2a (*The balance-sheet channel***).** If external debt liabilities reduce bilateral RER jump risk through the balance-sheet channel, countries facing more credit constraints are more sensitive to RER jump risk when external debt liabilities increase.

Hypothesis 2b (*The risk-sharing channel***).** If external debt liabilities reduce bilateral RER jump risk through the risk-sharing channel, the negative impact is increasingly pronounced for country pairs with more asymmetric business cycles.

Hypothesis 2c (*The risk-amplifying channel***).** If the impact of external debt liabilities on bilateral RER jump risk is significantly positive, external debt liabilities affect bilateral RER jump risk through the risk-amplifying channel.

In a similar vein, as another important component of financial globalization, external equity liabilities may affect bilateral RER jump risk through two different channels, i.e., the risk-sharing channel and the risk-amplifying channel, thus the net effect is also ambiguous. Similarly, I set up the following null hypothesis:

Hypothesis 3. External equity liabilities are not related to bilateral RER jump risk.

To explore the transmission channels through which external equity liabilities have an impact on bilateral RER jump risk, the following hypotheses are developed.

Hypothesis 4a (*The risk-sharing channel***).** If external equity liabilities reduce bilateral RER jump risk through the risk-sharing channel, the negative impact is increasingly pronounced for country pairs with more asymmetric business cycles.

Hypothesis 4b (*The risk-amplifying channel***).** If the impact of external equity liabilities on bilateral RER jump risk is significantly positive, external equity liabilities affect bilateral RER jump risk through the risk-amplifying channel.

3. Empirical model, variables, and data

Based on the discussion aforementioned, the basic empirical model is specified as follows:

$$ln(\lambda_{ijt}) = \alpha_0 + \beta_1 Cycle_{ij,t} + \beta_2 Trade_{ij,t} + \beta_3 FIN_{j,t} + \beta_4 EXTFIN_{ij,t} + \beta_5 EXTFIN_{ij,t} \times FIN_{j,t} + \beta_6 GDPperca_{j,t} + \gamma_t + \alpha_{1,ij} + \varepsilon_{ij,t} \quad (1)$$

where λ_{ijt} denotes bilateral RER jump intensities between countries *i* and *j* in period *t*. The explanatory variable of interest is the external debt/equity liabilities of country *j* held by country *i* in period *t* (***EXTFIN***).[2] The other controls include business cycle asymmetry between country *i* and country *j* in period *t* (***Cycle***), trade openness as a proxy for external economic linkage between countries *i* and *j* in period *t* (***Trade***), the ratio of domestic liquid liabilities to GDP in period *t* as a proxy for country *j*'s domestic financial development (***FIN***), and GDP per capita of country *j* in period *t* (***GDPperca***). Finally, $\alpha_{1,ij}$ captures the unobservable, time-invariant, country-pair specific effects, and γ_t is the time-fixed effect variable.

3.1. The bilateral RER jump intensities

In this study, I apply the ARJI-R^2_{t-1} model developed by Chan and Maheu (2002) and further augmented by Maheu and McCurdy (2004) to the weekly bilateral RER returns of 31 countries over the time period 2001–2013 to measure the time-varying conditional RER jump intensities. The model combines the jump specification with a GARCH parameterization of volatility and is specified as:

[2] For simplicity, I abstract from time and country subscripts hereafter.

$$R_t = \mu + \phi_1 R_{t-1} + \sqrt{h_t} z_t + \sum_{k=1}^{n_t} Y_{t,k},\ h_t = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1},\ Y_{t,k}\ N(\theta_t, \delta_t^2),\ z_t\ NID(0, 1),\ P(n_t = j|\Phi_{t-1}) = \frac{\exp(-\lambda_t)\lambda_t^j}{j!},\ \lambda_t = \lambda_0 + \rho\lambda_{t-1} + \gamma\xi_{t-1},\ \theta_t = \eta_0 + \eta_1 R_{t-1} D(R_{t-1}) + \eta_2 R_{t-1}(1 - D(R_{t-1})),\ \delta_t^2 = \zeta_0^2 + \zeta_1 R_{t-1}^2 \tag{2}$$

where R_t is the first difference of RER in logarithm, and $D(R_{t-1}) = 1$ if $R_{t-1} > 0$ and $D(R_{t-1}) = 0$ otherwise. The RERs are computed in the conventional way as follows:

$$RER_{ij,t} = ER_{ij,t} \times \frac{CPI_{j,t}}{CPI_{i,t}} \tag{3}$$

where $ER_{ij,t}$ is the nominal exchange rate of country *i*'s currency against country *j*'s currency in period *t*; $CPI_{i,t}$ and $CPI_{j,t}$ denote the consumer price index of country *i* and country *j* in period *t*, respectively. The conditional volatility of returns, h_t, is specified to follow a GARCH(1, 1) process, and z_t is specified as an independent normal random variable.

The jump size $Y_{t,k}$ is postulated to be independently drawn from a Normal distribution with time-varying mean θ_t and varianceδ_t^2, and θ_t and δ_t^2 are functions of past returns. Such specifications of the conditional mean and variance of the jump size allow some flexibility regarding where jumps are centered and may capture the rally after a market crash through a change in jump direction. For example, if in the last period the market experienced a gain (decline), then the conditional mean of the jump size is $\eta_0 + \eta_1 R_{t-1}$ ($\eta_0 + \eta_2 R_{t-1}$). Thus the first moment of the jump size distribution can respond to whether the last period's market return was positive or negative, and to its magnitude, and we would expect $\eta_1 > 0$ and $\eta_2 < 0$. This specification also allows R_{t-1}^2 to affect δ_t^2, to explore whether the jump size variance is sensitive to the overall level of market volatility.

A discrete-valued number of jumps that arrive between *t*-1 and *t* is denoted by n_t, whose distribution is assumed to be Poisson with a time-varying parameter λ_t. The ARJI model allows the conditional jump intensity λ_t to endogenously evolve according to a parsimonious ARMA structure. The conditional jump intensity at time *t* is related to the conditional jump intensity at time *t*-1 plus 1 lag of ξ_t, where ξ_{t-1} represents the innovation to λ_{t-1} and is defined as

$$\xi_{t-1} \equiv \mathrm{E}[n_{t-1}|\Phi_{t-1}] - \lambda_{t-1} = \sum_{j=0}^{\infty} jP(n_{t-1} = j|\Phi_{t-1}) - \lambda_{t-1} \tag{4}$$

where $P(n_{t-1} = j|\Phi_{t-1})$ is ex post inference on n_{t-1} given time *t*-1 information. Formally, $P(n_{t-1} = j|\Phi_{t-1})$ is defined as

$$P(n_t = j|\Phi_t) = \frac{f(R_t|n_t = j, \Phi_{t-1})P(n_t = j|\ \Phi_{t-1})}{P(R_t|\ \Phi_{t-1})},\ j = 0, 1, 2, \cdots \tag{5}$$

where $f(R_t|n_t = j, \Phi_{t-1})$ denotes the conditional density of returns given that *j* jumps occurring at time *t* and time *t*-1 information.

Finally, the assumptions in Eq. (2) imply that the distribution of returns conditional on the most recent information set and *j* jumps at time *t* is normally distributed as

$$f(R_t|n_t = j, \Phi_{t-1}) = \frac{1}{\sqrt{2\pi(h_t + j\delta_t^2)}} \times exp\left(-\frac{(R_t - \mu - \sum_{i=1}^{l}\phi_i R_{t-i} - \theta_t j)^2}{2(h_t + j\delta_t^2)}\right) \tag{6}$$

Integrating out the number of jumps yields the conditional density in terms of observables,

$$P(R_t|\Phi_{t-1}) = \sum_{j=0}^{\infty} f(R_t|n_t = j, \Phi_{t-1})P(n_t = j|\Phi_{t-1}) \tag{7}$$

In this study, I apply the ARJI model to weekly bilateral RER returns to obtain the weekly RER jump intensities for each country pair, and then I sum up the weekly RER jump intensities in each year to obtain the annual conditional jump intensities λ_{ijt} in Eq. (1).

3.2. The financial variables

I measure the external financial liabilities for host country *j* as external debt/equity liability of country *j* held by country *i* at the end of each year, divided by country *j*'s GDP. Since the foreign liabilities a country holds can also be determined by the level of exchange rate risk, this variable in Model (1) confronts with endogeneity problems. To address this issue, I adopt a 2SLS approach where the first step regresses the bilateral external financial liabilities on a set of exogenous determinants. Following Wälti (2011), the exogenous determinants for external financial liabilities include the log of the product of GDP *per capita* of country *i* and country *j*, an indicator of creditor rights in La Porta et al. (1998), an index of corruption taken from Transparency International, a dummy variable for joint EMU (the European Monetary Union) membership, the log of the distance between the main business centers of each country, and a dummy variable for common language (see also Devereux and Lane, 2003; Imbs, 2006; Lane and Milesi-Ferretti,2008; Portes and Rey, 2005). For external equity liabilities, I also include an anti-director rights index and an anti-self dealing index in Djankov et al. (2008) as additional exogenous determinants. The predicted values from the first step model are used in the second step regression, the panel estimation of the determinants of the bilateral RER jump intensities.

Devereux and Lane (2003) find that the greater is domestic financial depth, the less external financial dependence influences exchange rate policy. Thus, in addition to the external financial factors, I also include the development of host country *j*'s domestic financial sector, measured as the ratio of liquid liability to GDP at the end of each year, to see if the degree of financial depth within a country influences the relation between external financial linkages and RER jump risk.

3.3. Control variables

As control variables, I include standard OCA factors in the analysis. ***Trade*** is the ratio of bilateral exports and imports relative to host country *j*'s GDP during year *t*. It is included for the standard logic that trade interdependence makes countries reluctant to tolerate too much exchange rate fluctuations. ***Cycle*** is the degree of business cycle asymmetry. It is measured by the conditional standard deviation of the innovation to the real GDP growth rate differential between countries *i* and *j*, using the generalized autoregressive conditional heteroskedasticity (GARCH) specification of Bollerslev (1986).[3]

The bilateral trade flows in Model (1) also confront with the endogeneity problem because the bilateral international trade can also be affected by the bilateral exchange rate risk. To address this issue, I run 2SLS regressions. Similarly, I first regress bilateral trade flows on a series of exogenous determinants identified in the gravity model of international trade, which include: the log of the distance between the main business centers of countries *i* and *j*, the log of the GDPs of countries *i* and *j* respectively, a dummy variable for a common border, a dummy variable for common language, a dummy variable for joint EMU membership, the number of landlocked countries in the country-pair (0, 1, or 2), the number of island nations in the pair (0, 1, or 2), the log of the product of the areas of countries *i* and *j* (in square kilometers), the log of the populations of countries *i* and *j* respectively, a dummy variable which is unity if country *i* ever colonized country *j* or vice versa, a dummy variable for joint NAFTA (the North American Free Trade Agreement) membership, and a dummy variable for joint APEC (the Asia-Pacific Economic Cooperation) membership. The predicted values from the first step model are used in the second step regression, the panel estimation of the determinants of the bilateral RER jump intensities.

Finally, I also follow Devereux and Lane (2003) by including host country *j*'s GDP per capita as an extra control variable to address potential omitted variable bias that external finance may systematically vary with the level of development and so may just proxy for other economic and institutional developments associated with rising per capita income.

3.4. Data

A panel dataset of 31 countries over the period 2001–2013 is used in this study (See Appendix A for country list). The developed countries selected in this study are based on data availability and whether or not the selected countries have maintained a floating exchange rate system over the sample period. Currencies in those developed countries are consistently classified as a "floating" or "managed floating without a predetermined path" in the IMF Annual Report on Exchange Arrangements and Exchange Restrictions. The countries in the Euro area listed above use euro as their local currency. For a completer exposition, I also include some large developing countries, including China and other Asian countries in the analysis.

The sample begins in January 2001 and ends in December 2013 since data on external debt and equity liabilities of country *j* held by country *i* retrieved from the IMF's Coordinated Portfolio Investment Survey database are available from 2001. Bilateral trade flows data are gathered from the IMF's Direction of Trade Statistics database. Data on country *j*'s GDP per capita in current US dollars are taken from the World Bank's WDI database. The weekly nominal exchange rate data retrieved from Bloomberg database are used to calculate RER jump intensity. Since the CPI data for each country are not available at a weekly frequency, to construct weekly RER for each country pair I replace each weekly CPI observation of each country by the corresponding monthly CPI observation of that country in the corresponding month. Data on CPI are retrieved from World Bank's Global Economic Monitor database.

Since the sample includes 31 countries, I have 930 (30×31) country pairs in total. Therefore, to obtain the conditional RER jump intensities for each country pair, I estimate the ARJI model 930 times. The estimation results show that among the 930 pairs, 430 pairs yield time-varying jump intensities, while the other 500 pairs yield either constant jump intensities or no convergence in the sample period. For the research purpose in this study, those 500 country pairs are excluded from the analysis. Table 1 reports summary statistics for the weekly bilateral RER jump intensities estimated from the ARJI model for all the country pairs. It shows that the differences in the jump intensities across country pairs are substantial. For example, the average weekly RER jump intensity estimated from the ARJI model is 1.176 for South Africa/Austria, 1.193 for South Africa/France, 2.967 for Singapore/Malaysia, and only 0.009 for Singapore/Austria. It implies that jumps on RER for South Africa/Austria and South Africa/France arrive on average approximately 5 times per month, but as often as 12 times for Singapore/Malaysia. On the other hand, RER jumps rarely happen for Singapore/Austria. It is about 1 time every two years.

Before a thorough analysis of why bilateral RER jump intensities differ across country pairs, in Fig. 1 I plot the weekly jump intensities series for RERs of Singapore/Malaysia and Singapore/Austria to conduct a visual inspection of their jump dynamics. I find that the distinct difference between their average weekly jump intensities comes from their different jump patterns. For Singapore/Malaysia, I observe that the dramatic increase in RER jump intensity in early 2001 coincides quite well with the bursting of the dot.com bubble which adversely affected Malaysia's economy. After that, the RER of Singapore/Malaysia started to experience high intensity of jumps. In contrast, jump patterns for the RER of Singapore/Austria are relatively stable, with the jump intensities mostly remaining around zero. The only exceptions are during the Swedish euro referendum in 2003,[4] the U.S. subprime crisis, and the

[3] The growth rate differentials are measured as the differences of the real GDP growth rates between countries *i* and *j*, and the sample used for GARCH estimation spans from 1961 to 2013.

[4] The Swedish people voted against the adoption of euro in a referendum held in Sweden on 14 September 2003.

Table 1
Bilateral RER jump intensities: summary statistics.

Country	AUS	AUT	BEL	BRA	CAN	CHN	DNK	FIN	FRA	DEU	GRC	IDN	IND	ISR	ITA	JPN	KOR	MYS	MEX	NLD	NZL	NOR	SGP	ZAF	ESP	SWE	CHE	THA	TUR	GBR	USA
AUS												0.060	1.803	0.149		0.094												0.037			
												(0.05)	(0.05)	(0.02)		(0.03)												(0.04)			
AUT				0.8-04								0.118				0.039		0.0-18			0.6-03	0.0-94	0.0-09	1.1-76			0.3-60				0.2-30
				(0.-56)								(0.08)				(0.08)		(0.-06)			(0.-11)	(0.-15)	(0.-01)	(0.-52)			(0.-08)				(0.-01)
BEL				0.8-21		0.0-25						0.166				0.104					0.8-61	0.0-99	0.0-15	1.1-57		0.0-33	0.3-29				0.1-69
				(0.-59)		(0.-02)						(0.15)				(0.09)					(0.-14)	(0.-16)	(0.-04)	(0.-52)		(0.-08)	(0.-07)				(0.-04)
BRA		0.8-04	0.-821		0.1-40	0.4-59	0.7-44	0.-81-3	0.8-49	0.6-99	0.8-43	0.460	0.123	0.088	0.-76-2	1.258	0.2-50	0.5-45	0.7-52	0.7-54	0.0-53	0.6-52	0.4-97		0.-89-4	0.2-30	0.4-86	1.643		0.5-12	0.4-46
		(0.-56)	(0.-59)		(0.-16)	(0.-04)	(0.-54)	(0.-57)	(0.-61)	(0.-52)	(0.-57)	(0.30)	(0.10)	(0.08)	(0.-55)	(0.18)	(0.-06)	(0.-01)	(0.-32)	(0.-55)	(0.-14)	(0.-49)	(0.-05)		(0.-60)	(0.-24)	(0.-40)	(0.11)		(0.-39)	(0.-07)
CAN				0.1-40		0.0-12		0.-90-4				0.123				0.097		0.0-31			0.7-24	2.8-39	0.0-05					1.087			0.0-13
				(0.-16)		(0.-07)		(2.-11)				(0.02)				(0.26)		(0.-01)			(0.-13)	(0.-90)	(0.-03)					(0.74)			(0.-09)
CHN			0.-025	0.4-59	0.0-12		0.0-26	0.-03-1	0.2-43		0.2-26			0.075	0.-21-7	0.417	0.0-14			0.0-24	0.4-25		0.2-26		0.-03-2	0.1-51		1.392	0.0-58		
			(0.-02)	(0.-04)	(0.-07)		(0.-02)	(0.-02)	(0.-04)		(0.-02)			(0.02)	(0.-01)	(0.17)	(0.-04)			(0.-02)	(0.-08)		(0.-03)		(0.-03)	(0.-00)		(0.73)	(0.-02)		
DNK				0.7-44		0.0-26		0.-30-4	0.4-13	0.1-16	0.0-49	0.137			0.-30-0	0.116	0.0-78	0.1-07			0.5-32	0.0-88	0.0-10	1.1-39	0.-15-2	0.0-33	0.2-51				0.2-59
				(0.-54)		(0.-02)		(0.-01)	(0.-09)	(0.-02)	(0.-00)	(0.17)			(0.-02)	(0.09)	(0.-05)	(0.-04)			(0.-09)	(0.-16)	(0.-01)	(0.-57)	(0.-02)	(0.-08)	(0.-07)				(0.-01)
FIN				0.8-13	0.9-04	0.0-31	0.3-04					0.128				0.112		0.0-20			0.7-61		0.0-10				0.5-75	0.019			0.3-11
				(0.-57)	(2.-11)	(0.-02)	(0.-01)					(0.13)				(0.09)		(0.-05)			(0.-13)		(0.-01)				(0.-88)	(0.02)			(0.-01)
FRA				0.8-49		0.2-43	0.4-13					0.106		0.701		0.116						0.0-90		1.1-93		0.0-33	0.3-27				0.2-73
				(0.-61)		(0.-04)	(0.-09)					(0.06)		(0.07)		(0.09)						(0.-16)		(0.-42)		(0.-08)	(0.-05)				(0.-01)
DEU				0.6-99			0.1-16					0.148				0.036		0.0-48				0.0-95	0.0-10	1.1-32		0.0-31	0.2-56				0.0-31
				(0.-52)			(0.-02)					(0.18)				(0.07)		(0.-03)				(0.-16)	(0.-02)	(0.-34)		(0.-09)	(0.-04)				(0.-02)
GRC				0.8-43		0.2-26	0.0-49					0.095				0.036		0.0-21			2.5-45	0.1-18				0.0-37				0.4-61	0.2-50
				(0.-57)		(0.-02)	(0.-00)					(0.09)				(0.08)		(0.-03)			(0.-37)	(0.-18)				(0.-11)				(0.-10)	(0.-02)

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Table 1 (*continued*)

Country	AUS	AUT	BEL	BRA	CAN	CHN	DNK	FIN	FRA	DEU	GRC	IDN	IND	ISR	ITA	JPN	KOR	MYS	MEX	NLD	NZL	NOR	SGP	ZAF	ESP	SWE	CHE	THA	TUR	GBR	USA
IDN	0.0-60	0.1-18	0.-166	0.4-60	0.1-23		0.1-37	0.-12-8	0.1-06	0.1-48	0.0-95			0.073	0.-12-0	0.046				0.1-41	0.0-47	0.0-87		0.1-23	0.-12-3				0.0-98	0.0-61	
	(0.-05)	(0.-08)	(0.-15)	(0.-30)	(0.-02)		(0.-17)	(0.-13)	(0.-06)	(0.-18)	(0.-09)			(0.02)	(0.-10)	(0.01)				(0.-15)	(0.-07)	(0.-09)		(0.-18)	(0.-12)				(0.-10)	(0.-09)	
IND	1.8-03			0.1-23													0.3-92			0.4-77										0.0-19	
	(0.-05)			(0.-10)													(0.-45)			(0.-24)										(0.-04)	
ISR	0.1-49			0.0-88		0.0-75			0.7-01			0.073				0.018	0.1-29		1.7-67		0.1-51		0.2-43				0.0-29	1.003			
	(0.-02)			(0.-08)		(0.-02)			(0.-07)			(0.02)				(0.03)	(0.-10)		(0.-31)		(0.-02)		(0.-06)				(0.-03)	(0.55)			
ITA				0.7-62		0.2-17	0.3-00					0.120				0.117					2.2-78	0.0-88	0.0-10	1.1-69		0.0-39	0.2-24			0.0-08	0.2-33
				(0.-55)		(0.-01)	(0.-02)					(0.10)				(0.09)					(0.-33)	(0.-16)	(0.-01)	(0.-41)		(0.-10)	(0.-05)			(0.-03)	(0.-02)
JPN	0.0-94	0.0-39	0.-104	1.2-58	0.0-97	0.4-17	0.1-16	0.-11-2	0.1-16	0.0-36	0.0-36	0.046		0.018	0.-11-7		0.1-21	0.3-01		0.0-97	0.2-23	0.2-84	0.1-37	0.1-24	0.-07-8	0.0-76	0.0-94	0.171		0.0-48	0.6-08
	(0.-03)	(0.-08)	(0.-09)	(0.-18)	(0.-26)	(0.-17)	(0.-09)	(0.-09)	(0.-09)	(0.-07)	(0.-08)	(0.01)		(0.03)	(0.-09)		(0.-12)	(0.-19)		(0.-08)	(0.-03)	(0.-13)	(0.-15)	(0.-07)	(0.-08)	(0.-08)	(0.-15)	(0.26)		(0.-15)	(0.-09)
KOR				0.2-50		0.0-14	0.0-78						0.392	0.129		0.121		0.9-74	0.0-52	0.0-81	0.3-63		0.2-63	1.1-36			0.3-63	0.168		0.0-71	
				(0.-06)		(0.-04)	(0.-05)						(0.45)	(0.10)		(0.12)		(0.-06)	(0.-01)	(0.-06)	(0.-08)		(0.-54)	(0.-66)			(0.-51)	(0.32)		(0.-14)	
MYS		0.0-18		0.5-45	0.0-31		0.1-07	0.-02-0		0.0-48	0.0-21					0.301	0.9-74			0.0-16	0.3-24	0.1-94	2.9-67		0.-01-7					0.0-91	
		(0.-06)		(0.-01)	(0.-01)		(0.-04)	(0.-05)		(0.-03)	(0.-03)					(0.19)	(0.-06)			(0.-06)	(0.-06)	(0.-02)	(0.-35)		(0.-03)					(0.-01)	
MEX				0.7-52										1.767			0.0-52				0.3-30			0.0-56							
				(0.-32)										(0.31)			(0.-01)				(0.-03)			(0.-12)							
NLD				0.7-54		0.0-24						0.141	0.477			0.097	0.0-81	0.0-16				0.0-94	0.0-11			0.0-89					0.2-26
				(0.-55)		(0.-02)						(0.15)	(0.24)			(0.08)	(0.-06)	(0.-06)				(0.-16)	(0.-01)			(0.-01)					(0.-01)
NZL		0.6-03	0.-861	0.0-53	0.7-24	0.4-25	0.5-32	0.-76-1			2.5-45	0.047		0.151	2.-27-8	0.223	0.3-63	0.3-24	0.3-30				0.5-99	0.1-12	1.-37-7		0.2-14	0.425			0.4-05
		(0.-11)	(0.-14)	(0.-14)	(0.-13)	(0.-08)	(0.-09)	(0.-13)			(0.-37)	(0.07)		(0.02)	(0.-33)	(0.03)	(0.-08)	(0.-06)	(0.-03)				(0.-11)	(0.-14)	(0.-27)		(0.-19)	(0.07)			(0.-08)
NOR		0.0-94	0.-099	0.6-52	2.8-39		0.0-88		0.0-90	0.0-95	0.1-18	0.087			0.-08-8	0.284		0.1-94		0.0-94				0.1-11	0.-10-6	0.3-44	1.4-44				
		(0.-15)	(0.-16)	(0.-49)	(0.-90)		(0.-16)		(0.-16)	(0.-16)	(0.-18)	(0.09)			(0.-16)	(0.13)		(0.-02)		(0.-16)				(0.-16)	(0.-16)	(0.-51)	(0.-28)				

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Table 1 (*continued*)

Country	AUS	AUT	BEL	BRA	CAN	CHN	DNK	FIN	FRA	DEU	GRC	IDN	IND	ISR	ITA	JPN	KOR	MYS	MEX	NLD	NZL	NOR	SGP	ZAF	ESP	SWE	CHE	THA	TUR	GBR	USA
SGP		0.009	0.015	0.497	0.005	0.226	0.010	0.010		0.010				0.243	0.010	0.137	0.263	2.967		0.011	0.599				0.009			0.544			0.242
		(0.01)	(0.04)	(0.05)	(0.03)	(0.03)	(0.01)	(0.01)		(0.02)				(0.06)	(0.01)	(0.15)	(0.54)	(0.35)		(0.01)	(0.11)				(0.01)			(0.15)			(0.02)
ZAF		1.176	1.157				1.139		1.193	1.132		0.123			1.169	0.124	1.136		0.056		0.112	0.111			1.200	0.067	0.239				0.088
		(0.52)	(0.52)				(0.57)		(0.42)	(0.34)		(0.18)			(0.41)	(0.07)	(0.66)		(0.12)		(0.14)	(0.16)			(0.32)	(0.08)	(0.21)				(0.15)
ESP				0.894		0.032	0.152					0.123				0.078		0.017			1.377	0.106	0.009	1.200		0.039				0.363	0.245
				(0.60)		(0.03)	(0.02)					(0.12)				(0.08)		(0.03)			(0.27)	(0.16)	(0.01)	(0.32)		(0.09)				(0.10)	(0.01)
SWE			0.033	0.230		0.151	0.033		0.033	0.031	0.037				0.039	0.076				0.089		0.344		0.067	0.039		1.488				1.404
			(0.08)	(0.24)		(0.00)	(0.08)		(0.08)	(0.09)	(0.11)				(0.10)	(0.08)				(0.01)		(0.51)		(0.08)	(0.09)		(0.41)				(0.14)
CHE		0.360	0.329	0.486			0.251	0.575	0.327	0.256				0.029	0.224	0.094	0.363				0.214	1.444		0.239		1.488				0.477	
		(0.08)	(0.07)	(0.40)			(0.07)	(0.88)	(0.05)	(0.04)				(0.03)	(0.05)	(0.15)	(0.51)				(0.19)	(0.28)		(0.21)		(0.41)				(0.54)	
THA	0.037			1.643	1.087	1.392		0.019						1.003		0.171	0.168				0.425		0.544							0.200	1.430
	(0.04)			(0.11)	(0.74)	(0.73)		(0.02)						(0.55)		(0.26)	(0.32)				(0.07)		(0.15)							(0.41)	(0.08)
TUR						0.058						0.098																			0.074
						(0.02)						(0.10)																			(0.00)
GBR				0.512							0.461	0.061	0.019		0.008	0.048	0.071	0.091							0.363		0.477	0.200			
				(0.39)							(0.10)	(0.09)	(0.04)		(0.03)	(0.15)	(0.14)	(0.01)							(0.10)		(0.54)	(0.41)			
USA		0.230	0.169	0.446	0.013		0.259	0.311	0.273	0.031	0.250				0.233	0.608				0.226	0.405		0.242	0.088	0.245	1.404		1.430	0.074		
		(0.01)	(0.04)	(0.07)	(0.09)		(0.01)	(0.01)	(0.01)	(0.02)	(0.02)				(0.02)	(0.09)				(0.01)	(0.08)		(0.02)	(0.15)	(0.01)	(0.14)		(0.08)	(0.00)		

This table reports mean and standard deviation of weekly bilateral RER jump intensity of different country pairs based on ARJI-R^2_{t-1} model. Standard deviations are in parenthesis. Blank entries denote country pairs that yield no convergence or time-invariant jump intensity (insignificant ρ and γ) estimated by the ARJI-R^2_{t-1} model.

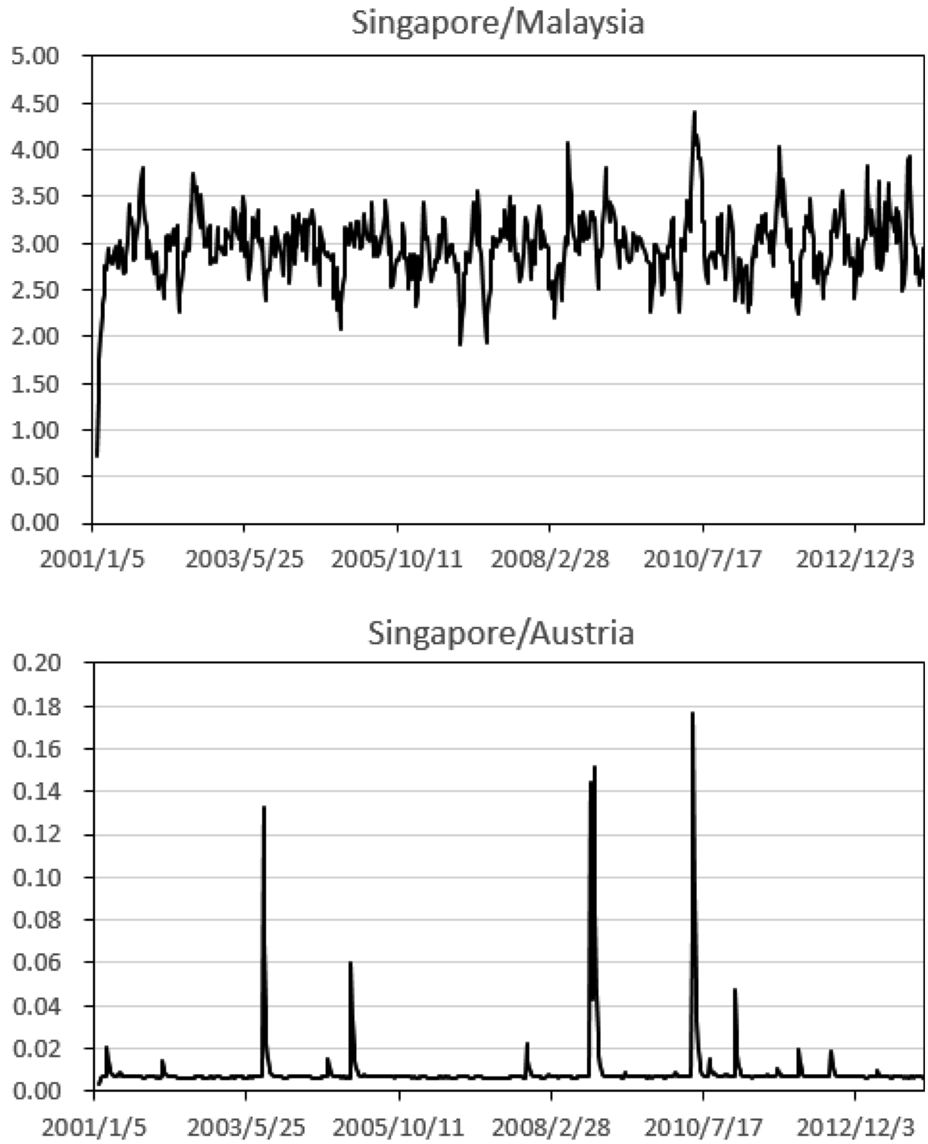

Fig. 1. Weekly bilateral RER jump intensities. This figure presents weekly jump intensities for RERs of Singapore/Malaysia and Singapore/Austria, estimated from the ARJI model. The sample period is from January 5, 2001 to December 27, 2013.

European sovereign debt crisis, when weekly RER jump intensity surged significantly.

To further demonstrate the efficiency of the ARJI models in capturing jump dynamics of bilateral RERs, I calculate the average of weekly bilateral RER jump intensities across all the country pairs and plot the series in Fig. 2.The graph show that the jump intensity estimates tend to increase dramatically during the financial crisis and other turbulent time periods, suggesting that the ARJI model can provide a good measure of the bilateral RER jump dynamics for the sample countries.

Table 2 reports the summary statistics for the explanatory variables. The mean value for the ratio of external debt liabilities to GDP (***EXTDEBT***) is twice as much as the mean value for the ratio of external equity liabilities to GDP (***EXTEQUITY***). It suggests that the sample countries tend to use more debt than equity as their external financing instrument. I include 930 country pairs in the first-stage estimation of the 2SLS approach; only the 430 pairs that yield time-varying jump intensities are then included in the second-stage estimation. Thus, I have more observations in the first-stage than in the second-stage estimation.

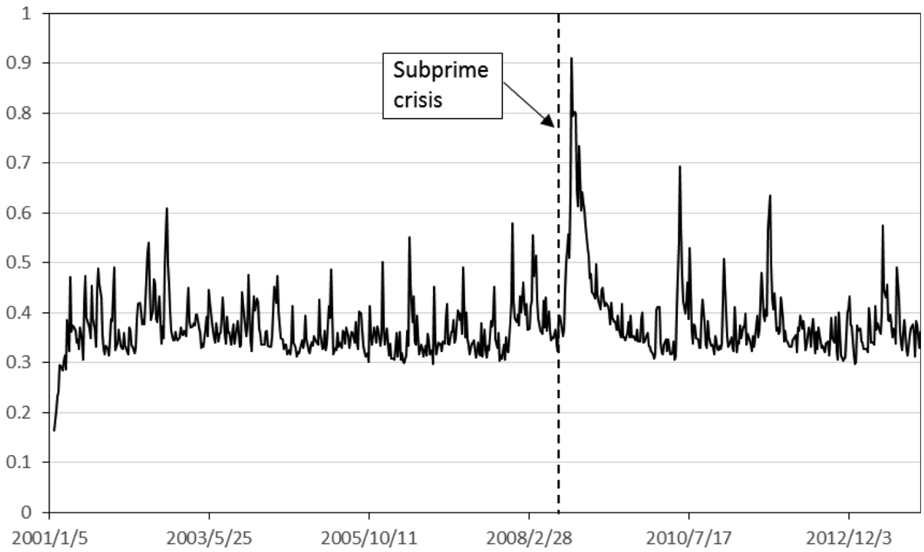

Fig. 2. Average weekly bilateral RER jump intensities. This figure presents average weekly bilateral RER jump intensities across all the country pairs, estimated from the ARJI model. The sample period is from January 5, 2001 to December 27, 2013.

Table 2
Summary statistics of the explanatory variables.

Variable	Obs.	Mean	Std. Dev.	Min	Max
EXTDEBT	6421	0.016	0.033	0.000	0.409
EXTEQUITY	10,102	0.008	0.028	0.000	0.627
Trade	12,051	0.018	0.041	0.000	0.524
Cycle	5286	0.019	0.025	0.000	0.365
FIN	5286	0.955	0.458	0.228	2.225
GDPperca	5286	0.029	0.019	0.000	0.088

This table reports the summary statistics of the explanatory variables in Models (1). ***EXTDEBT/EXTEQUITY*** is measured as external debt/equity liabilities of country *j* held by country *i* in period *t*, divided by host country *j*'s GDP. ***Trade*** is the ratio of bilateral exports and imports relative to host country *j*'s GDP in period *t*. ***Cycle*** is the conditional variance of the innovation to the growth rate differential between countries *i* and *j* in period *t*, constructed using the generalized autoregressive conditional heteroskedasticity (GARCH) specification of Bollerslev (1986). ***FIN*** is the ratio of liquid liability to GDP in host country *j* in period *t*. ***GDPperca*** is the GDP per capita (in million US dollars) of host country *j* in period *t*. All the variables are on an annual basis and the sample spans from 2001 to 2013.

4. Empirical results

4.1. The impact of external financial liabilities on bilateral RER jump intensities

In this subsection, I examine whether and how different types of external financial liabilities contribute to the time-variation of bilateral RER jump intensities.

Since external financial liabilities and bilateral trade flows are potentially endogenous, I regress each of these variables on different sets of exogenous variables. Tables 3 and 4 report the results of the first stage regressions for external financial liabilities and bilateral trade flows respectively. Almost all the coefficients carry the expected sign and are statistically significant.[5] For example, the external financial liabilities and trade decrease as the distance increases. The countries with common language, border, and EMU membership will have more bilateral trade flows. The R^2 is 0.206 for the regression of external debt liabilities, 0.072 for external equity liabilities, and 0.449 for trade flows. It reveals that the first stage regressions perform reasonably well. Predicted values from all the equations are retrieved and are used below as explanatory variables instead of the actual values.

[5] For bilateral trade flows, the coefficient on the log of host country *j*'s GDP is negative. This may be due to the fact that I use the ratio of bilateral exports and imports relative to host country *j*'s GDP as the dependent variable. When host country *j*'s log of GDP appears as a regressor in the right hand side of the regression, the increase of host country *j*'s GDP may reduce the ratio of bilateral exports and imports relative to host country *j*'s GDP.

Table 3
Determinants of external financial liabilities.

Dependent variable	External debt	External equity
Dis	-0.005^{***}	-0.001^{***}
	(−10.22)	(−3.16)
Lang	0.011^{***}	0.008^{***}
	(7.74)	(9.01)
EMU	0.020^{***}	-0.003^{***}
	(12.58)	(−4.51)
gdpperca	0.004^{***}	0.004^{***}
	(5.68)	(8.30)
Creditor	-0.002^{***}	-0.004^{***}
	(−3.95)	(−13.47)
Corruption	0.006^{***}	−0.0004
	(4.43)	(−0.40)
Anti_selfdealing		0.006^{***}
		(13.81)
Anti_director		-0.003^{***}
		(−4.98)
Constant	-0.041^{***}	-0.041^{***}
	(−3.46)	(−6.13)
Year Effects	Yes	Yes
Observations	6421	10,102
R2	0.206	0.072

Column (1) in this table reports the estimation results from the following model:
$EXTDEBT_{ij,t} = \alpha_0 + \alpha_1 Dis_{ij} + \alpha_2 Lang_{ij} + \alpha_3 EMU_{ij} + \alpha_4 gdpperca + \alpha_5 Creditor_{ij} + \alpha_6 Corruption_{ij} + \gamma_t + \varepsilon_{ij,t}$,
and column (2) in this table reports the estimation results from the following model:
$EXTEQUITY_{ij,t} = \alpha_0 + \alpha_1 Dis_{i,j} + \alpha_2 Lang_{ij} + \alpha_3 EMU_{ij} + \alpha_4 gdpperca + \alpha_5 Creditor_{ij} + \alpha_6 Corruption_{ij} + \alpha_7 Anti\_selfdealing_{ij} + \alpha_8 Anti\_director_{ij}$.
$+ \gamma_t + \varepsilon_{ij,t}$
EXTDEBT/EXTEQUITY is measured as external debt/equity liabilities of country *j* held by country *i* in period *t*, divided by host country *j*'s GDP. ***Dis*** is the log of the distance between the main business centers of countries *i* and *j*. ***Lang*** is a dummy variable equaling 1 if the two countries share a common language and 0 otherwise. ***EMU*** is a dummy variable equaling 1 if the two countries share joint EMU membership and 0 otherwise. ***gdpperca*** is the log of the product of GDP *per capita* of countries *i* and *j* in period *t*. ***Creditor*** is the log of the product of the creditor rights indicators of countries *i* and *j*. ***Corruption*** is the log of the product of the corruption indexes of countries *i* and *j*. ***Anti_selfdealing*** is the log of the product of the anti-self dealing indexes of countries *i* and *j*, and ***Anti_director*** is the log of the product of the anti-director indexes of countries *i* and *j*. All the variables are on an annual basis and the sample spans from 2001 to 2013. White (1980) robust standard errors adjusted for heteroskedasticity and country-pair-level clustering are used in the estimation. Coefficient estimates significantly different from zero at 10%, 5%, and 1% level are marked *, ** and ***, respectively.

Table 5 reports the results of the second-stage fixed effects regressions. Columns (1)-(2) report estimation results for external debt liabilities. Columns (3)-(4) report estimation results for external equity liabilities. In columns (2) and (4) the U.S. observations are excluded. Consistent with the standard OCA theory, across columns (1)-(4) the coefficients on ***Cycle*** is positive and statistically significant, suggesting that the increase of business cycle asymmetry increases the desirability of a flexible exchange rate as an adjustment mechanism. The coefficients on ***Trade*** carry the expected signs, but are not statistically significant. Most importantly, for the external financial liability variables (***EXTDEBT*** and ***EXTEQUITY***), I observe significantly negative coefficients, indicating that external financial linkage do help reduce RER jumps. Finally, while the coefficients on the interaction term ***FIN×EXTDEBT*** are positive and statistically significant, the coefficients on the interaction term ***FIN×EXTEQUITY*** are statistically insignificant. It indicates that domestic financial development can help attenuate the negative effect of external debt liabilities on RER jumps, but it does not help reduce the negative effect of external equity liabilities.

4.2. The transmission mechanisms between external financial liabilities and RER jump intensities

In this subsection I conduct some analysis to further explore the underlying transmission mechanisms through which different types of external financial liabilities exert a negative effect on bilateral RER jump intensities.

4.2.1. The balance-sheet channel

As aforementioned, external debt liabilities may help stabilize exchange rate fluctuations through the balance-sheet channel and the risk-sharing channel. In terms of the balance-sheet channel, Devereux and Lane (2003) suggest that the presence of external debt makes countries more reluctant to tolerate high exchange rate volatility, especially for those countries with binding borrowing constraints. Therefore, if the balance sheet effects account for what I found in the previous section, I should observe countries facing more credit constraints being more sensitive to RER jump risks when external debt liabilities increase and the lack of such pattern when external equity liabilities increase.

Table 4
Gravity equations for bilateral trade flows.

Regressors	Coefficients	t-value
Dis	−0.009**	−14.98
Lang	0.005**	5.03
EMU	0.008**	5.53
Bor	0.039**	13.94
$\boldsymbol{gdp_j}$	−0.006**	−17.67
$\boldsymbol{gdp_i}$	0.012**	21.96
Landl	−0.008**	−10.85
Island	0.005**	6.25
Area	−0.003**	−18.92
$\boldsymbol{pop_j}$	0.002**	10.01
$\boldsymbol{pop_i}$	0.003**	7.30
Colony	0.007**	2.99
NAFTA	0.075**	4.66
APEC	0.029**	19.44
Year Effects	Yes	
Observations	12,051	
R2	0.449	

The table reports the estimation results from the following model:

$$Trade_{ij,t} = \alpha_0 + \alpha_1 Dis_{ij} + \alpha_2 Lang_{ij} + \alpha_3 EMU_{ij} + \alpha_4 Bor_{ij} + \alpha_5 gdp_{i,t} + \alpha_6 gdp_{j,t} + \alpha_7 Landl_{ij} + \alpha_8 Island_{ij} + \alpha_9 Area_{ij} + \alpha_{10} pop_{i,t} + \alpha_{11} pop_{j,t}.$$
$$+ \alpha_{12} Colony_{ij} + \alpha_{13} NAFTA_{ij} + \alpha_{14} APEC_{ij} + \gamma_t + \varepsilon_{ij,t}$$

Trade is the ratio of bilateral exports and imports relative to host country *j*'s GDP in period *t*. ***Dis*** is the log of the distance between the main business centers of country *i* and country *j*. ***Lang*** is a dummy variable equaling 1 if the two countries share a common language and 0 otherwise. ***EMU*** is a dummy variable equaling 1 if the two countries share joint EMU membership and 0 otherwise. ***Bor*** is a dummy variable equaling 1 if the two countries share a common border and 0 otherwise. $\boldsymbol{gdp_i}$ and $\boldsymbol{gdp_j}$ are the log of the GDPs of countries *i* and *j* in period *t*, respectively. ***Lang*** is the number of landlocked countries in the country-pair (0, 1, or 2). ***Island*** is the number of island nations in the pair (0, 1, or 2). ***Area*** is the log of the product of the areas of countries *i* and *j* (in square kilometers).$\boldsymbol{pop_i}$ and $\boldsymbol{pop_j}$ are the log of the populations of countries *i* and *j* in period *t*, respectively. ***Colony*** is a dummy variable equaling 1 if country *i* ever colonized country *j* or vice versa and 0 otherwise. ***NAFTA*** is a dummy variable equaling 1 if the two countries share joint NAFTA membership and 0 otherwise. ***APEC*** is a dummy variable equaling 1 if the two countries share joint APEC membership and 0 otherwise. All the variables are on an annual basis and the sample spans from 2001 to 2013. White (1980) robust standard errors adjusted for heteroskedasticity and country-pair-level clustering are used in the estimation. Coefficient estimates significantly different from zero at 10%, 5%, and 1% level are marked *, ** and ***, respectively.

To test the existence of the balance-sheet channel, I consider two measures of credit constraint for host country *j*. First, I divide the host countries into the set of developing countries and the set of developed countries. The intuition behind this is that developing counties are more likely to face credit constraints than developed countries. Second, I consider sovereign credit ratings produced by Standard and Poor's (S&P) for the host countries. I define countries facing more/less credit constraints as those with S&P's long-term sovereign credit ratings (foreign currency denominated debt) below/above or equal to AA+.[6]

Tables 6 and 7 report the subsample estimation results for the test of the balance-sheet channel. In both tables I observe that while external debt liabilities only significantly reduce bilateral RER jump intensities for countries facing more credit constraints, external equity liabilities significantly reduce bilateral RER jump intensities for both subsamples. Consistent with the balance-sheet effect in the open economy literature, it indicates that external debt liabilities reduce RER jump intensities through the balance-sheet channel. To check the robustness, I also compute the net effect of external debt/equity liabilities on RER jump intensities in each column. The net effect equals $\text{std}(EXTFIN) \times 100\% \times (\beta_{EXTFIN} + \beta_{FIN\times EXTFIN} \times meanFIN_j)$ if both β_{EXTFIN} and $\beta_{FIN\times EXTFIN}$ are statistically significant or $\text{std}(EXTFIN) \times 100\% \times \beta_{EXTFIN}$ if only β_{EXTFIN} is statistically significant, where $\text{std}(EXTFIN)$ implies a one standard deviation increase in host country *j*'s external financial liabilities to GDP and $meanFIN_j$ is the mean value of the proxy for host country *j*'s domestic financial development. The net effect of external debt liabilities is more pronounced for countries facing more credit constraints, thus reinforce the implications of the subsample estimation results.

4.2.2. The risk-sharing channel

Both external debt and equity liabilities can help stabilize exchange rate fluctuations through the risk-sharing channel. If this is the case, the effect of external financial liabilities on RER jump intensities is expected to be increasingly pronounced for country pairs with higher degree of business cycle asymmetry.

To test the existence of the risk-sharing channel, I define country pairs with higher/lower degree of business cycle asymmetry if

[6] S&P's sovereign ratings include long-term ratings and their outlooks for the six months hence for foreign currency denominated debt. The long-term ratings range from AAA (highest credit quality) to D/SD (default/selective default) and these ratings are attached with rating outlook that varies from Credit Watch-Positive to Credit Watch-Negative. The ratings of BBB- and above are considered investment grade and the ratings BB+ and below are considered speculative.

Table 5
Bilateral RER jump intensity regressions.

	Full sample	U.S. excluded	Full sample	U.S. excluded
Cycle	1.145***	1.154***	1.152***	1.128***
	(4.16)	(4.04)	(4.41)	(4.20)
Trade	−2.997	−3.522	−0.081	−0.121
	(−1.34)	(−1.49)	(−0.03)	(−0.05)
FIN	−0.098	−0.080	0.007	−0.014
	(−1.16)	(−0.89)	(0.07)	(−0.15)
EXTDEBT	−18.806***	−20.942***		
	(−4.81)	(−5.16)		
FIN×EXTDEBT	14.503***	14.550***		
	(6.12)	(5.96)		
EXTEQUITY			−52.894***	−65.457***
			(−6.93)	(−7.88)
FIN×EXTEQUITY			3.230	7.333
			(0.69)	(1.58)
GDPperca	−1.321	−1.518	−0.212	−0.604
	(−0.81)	(−0.91)	(−0.13)	(−0.36)
Constant	2.196***	2.158***	2.412***	2.430***
	(20.79)	(18.86)	(20.83)	(19.41)
Year Effects	Yes	Yes	Yes	Yes
Country-pair Effects	Yes	Yes	Yes	Yes
Observations	5286	4800	5286	4800
R2	0.203	0.216	0.207	0.222
No. of group	428	390	428	390

The table reports the estimation results from the following model:
$$ln(\lambda_{ijt}) = \alpha_0 + \beta_1 Cycle_{ij,t} + \beta_2 Trade_{ij,t} + \beta_3 FIN_{j,t} + \beta_4 EXTFIN_{ij,t}$$
$$+\beta_5 EXTFIN_{ij,t} \times FIN_{j,t} + \beta_6 GDPperca_{j,t} + \gamma_t + \alpha_{1,ij} + \varepsilon_{ij,t}.$$
$\boldsymbol{ln(\lambda_{ijt})}$ is the log of bilateral RER jump intensities of the corresponding country pair in period t. Columns (1)-(2) report estimation results for external debt liabilities. Columns (3)-(4) report estimation results for external equity liabilities. In columns (2) and (4) the U.S. observations are excluded. The explanatory variables include the conditional variance of the innovation to the growth rate differential between countries i and j in period t (**Cycle**), constructed using the generalized autoregressive conditional heteroskedasticity (GARCH) specification of Bollerslev (1986); the predicted value of bilateral trade flows between countries i and j in period t, estimated from Table 4 (**Trade**); the ratio of liquid liability to GDP in host country j in period t (**FIN**); the predicted value of external debt/equity liabilities between countries i and j in period t, estimated from Table 3 (**EXTDEBT/EXTEQUITY**); and GDP per capita (in million US dollars) of host country j in period t (**GDPperca**). All the variables are on an annual basis and the sample spans from 2001 to 2013. White (1980) robust standard errors adjusted for heteroskedasticity and country-pair-level clustering are used in the estimation. Coefficient estimates significantly different from zero at 10%, 5%, and 1% level are marked *, ** and ***, respectively.

the value of the proxy for business cycle asymmetry (***Cycle***) for the corresponding country pair is above/below the sample median. In addition, as a robustness check, I follow Calderón and Kubota (2018) and compute each country pair's volatility of productivity shocks (***Dif_prod***) as the standard deviation of annual changes in the ratio of country *j*'s to country *i*'s labor productivity. Labor productivity is the ratio of real GDP to total employment. Then I define country pairs with higher/lower degree of business cycle asymmetry if their volatility of productivity shocks is above/below the sample median. The intuition behind this is that labor productivity is a key economic indicator commonly used to measure economic performance. According to the OECD, in most OECD countries, labor productivity tends to increase over economic booms and decrease during recessions. Thus if the volatility of labor productivity shocks is high, it is very likely that the degree of business cycle asymmetry is also high for the corresponding country pair.

Tables 8 and 9 report the subsample estimation results for the test of the risk-sharing channel. Consistent with my predictions, in both tables I observe a significantly negative effect of external debt/equity liabilities on bilateral RER jump intensities for country pairs with higher degree of business cycle asymmetry. Similarly, I also compute the net effect of external debt/equity liabilities on RER jump intensities to check the robustness. Interestingly, I find that the net effect of external equity liabilities is much stronger than that of external debt liabilities. For example, in Table 8 (Table 9), while a one standard deviation increase in external equity liabilities reduces bilateral RER jump intensity by 50.76 (41.66) percent for country pairs with higher degree of business cycle asymmetry, a one standard deviation increase in external debt liabilities only reduces bilateral RER jump intensity by 14.36 (5.27) percent. It implies that external equities play a more important role in international risk sharing.

4.2.3. Other potential transmission mechanisms

To investigate the mechanisms by which external financial liabilities affect bilateral RER jump intensities more thoroughly, I interact each of the control variables with external financial liabilities (i.e., external debt liability and external equity liability) and

Table 6
Test of the balance-sheet channel I.

	Developing	Developed	Developing	Developed
Cycle	0.639*	1.344**	0.802**	1.405***
	(1.78)	(2.59)	(2.42)	(3.08)
Trade	0.358	−11.544***	3.141	18.572**
	(0.09)	(−2.87)	(0.69)	(2.55)
FIN	−0.302*	−0.097	−0.118	0.051
	(−1.93)	(−0.94)	(−0.70)	(0.45)
EXTDEBT	−32.965***	−0.034		
	(−4.81)	(−0.00)		
FIN×EXTDEBT	25.907***	11.844***		
	(5.38)	(4.14)		
EXTEQUITY			−81.827***	−111.951***
			(−5.06)	(−4.37)
FIN×EXTEQUITY			22.957***	−1.531
			(3.90)	(−0.21)
GDPperca	9.886	−6.199***	9.748	5.849*
	(1.26)	(−3.06)	(1.22)	(1.66)
Constant	2.388***	2.273***	2.459***	2.377***
	(19.32)	(14.57)	(17.86)	(14.70)
Year Effects	Yes	Yes	Yes	Yes
Country-pair Effects	Yes	Yes	Yes	Yes
Net effect of ***EXTFIN***	−12.17%	/	−42.69%	−76.31%
Observations	1911	3375	1911	3375
R2	0.189	0.224	0.196	0.227
No. of group	147	281	147	281

The table reports subsample estimation results from the following model:

$$ln(\lambda_{ijt}) = \alpha_0 + \beta_1 Cycle_{ij,t} + \beta_2 Trade_{ij,t} + \beta_3 FIN_{j,t} + \beta_4 EXTFIN_{ij,t} + \beta_5 EXTFIN_{ij,t} \times FIN_{j,t} + \beta_6 GDPperca_{j,t} + \gamma_t + \alpha_{1,ij} + \varepsilon_{ij,t}.$$

Columns (1) and (3) report estimation results for the developing countries, and columns (2) and (4) report estimation results for the developed countries. The net effect of **EXTFIN** in each column equals std($EXTFIN$) × 100% × ($\beta_{EXTFIN} + \beta_{FIN\times EXTFIN} \times meanFIN_j$) if both β_{EXTFIN} and $\beta_{FIN\times EXTFIN}$ are statistically significant or std($EXTFIN$) × 100% × β_{EXTFIN} if only β_{EXTFIN} is statistically significant, where std($EXTFIN$) implies a one standard deviation increase in host country j's external financial liabilities to GDP. The rest of the setup of this table is identical to Table 5. White (1980) robust standard errors adjusted for heteroskedasticity and country-pair-level clustering are used in the estimation. Coefficient estimates significantly different from zero at 10%, 5%, and 1% level are marked *, ** and ***, respectively.

include the interaction terms in the regressions.[7] Table 10 reports the estimation results. Consistent with the results of subsample analysis in the previous subsection, I find that the increase of business cycle asymmetry will strengthen the negative impact of external financial liabilities on bilateral RER jump intensities, indicating that both external debt liabilities and equity liabilities reduce bilateral RER jump risk through a risk-sharing channel.

More importantly, I find that the increase of trade openness attenuates the negative impact of external debt liabilities on bilateral RER jump intensities. It suggests that trade openness erodes the effectiveness of external debt liabilities in reducing bilateral RER jump risk. This might be because higher degree of openness to trade makes a country more exposed to shocks coming from abroad, thus eliminating the negative effect of external debt liabilities on bilateral RER jump risk.

Finally, the significantly positive coefficient on ***EXTDEBT×GDPperca*** suggests that external debt liabilities play a more significant role in reducing bilateral RER jump risk for less developed countries (with lower GDP *per capita*), which further supports the existence of the balance-sheet channel.

4.3. Robustness check and discussion

In this paper, I adopt the 2SLS approach to address potential endogeneity problems. To ensure the appropriateness of this approach, I conduct a regression-based Hausman test.[8] Specifically, in the first stage, I regress the potential endogenous variables against all the explanatory and instrumental variables. In the second stage, the residuals of the endogenous variables are added to the original regression specification as additional regressors. I find that the coefficients on the residuals of external financial liabilities are statistically significant, thus I can reject the null hypothesis of exogeneity and use the instrument variables. The results are not reported here due to space limitations, but they are available upon request.

Consequently, the results suggest that both external debt and equity liabilities significantly reduce RER jumps, but through

[7] I would like to thank the anonymous referee for this suggestion.
[8] I would like to thank the anonymous referee for suggesting me conduct this test.

Table 7
Test of the balance-sheet channel II.

	Below AA+	Above AA+ (AA + included)	Below AA+	Above AA+ (AA + included)
Cycle	0.865***	1.493**	0.924***	1.585***
	(2.66)	(2.55)	(3.01)	(3.05)
Trade	−1.222	−15.342***	0.646	7.982
	(−0.36)	(−3.36)	(0.19)	(1.14)
FIN	−0.110	−0.045	0.029	0.093
	(−1.01)	(−0.29)	(0.23)	(0.56)
EXTDEBT	−26.140***	7.303		
	(−4.88)	(0.89)		
FIN×EXTDEBT	13.879***	11.481***		
	(4.18)	(2.66)		
EXTEQUITY			−59.358***	−82.175***
			(−5.51)	(−3.14)
FIN×EXTEQUITY			4.961	2.111
			(0.89)	(0.21)
GDPperca	−1.526	−3.611	−1.325	5.809
	(−0.33)	(−1.44)	(−0.27)	(1.55)
Constant	2.069***	2.095***	2.165***	2.201***
	(21.74)	(11.69)	(20.90)	(11.89)
Year Effects	Yes	Yes	Yes	Yes
Country-pair Effects	Yes	Yes	Yes	Yes
Net effect of ***EXTFIN***	−13.23%	/	−40.80%	−58.40%
Observations	2588	2698	2588	2698
R2	0.203	0.208	0.21	0.208
No. of group	222	257	222	257

The table reports subsample estimation results from the following model:
$ln(\lambda_{ijt}) = \alpha_0 + \beta_1 Cycle_{ij,t} + \beta_2 Trade_{ij,t} + \beta_3 FIN_{j,t} + \beta_4 EXTFIN_{ij,t}$
$+\beta_5 EXTFIN_{ij,t} \times FIN_{j,t} + \beta_6 GDPperca_{j,t} + \gamma_t + \alpha_{1,ij} + \varepsilon_{ij,t}$.
Columns (1) and (3) report estimation results for host countries facing more credit constraints based on S&P's long-term sovereign credit ratings (foreign currency denominated debt), and columns (2) and (4) report estimation results for host countries facing less credit constraints. The net effect of **EXTFIN** in each column equals $\text{std}(EXTFIN) \times 100\% \times (\beta_{EXTFIN} + \beta_{FIN\times EXTFIN} \times meanFIN_j)$ if both β_{EXTFIN} and $\beta_{FIN\times EXTFIN}$ are statistically significant or $\text{std}(EXTFIN) \times 100\% \times \beta_{EXTFIN}$ if only β_{EXTFIN} is statistically significant, where $\text{std}(EXTFIN)$ implies a one standard deviation increase in host country j's external financial liabilities to GDP. The rest of the setup of this table is identical to Table 5. White (1980) robust standard errors adjusted for heteroskedasticity and country-pair-level clustering are used in the estimation. Coefficient estimates significantly different from zero at 10%, 5%, and 1% level are marked *, ** and ***, respectively.

different transmission mechanisms. Specifically, while external debt liabilities reduce RER jump intensities through a balance-sheet as well as a risk-sharing channel, external equity liabilities reduce RER jump intensities only through a risk-sharing channel. This might be the reason why the development of domestic financial sectors can help attenuate the negative effect of external debt liabilities, but not the negative effect of external equity liabilities. As suggested by Devereux and Lane (2003), for countries with more sophisticated domestic financial sectors, external debt liabilities are less relevant for exchange rate policy, since credit constraints are less binding in these countries.

Finally, there is also evidence suggesting that a country's openness to trade will attenuate the negative impact of external financial liabilities on bilateral RER jump risk. Although the theoretical implication of this finding is not the main focus of this paper, I have left this as a possible direction for future research.

Table 8
Test of the risk-sharing channel I.

	Cycle above median	***Cycle*** below median	***Cycle*** above median	***Cycle*** below median
Cycle	0.495	12.256	0.543*	13.163*
	(1.56)	(1.64)	(1.85)	(1.71)
Trade	−3.882*	−1.623	−0.652	−0.445
	(−1.71)	(−0.30)	(−0.28)	(−0.07)
FIN	−0.086	0.032	0.003	0.147
	(-0.88)	(0.21)	(0.04)	(0.82)
EXTDEBT	−31.395***	3.826		
	(−5.24)	(0.52)		
FIN×EXTDEBT	18.142***	5.689		
	(4.17)	(1.46)		
EXTEQUITY			−72.001***	−4.094
			(−6.67)	(−0.25)
FIN×EXTEQUITY			2.807	−5.853
			(0.42)	(−0.61)
GDPperca	0.186	−4.493*	1.034	−3.539
	(0.09)	(−1.70)	(0.51)	(−1.33)
Constant	2.189***	1.822***	2.417***	1.903***
	(18.86)	(8.25)	(19.34)	(8.34)
Year Effects	Yes	Yes	Yes	Yes
Country-pair Effects	Yes	Yes	Yes	Yes
Net effect of ***EXTFIN***	−14.36%	/	−50.76%	/
Observations	2695	2591	2695	2591
R2	0.236	0.212	0.246	0.211
No. of group	310	325	310	325

The table reports subsample estimation results from the following model:
$$ln(\lambda_{ijt}) = \alpha_0 + \beta_1 Cycle_{ij,t} + \beta_2 Trade_{ij,t} + \beta_3 FIN_{j,t} + \beta_4 EXTFIN_{ij,t}$$
$$+\beta_5 EXTFIN_{ij,t} \times FIN_{j,t} + \beta_6 GDPperca_{j,t} + \gamma_t + \alpha_{1,ij} + \varepsilon_{ij,t}.$$
Columns (1) and (3) report estimation results for country pairs with the value of the proxy for business cycle asymmetry (**Cycle**) above median, and columns (2) and (4) report estimation results for country pairs with **Cycle** below median. The net effect of **EXTFIN** in each column equals $\text{std}(EXTFIN) \times 100\% \times (\beta_{EXTFIN} + \beta_{FIN\times EXTFIN} \times meanFIN_j)$ if both β_{EXTFIN} and $\beta_{FIN\times EXTFIN}$ are statistically significant or $\text{std}(EXTFIN) \times 100\% \times \beta_{EXTFIN}$ if only β_{EXTFIN} is statistically significant, where $\text{std}(EXTFIN)$ implies a one standard deviation increase in host country j's external financial liabilities to GDP. The rest of the setup of this table is identical to Table 5. White (1980) robust standard errors adjusted for heteroskedasticity and country-pair-level clustering are used in the estimation. Coefficient estimates significantly different from zero at 10%, 5%, and 1% level are marked *, ** and ***, respectively.

5. Conclusions

In this study, I investigate the causal impact of external financial liabilities on bilateral RER jump intensities of 31 economies over the period 2001–2013 and explore the underlying transmission channels. I find that bilateral RER jump intensities are significantly reduced by external debt/equity liabilities. In the subsample analysis, I find that countries facing more credit constraints will be more sensitive to RER jumps when external debt liabilities increase. This finding is consistent with the balance-sheet effect in the open economy literature. In addition, I find that country pairs with higher degree of business cycle asymmetry will be more sensitive to RER jumps when external financial liabilities (both debt and equity) increase, suggesting that external financial liabilities can reduce RER jump risk through the international risk-sharing channel.

This study extends the current literature by providing a different dimension to how external financial linkages affect exchange rate risk. It has some important policy implications for policymakers. For example, when a country faces severe credit constraints in the global capital market, the development of domestic financial market would be a choice to help avoid state insolvency caused by extreme exchange rate fluctuations.

Table 9
Test of the risk-sharing channel II.

	Dif_prod above median	***Dif_prod*** below median	***Dif_prod*** above median	***Dif_prod*** below median
Cycle	0.896***	0.195	0.829***	1.023
	(3.07)	(0.16)	(2.97)	(0.87)
Trade	−4.591	−2.587	−0.205	−0.884
	(−1.59)	(−0.70)	(−0.07)	(−0.22)
FIN	−0.063	−0.029	0.017	0.038
	(−0.57)	(−0.23)	(0.15)	(0.26)
EXTDEBT	−25.118***	2.287		
	(−4.71)	(0.32)		
FIN×EXTDEBT	21.832***	4.452		
	(5.78)	(1.24)		
EXTEQUITY			−59.470***	−18.394
			(−6.73)	(−1.06)
FIN×EXTEQUITY			−1.841	−3.561
			(−0.25)	(−0.40)
GDPperca	−0.332	−3.289	1.163	−2.726
	(−0.15)	(−1.43)	(0.51)	(−1.19)
Constant	2.409***	1.757***	2.594***	2.014***
	(21.69)	(8.30)	(21.50)	(7.91)
Year Effects	Yes	Yes	Yes	Yes
Country-pair Effects	Yes	Yes	Yes	Yes
Net effect of ***EXTFIN***	−5.27%	/	−41.66%	/
Observations	2,680	2,606	2,680	2,606
R2	0.209	0.222	0.215	0.223
No. of group	213	215	213	215

The table reports subsample estimation results from the following model:

$$\ln(\lambda_{ijt}) = \alpha_0 + \beta_1 Cycle_{ij,t} + \beta_2 Trade_{ij,t} + \beta_3 FIN_{j,t} + \beta_4 EXTFIN_{ij,t}$$
$$+\beta_5 EXTFIN_{ij,t} \times FIN_{j,t} + \beta_6 GDPperca_{j,t} + \gamma_t + \alpha_{1,ij} + \varepsilon_{ij,t}$$

Columns (1) and (3) report estimation results for country pairs with the volatility of productivity shocks (***Dif_prod***) above median, and columns (2) and (4) report estimation results for country pairs with ***Dif_prod*** below median. The net effect of ***EXTFIN*** in each column equals $\text{std}(EXTFIN) \times 100\% \times (\beta_{EXTFIN} + \beta_{FIN\times EXTFIN} \times meanFIN_j)$ if both β_{EXTFIN} and $\beta_{FIN\times EXTFIN}$ are statistically significant or $\text{std}(EXTFIN) \times 100\% \times \beta_{EXTFIN}$ if only β_{EXTFIN} is statistically significant, where $\text{std}(EXTFIN)$ implies a one standard deviation increase in host country *j*'s external financial liabilities to GDP. The rest of the setup of this table is identical to Table 5. White (1980) robust standard errors adjusted for heteroskedasticity and country-pair-level clustering are used in the estimation. Coefficient estimates significantly different from zero at 10%, 5%, and 1% level are marked *, ** and ***, respectively.

Table 10
Tests of other potential transmission mechanisms.

	(1)	(2)	(3)	(4)	(5)	(6)
EXTDEBT	−8.113*	−14.972***	−11.320***			
	(−1.96)	(−3.66)	(−2.82)			
EXTDEBT×Cycle	−74.383***					
	(−2.77)					
EXTDEBT×Trade		259.461***				
		(3.96)				
EXTDEBT×GDPperca			223.198***			
			(3.39)			
EXTEQUITY				−47.860***	−51.172***	−50.740***
				(−6.65)	(−7.28)	(−7.13)
EXTEQUITY×Cycle				−74.531**		
				(−2.34)		
EXTEQUITY×Trade					32.040	
					(0.19)	
EXTEQUITY×GDPperca						77.940
						(0.76)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5286	5286	5286	5286	5286	5286
R2	0.200	0.201	0.201	0.207	0.207	0.207
No. of group	428	428	428	428	428	428

Columns (1) and (3) in this table report estimation results from the following model:
$ln(\lambda_{ijt}) = \alpha_0 + \beta_1 Cycle_{ij,t} + \beta_2 Trade_{ij,t} + \beta_3 FIN_{j,t} + \beta_4 EXTFIN_{ij,t} + \beta_5 EXTFIN_{ij,t} \times Cycle_{ij,t} + \beta_6 GDPperca_{j,t} + \gamma_t + \alpha_{1,ij} + \varepsilon_{ij,t}$.
Columns (2) and (4) in this table report estimation results from the following model:
$ln(\lambda_{ijt}) = \alpha_0 + \beta_1 Cycle_{ij,t} + \beta_2 Trade_{ij,t} + \beta_3 FIN_{j,t} + \beta_4 EXTFIN_{ij,t} + \beta_5 EXTFIN_{ij,t} \times Trade_{ij,t} + \beta_6 GDPperca_{j,t} + \gamma_t + \alpha_{1,ij} + \varepsilon_{ij,t}$.
Columns (3) and (5) in this table report estimation results from the following model:
$ln(\lambda_{ijt}) = \alpha_0 + \beta_1 Cycle_{ij,t} + \beta_2 Trade_{ij,t} + \beta_3 FIN_{j,t} + \beta_4 EXTFIN_{ij,t} + \beta_5 EXTFIN_{ij,t} \times GDPperca_{j,t} + \beta_6 GDPperca_{j,t} + \gamma_t + \alpha_{1,ij} + \varepsilon_{ij,t}$.
To save space, only coefficients on the external financial variables and the interaction terms are reported. The rest of the setup of this table is identical to Table 5. White (1980) robust standard errors adjusted for heteroskedasticity and country-pair-level clustering are used in the estimation. Coefficient estimates significantly different from zero at 10%, 5%, and 1% level are marked *, ** and ***, respectively.

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Appendix A

List of developed and developing countries

Developed countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Israel, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Singapore, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.
Developing countries: Brazil, China, India, Indonesia, Malaysia, Mexico, South Africa, Thailand.

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