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Causality between banking and currency fragilities: A dynamic panel model

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ABSTRACT

A panel dynamic model both with and without a threshold is specified to reexamine the lead-lag relationship between banking and currency fragilities. We employ banking sector fragility (BSF) and exchange market pressure (EMP) as the proxies for banking and currency fragilities, respectively, where BSF is made up of real deposits, banks' real claims on the domestic private sector and the real foreign liabilities of banks, and EMP uses the weighted average of the exchange rate changes and foreign reserves. Among the banking sector fragilities, we consider three different proxies, namely, BSF1, BSF2 and BSF3, depending on the components used. Our 51 sample countries include 21 industrial and 30 developing countries. When the whole panel dynamic model is used, bilateral causality is found between the two fragilities using all sample countries. When using only industrial country data, the bilateral causation is found only between EMP and BSF2, but no relationship is found between BSF3 and EMP, or between BSF2* and EMP. When developing countries are employed, stronger bilateral causality is found between banking and currency fragilities. When the panel threshold dynamic model is used, the results overwhelmingly suggest that bilateral causality exists.

1. Introduction

Studying the relationship between currency and banking crises has recently drawn renewed attention. Studies of such crises are important because they are frequent in number, and they are extremely costly in terms of declines in real output. For example, as mentioned by Kaufman (2000), the losses arising from

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currency crises averaged 4.3% of the trend GDP and the losses from banking crises were significantly greater than those from the currency crises, averaging 11.6% of the trend GDP. In addition, banking crises lasted 3.1 years on average, or twice as long as currency crises. The estimated loss in terms of output was greater when the two crises occurred together than when each fragility was experienced separately. Hutchison and Noy (2005) find that both currency and banking crises are very damaging to emerging-market economies and the combined effect of the two crises occurring simultaneously is therefore about 13%–18% of output.[2] Thus, studying these two types of crises is a major public concern.

The causal relationship between the two types of crises is often investigated. One view is that causality may run from banking problems to currency crises. Velasco (1987) and Calvo (1997), for example, argue that a bank run can result in a currency attack if the increased liquidity associated with a government bailout of the banking system is inconsistent with a stable exchange rate. Obstfeld (1994) presents a similar view. A reverse chain of causality from a currency fragility to an onset of banking fragility is also well documented. Miller (1996), for example, demonstrates that a speculative attack on a currency can lead to a bank fragility if deposit money is used to speculate in the foreign exchange market and banks are loaned up. Chang and Velasco (2000) also show that the banking system, the exchange rate regime, and central bank credit policy are seen as parts of a mechanism intended to maximize the social welfare. If the mechanism fails, banking crises and speculative attacks on the currency board become possible.

The simultaneous occurrence of balance-of-payments and banking crises has also been researched. Kaminsky and Reinhart (1999) study a sample of 76 documented balance-of-payments crises and 26 banking crises, showing that problems in the banking sector typically precede a currency fragility but are not necessarily the immediate cause of such a fragility. In turn, however, the currency fragility deepens the banking fragility, activating a vicious spiral. Kaminsky (1998) proposes composite leading indicators of crises and suggests that the Asian crises are still forecastable. Glick and Hutchison (2001) find that the twin fragility phenomenon is mainly concentrated in a limited set of countries, i.e. financially-liberalized emerging-market economies. This implies that in financially-liberalized emerging-market economies, policy measures taken to help avoid a banking fragility or currency fragility have the additional benefit of lowering the probability of either one of them occurring. Goldfajn and Valdes (1997) develop a model linking capital flows to the twin fragility phenomenon. Kaufman (2000) also provides a detailed review.

Three empirical approaches are found to investigate the causal relationship between the two crises. The first one is the signal-to-noise ratio, proposed by Kaminsky and Reinhart (1999), that compares the unconditional probability and conditional probability of the two crises. The former is simply based on own information without there being any information regarding another fragility. The latter uses one fragility occurring on any day during the last 24 months to predict the probability of the other fragility occurring. Glick and Hutchison (2001) have suggested a second approach that involves the use of a parametric model. The currency and banking crises in their model function as dependent variables, which are assigned binary numbers of 0 and 1. They then adopt a multivariate probit model to explore the lead and lag relationship. In regard to the explanatory variables, however, the own lagged dependent variables are not considered. Such an approach differs from conventional lead-lag studies.

The above two approaches first of all identify the dates of the two crises. The dates of the currency fragility are defined by assessing whether the exchange market pressure (EMP), which is the weighted average of the percentage change in the exchange rate and foreign reserves, exceeds a certain threshold or not. This threshold is typically defined as the three standard deviations of the country's EMP (Eichengreen, Rose & Wyplosz, 1996; Kaminsky & Reinhart, 1999). The currency fragility occurs when the EMP exceeds this threshold, making the fragility a binary number. Alternatively, the identification of the dates of the banking fragility is based on the reading of institutional events and the studying of financial ratios. The former includes forced closures, mergers, or government intervention in the operations of financial institutions, runs on banks, and the extension of large-scale government assistance, whereas the latter includes measures for non-performing assets, and problem loans. The dates are then determined based on the subjective opinions of researchers. In relation to this, see Caprio and Klingebiel (1996) and Demirgüç-Kunt and Detragiache (1998a). Once the dates of the two crises are identified, the literature suggests that the conditional probability of a banking fragility provides a better prediction than a currency fragility.

[2] They, however, do not find that twin crises appear to contribute an additional negative impact on output growth above and beyond the combined effect of the two crises.

The last approach used by Shen (2002) is the panel cointegration method that requires proxies for the two fragilities. He uses the non-performing loan (NPL), aggregated from individual banks, as a proxy for the banking fragility, and EMP as the proxy for currency. Because of the limitations of the data, the sample span in his panel data covers only five years. Shen finds that these two series are cointegrated, suggesting a panel error correction model. Based on this new specification, his results demonstrate that a banking fragility precedes a currency fragility.

This paper proceeds along similar lines to past studies in terms of investigating the causality between banking and currency vulnerability using panel data. Our paper, however, differs from them in three respects. First, our focus is on the causality between banking and currency fragilities and not between their crises. Our banking sector fragility (BSF) is constructed based on Kibritçioğlu (2002)'s study. We do not consider the binary dummy of the banking fragility because the dummy variable may not exhibit enough variation to detect the possible causal relationship. Furthermore, the non-performing loan ratio is not used because of the short time span. Moreover, it is not a compulsory ratio for banks to report, and so many banks choose not to release the data, which substantially limits the sample size and time span. The use of BSF, which extends over a long time period, overcomes these weaknesses.

Our BSF at first includes the three factors of deposit withdrawal, over lending and foreign liabilities. Then, we exclude one factor to examine the robustness of the estimated results. We do this because one reason why the two sectors are intertwined is because the large foreign liabilities are held by banks. A fall in the exchange rate worsens the bank's liabilities and further exacerbates the values of exchange rate. This permits us to explore the question as to whether the relationship is related to the factor of foreign liabilities.

Next, a panel vector autoregressive (PVAR) model is employed to investigate the Granger causality between the two fragilities, making the model become a panel dynamic model. The estimation of a panel dynamic model using conventional fixed effects is biased because of the correlation between the lagged dependent variable and the errors. We therefore apply Arellano and Bond's (1991) instrumental variable method to remedy this weakness.

Finally, we further consider the inclusion of thresholds in the PVAR model, i.e. we examine the causality only when EMP and BSF are larger than the cutoff. This new model could be thought of as an extension of Hansen's (1999) non-dynamic threshold model; however, there are other differences. First, he removes the individual effect by subtracting the deviation from the group mean whereas we use the differenced form. Next, his threshold value is determined by the model but in our model it is determined based on prior knowledge. This new model, however, is still in its infancy and its asymptotic properties are unknown.[3]

The plan of this paper is as follows. Section 2 discusses the definitions of currency and banking fragilities, respectively. In Section 3, we introduce the PVAR model both with and without thresholds. In Section 4, we give a brief discussion of the data. The estimation results are reported in Section 5. We summarize our findings in Section 6.

2. Currency and banking fragilities

2.1. Currency fragility

Our definition of currency fragility measure is similar to that of currency crisis, and thus we introduce the currency crisis first. The crisis is typically defined as "large" changes in some indicator of actual or potential currency value. Such a change is generally taken to be synonymous with a "speculative attack" or with external pressure on the exchange rate. As a consequence, four definitions of a currency fragility have arisen based on identifying sufficiently sharp changes either in the exchange rate alone (Frankel & Rose, 1996), the weighted averages of exchange rates and foreign reserves (Kaminsky & Reinhart, 1999), the weighted averages of exchange rates, reserves, and interest rates (Eichengreen, Rose & Wyplosz, 1996) or a decline in imports (Kamin & Babson, 1999).

[3] For example, while the threshold is exogenously determined, the endogeneity problem exists when y is a dependent variable as well as a threshold. For the time being, we are uncertain how this endogenous problem affects our estimation results. The problem, however, may be mitigated when the threshold is different from the dependent variable.

The first three approaches are similar in nature except for the variables considered. The fourth approach chooses imports as the reference variable, which is less often used. The Kaminsky and Reinhart (1999) approach is adopted here since it is widely used. Their EMP is constructed as follows. Construct

$$\begin{aligned} &\mathrm{EMP}_{it} = w_1\%\mathrm{exch}_{it} + w_2\%\mathrm{fr}_{it} \\ &t = 1, 2, \ldots, T; i = 1, 2, \ldots, N \end{aligned} \tag{1}$$

where exch and fr are the real exchange rate and foreign reserve losses, respectively,[4] and w_1 and w_2 are the weighted averages using the inverse of the variance of percentage changes in the exchange rate and the foreign reserve, respectively, at time t for country i.[5] The subscripts i and t may be depressed for simplicity if no confusion is created. The percentage change in the exchange rate is calculated first by converting each local currency into the indirect quotation system after which the conventional approach is followed to calculate the growth rate. Therefore, the negative sign of the percentage change in the exchange rate means that there has been currency depreciation. The percentage change in the foreign reserve is self-evident. The currency crisis is defined when the EMP exceeds a certain threshold but currency fragility here simply employs EMP. Hence, the larger the negative EMP found, the higher will be the exchange rate depreciation and, hence, the greater will be the impending fragility.

2.2. Banking fragility

The sources of a banking fragility encompass two different aspects, the liability side and the asset side. In the past, the fragility has usually been related to the liability side, for example, a bank run is related to the liability side. Nowadays, the asset side has come more into the picture, for example, as the quality of loan assets deteriorates. By combining both conditions, Demirgüç-Kunt and Detragianche (1998b) identify banking sector distress as a situation where one of the following conditions holds: the ratio of non-performing assets to total assets in the banking system exceeds 10%; the cost of the rescue operation is at least 2% of GDP; banking sector problems have resulted in a large-scale nationalization of banks; and extensive bank runs have taken place or else emergency measures such as deposit freezes, prolonged bank holidays, or generalized deposit guarantees have been enacted by the government. The first three are related to the asset side and the last one to the liability side.

Kibritçioğlu (2002) constructs three banking sector fragility (BSF) indices based on both the asset and liability sides. Furthermore, his method helps us to trace the source of the banking fragility by removing each component in turn. The data used to construct his indices have been available quarterly for 22 years and hence the time span covers 88 time periods. The first BSF, which is referred to as BSF3, includes banks' real deposits (DEP), banks' real claims on domestic private sector (LEND) and the real foreign liabilities of banks (FOR). It is an average of the standardized values of the above “three” variables, that is,

$$\mathrm{BSF3}_t = \frac{(\Delta LEND_t - \mu_{\Delta LEND})/\sigma_{\Delta LEND} + (\Delta FOR_t - \mu_{\Delta FOR})/\sigma_{\Delta FOR} + (\Delta DEP_t - \mu_{\Delta DEP})/\sigma_{\Delta DEP}}{3}$$

where Δ denotes the seasonal (fourth) difference of variables, and μ and σ stand for the arithmetic average and standard deviation of these three variables, respectively.[6]

The BSF3 index is proposed to measure the fluctuations in the domestic banking sector. The decreases in the value of BSF3 may be interpreted as representing a tendency towards an increase in the fragility of the banking system. The theoretical reasoning behind this is the fact that banking sector fragilities are usually caused by the mean of substantial falls in bank deposits (due to bank withdrawals), claims on the private sector (due to the rise in non-performing loans) and foreign liabilities (due to an actual or potential depreciation in the domestic currency). A coincidental occurrence of these three events would enhance the severity of the impending banking sector problem.

[4] The exchange rate has been adjusted in terms of U.S. dollars per unit of local currency. In addition, since the interest rate data used are not available in many developing countries, they are excluded from our EMP.

[5] w_1 is equal to (1/var(%exch))/((1/var(%exch)+(1/var(%fr)) and w_2 is equal to (1/var(%fr))/((1/var(%exch)+(1/var(%fr)).

[6] The use of annual fluctuations rather than quarter-to-quarter changes is based on that banking fragilities being seen as those types of far-reaching financial difficulties that cannot be signaled simply by “quarterly” fluctuations in banking variables. They are caused over longer periods by powerful deteriorations in the banking sector.

It is worth noting that every fall in the BSF index does not necessarily imply that a banking system is moving into a (deep) systemic fragility. Kibritçioğlu (2002) thus proposes two alternative indices of banking fragility, BSF2 and BSF2*, where the former removes the changes in real bank deposits and the latter removes foreign liabilities. That is,

$$\mathrm{BSF2}_t = \frac{(\Delta LEND_t - \mu_{\Delta LEND})/\sigma_{\Delta LEND} + (\Delta FOR_t - \mu_{\Delta FOR})/\sigma_{\Delta FOR}}{2}$$

$$\mathrm{BSF2}_t^* = \frac{(\Delta LEND_t - \mu_{\Delta LEND})/\sigma_{\Delta LEND} + (\Delta DEP_t - \mu_{\Delta DEP})/\sigma_{\Delta DEP}}{2}.$$

Any deviation between BSF2 and BSF3 reflects the relative importance of bank runs in banking fragilities. If BSF2 is high but BSF3 is low, the banking fragility is less relevant to the liability side (deposits). Similarly, any deviation between BSF2* and BSF3 reflects the relative importance of foreign liabilities. If BSF2* is high and BSF3 is low, the banking fragility is caused more by deposit withdrawals and less by foreign liabilities.[7]

3. Econometric model

To investigate the lead-lag relationship in the panel, we adopt the following panel Granger causality and panel threshold Granger causality models.

3.1. Panel Granger causality model

The panel Granger causality model is

$$y_{i,t} = \alpha_{0,i} + \alpha_1 y_{i,t-1} + \alpha_2 y_{i,t-2} + \cdots + \alpha_p y_{i,t-p} + \beta_1 x_{i,t-1} + \beta_2 x_{i,t-2} + \cdots + \beta_p x_{i,t-p} + \varepsilon_{i,t} \tag{2}$$

where i and t denote country i and time t, respectively, p is the lag length, α and β are coefficients, and ε is the unobservable error term.

We examine the Granger causality from a banking fragility to a currency fragility when y is proxied by EMP and x is proxied by BSF; alternatively we examine the causality from a currency fragility to a banking fragility when y is proxied by BSF and x by EMP. The null hypothesis of no Granger causality is

$$H_0 : \beta_1 = \beta_2 = \cdots = \beta_p = 0.$$

To eliminate the country-specific effect, we take the first-difference of Eq. (2),

$$\begin{aligned} y_{i,t} - y_{i,t-1} = {} & \alpha_1 (y_{i,t-1} - y_{i,t-2}) + \alpha_2 (y_{i,t-2} - y_{i,t-3}) + \cdots + \alpha_p (y_{i,t-p} - y_{i,t-p-1}) + \beta_1 (x_{i,t-1} - x_{i,t-2}) \\ & + \beta_2 (x_{i,t-2} - x_{i,t-3}) + \cdots + \beta_p (x_{i,t-p} - x_{i,t-p-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}). \end{aligned} \tag{3}$$

Because the new error term $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$ is correlated with the lagged dependent variable, the use of the instrumental variables is required to deal with the likely endogeneity of the explanatory variables, and also the problem that, by construction, the new error term, $\varepsilon_{i,t} - \varepsilon_{i,t-1}$, is correlated with the lagged dependent variable, $y_{i,t-1} - y_{i,t-2}$. Under the assumptions that the error term, ε_t is not serially correlated, and the explanatory variables, x, are weakly exogenous (i.e. the explanatory variables are assumed to be uncorrelated with future realizations of the error term),[8] the generalized method of moment (GMM) estimators, suggested by Arellano and Bond (1991), is employed here.[9]

[7] Kibritçioğlu (2002) finds that Chile, Kenya, Mexico, Paraguay, Trinidad and Tobago and Venezuela exhibit a relatively high deposit and low foreign ratios.

[8] That is, the past x does not affect the future error terms, which is similar to the concept that the past y does not affect future errors.

[9] The application of this method can be found in Levine, Loayza and Beck (2000) and Rousseau and Wachtel (2000).

The orthogonal condition suggested by Arellano and Bond (1991) is

$$E\left[\left(\varepsilon_{i,t}-\varepsilon_{i,t-1}\right)y_{i,t-s}\right]=0,\quad s\geq 2, t=3,\dots,T$$
$$E\left[\left(\varepsilon_{i,t}-\varepsilon_{i,t-1}\right)x_{i,t-s}\right]=0,\quad s\geq 2, t=3,\dots,T.$$

Then, there are $(T-2)\times(T-1)/2$ orthogonal conditions.

3.2. Panel threshold Granger causality model

While Eq. (2) investigates the causality between EMP and BSF, it may deviate from the intrinsic meanings of currency and banking fragilities in the literature. The currency fragility is typically defined by examining whether EMP exceeds a threshold. Only when EMP exceeds a certain threshold, is the currency fragility deemed to occur (Kaminsky & Reinhart, 1999). We then divide each sample country into two regimes, "the currency fragility regime" and "the non-currency fragility regime" based on the threshold of $1.5\times\sigma_{\mathrm{EMP}_i}$, where σ_{EMP_i} is the standard deviation of the ith country's EMP.[10] The threshold of the banking fragility is −0.5, as suggested by Kibritçioğlu (2002), to distinguish the highly fragile banking systems from the less fragile banking systems. Hence, if BSF falls short of −0.5 it presents the "banking fragility" and above it the "non-banking fragility". Accordingly, we have a panel threshold Granger causality model as follows:

$$y_{i,t}=\alpha_{0,i}^{(1)}+\alpha_1^{(1)}y_{i,t-1}+\cdots+\alpha_p^{(1)}y_{i,t-p}+\beta_1^{(1)}x_{i,t-1}+\cdots+\beta_p^{(1)}x_{i,t-p}+\varepsilon_{i,t} \quad \text{under a currency fragility regime and/or banking fragility regime} \tag{4}$$

$$y_{i,t}=\alpha_{0,i}^{(2)}+\alpha_1^{(2)}y_{i,t-1}+\cdots+\alpha_p^{(2)}y_{i,t-p}+\beta_1^{(2)}x_{i,t-1}+\cdots+\beta_p^{(2)}x_{i,t-p}+\varepsilon_{i,t} \quad \text{under a non-currency fragility regime and/or non-banking fragility regime} \tag{5}$$

where y is EMP or BSF. We consider three specifications here. First, we consider only the currency fragility when BSF is employed as a dependent variable. Then, we consider only the banking fragility using EMP as a dependent variable. Last, we consider both the banking and currency fragilities regimes simultaneously. The first two models can reduce the endogeneity bias since the threshold is different from the dependent variable. These three approaches can help us to investigate the sensitivity of the models. As we mentioned in the Introduction, this dynamic panel threshold model is still in its infancy. This paper does not pursue its asymptotic properties but leaves such a task to future studies.

4. Data

Our data are obtained from *International Financial Statistics* published by the IMF. The sample period extends from 1980:Q1 to 2001:Q4 based on quarterly data. There are 51 countries used in this paper and they are further separated into two groups, the industrial countries (21) and the developing countries (30). The 21 industrial countries include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden and the UK, whereas the 30 developing countries comprise Argentina, Poland, Bolivia, Sierra Leone, Brazil, South Africa, Chile, Swaziland, Colombia, Thailand, Ecuador, Turkey, Egypt, Uruguay, Hong Kong, Venezuela, Indonesia, Zimbabwe, Israel, Jordan, Kenya, Korea, Malaysia, Mexico, Niger, Nigeria, Pakistan, Paraguay, Peru, and the Philippines.

Table 1 presents the averages of EMP, BSF3, BSF2 and BSF2* for the 51 countries, respectively. Recall that a negative EMP implies a high actual rate of exchange market pressure. Except for Jordan, Niger, Pakistan and Paraguay, positive EMPs are common but close to zero. This evidence, together with high standard deviations, suggests that most countries have experienced more or less exchange market pressure during some periods. Because the reduction in BSF3 indicates the fragility of the banking sector, a negative sign

[10] The k used here is 1.5 in order to have more observations available for estimation. Different authors choose different values of k. Kaminsky and Reinhart (1999) select 3, Glick and Hutchison (2001) select 2, and Eichengreen, Rose, and Wyplosz (1996) choose 1.5. Our reason for using 1.5 is to increase the size of sample for estimation.

Table 1
Basic statistics

	EMP		BSF3		BSF2		BSF2*	
Country name	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Argentina	0.0979	0.3973	2.9e−08	0.9001	5.4e−09	0.9583	3.6e−09	0.9476
Australia	0.0109	0.1168	2.2e−09	0.8009	1.3e−08	0.8347	1.1e−17	0.9536
Austria	0.0457	0.1349	0.0062	0.6566	0.03639	0.7307	2.2e−08	0.8199
Belgium	0.0283	0.1457	2.0e−08	0.7295	5.3e−09	0.7047	9.3e−09	0.9915
Bolivia	0.0568	0.2162	1.0e−08	0.7806	3.0e−08	0.8293	4.7e−18	0.9310
Brazil	0.0395	0.1706	1.5e−08	0.9464	2.0e−08	0.9354	1.5e−08	0.9825
Canada	0.0056	0.0746	1.9e−08	0.7657	5.6e−09	0.8527	2.2e−09	0.9232
Chile	0.0257	0.1473	7.9e−09	0.7550	5.6e−09	0.7931	2.2e−08	0.9194
Colombia	0.0395	0.0660	1.4e−08	0.7898	2.9e−08	0.8879	1.0e−08	0.9076
Denmark	0.0071	0.1056	4.3e−08	0.7350	2.3e−08	0.7837	2.4e−09	0.9032
Ecuador	0.0245	0.1541	2.6e−08	0.8934	1.1e−09	0.9049	1.8e−08	0.9753
Egypt	0.0114	0.1807	1.8e−08	0.7745	3.7e−09	0.8098	2.8e−08	0.8472
Finland	0.0737	0.1463	6.5e−09	0.8824	6.5e−09	0.9318	6.5e−09	0.9472
France	0.0339	0.1751	1.8e−08	0.5133	2.8e−08	0.7219	2.7e−08	0.6719
Germany	0.0239	0.1414	4.2e−08	0.8225	1.1e−08	0.8643	2.6e−08	0.9450
Greece	0.0132	0.1395	2.3e−09	0.7422	1.7e−08	0.7445	2.3e−09	0.8091
Hong Kong	0.0323	0.1399	0.03029	0.5794	0.0615	0.8852	0.1379	0.5855
Iceland	0.0285	0.1322	1.2e−09	0.7434	3.0e−08	0.9152	8.7e−09	0.7765
Indonesia	0.0357	0.1884	4.7e−09	0.8512	2.2e−08	0.8860	1.6e−08	0.9282
Ireland	0.0327	0.1156	1.8e−08	0.7666	2.8e−08	0.7238	2.8e−08	0.8325
Israel	0.0304	0.0969	1.4e−08	0.7089	5.6e−09	0.6795	2.1e−08	0.6677
Italy	0.2759	0.1361	6.5e−09	0.7364	6.5e−09	0.8576	1.7e−08	0.8418
Japan	0.6282	0.1553	5.6e−09	0.8432	1.1e−08	0.8564	1.0e−08	0.9621
Jordan	0.0062	0.0675	1.4e−08	0.8191	1.4e−08	0.8183	1.1e−09	0.8954
Kenya	0.0177	0.1819	1.0e−08	0.7757	3.4e−09	0.7537	2.2e−09	0.9585
Korea	0.0303	0.1484	2.6e−08	0.6442	4.5e−09	0.7766	7.0e−08	0.8607
Luxembourg	0.0227	0.1092	4.5e−09	0.7630	1.5e−09	0.8574	4.5e−09	0.8504
Malaysia	0.0056	0.1005	1.5e−08	0.7644	3.0e−08	0.8149	1.0e−08	0.8252
Mexico	0.0706	0.2027	0.0005	0.6988	0.0021	0.7518	6.8e−09	0.8408
Netherlands	0.0252	0.1310	3.3e−08	0.8990	8.3e−09	0.9174	1.9e−08	0.9626
New Zealand	0.0240	0.1557	2.2e−09	0.9820	6.8e−09	0.9851	2.2e−09	0.9910
Niger	0.0204	0.1824	6.8e−09	0.6912	6.8e−09	0.8076	3.4e−09	0.8458
Nigeria	0.0851	0.4198	2.2e−09	0.7817	2.2e−09	0.8192	3.4e−09	0.9058
Norway	0.0251	0.0933	1.4e−08	0.7466	2.3e−09	0.8521	8.3e−09	0.8729
Pakistan	0.0268	0.0922	2.2e−09	0.6950	2.1e−08	0.8097	1.9e−08	0.8684
Paraguay	0.0140	0.1826	2.2e−09	0.9540	1.1e−08	0.9585	7.9e−09	0.9941
Peru	0.1046	0.2532	8.1e−09	0.8355	2.6e−08	0.8486	2.6e−08	0.9824
Philippines	0.0159	0.1494	1.3e−08	0.8688	4.0e−09	0.9317	8.0e−09	0.9371
Poland	0.1069	0.1838	1.2e−08	0.6223	9.0e−09	0.5964	2.4e−08	0.6722
Portugal	0.0581	0.1647	5.2e−09	0.5689	2.6e−09	0.7007	2.6e−09	0.8775
Sierra Leone	0.0998	0.3927	0.0775	0.6396	0.0118	0.7123	1.0e−08	0.8498
South Africa	0.0174	0.1937	7.1e−09	0.6755	2.1e−08	0.7633	3.2e−08	0.7571
Spain	0.3653	0.1564	0.0968	0.4509	0.1082	0.6412	0.0370	0.5638
Swaziland	0.0104	0.1430	4.5e−09	0.5702	9.0e−09	0.6993	2.6e−08	0.7833
Sweden	0.0149	0.1429	8.3e−09	0.6714	2.1e−08	0.8955	1.0e−08	0.7454
Thailand	0.0301	0.1119	1.9e−08	0.8551	6.8e−09	0.9251	2.6e−08	0.9412
Turkey	0.0243	0.1805	1.8e−08	0.7343	6.8e−09	0.7552	1.4e−08	0.8813
UK	0.0179	0.1441	7.7e−09	0.7246	6.8e−09	0.7904	1.8e−08	0.8899
Uruguay	0.0530	0.1780	4.5e−09	0.8027	3.4e−09	0.8790	1.7e−08	0.8927
Venezuela	0.0375	0.1711	1.4e−08	0.6673	6.8e−09	0.7929	2.9e−08	0.8604
Zimbabwe	0.0187	0.2119	0.0056	0.6746	0.0072	0.7241	0.0157	0.7693

implies banking fragility. Banks in half of the countries are fragile during some periods since their signs are negative and since their standard deviations exceed their means. BSF2 differs from BSF3 in that deposits are removed from the latter. Hence, a country with a negative BSF3 and a positive BSF2 implies that bank fragilities may have arisen due to the reduction in the deposits. Australia, Canada, Germany, Italy, Jordan, the Netherlands, Nigeria, the Philippines, Poland, Sierra Leone, Switzerland and Zimbabwe are found to have a negative BSF3 and a positive BSF2, but their differences are small. BSF2* removes foreign liabilities

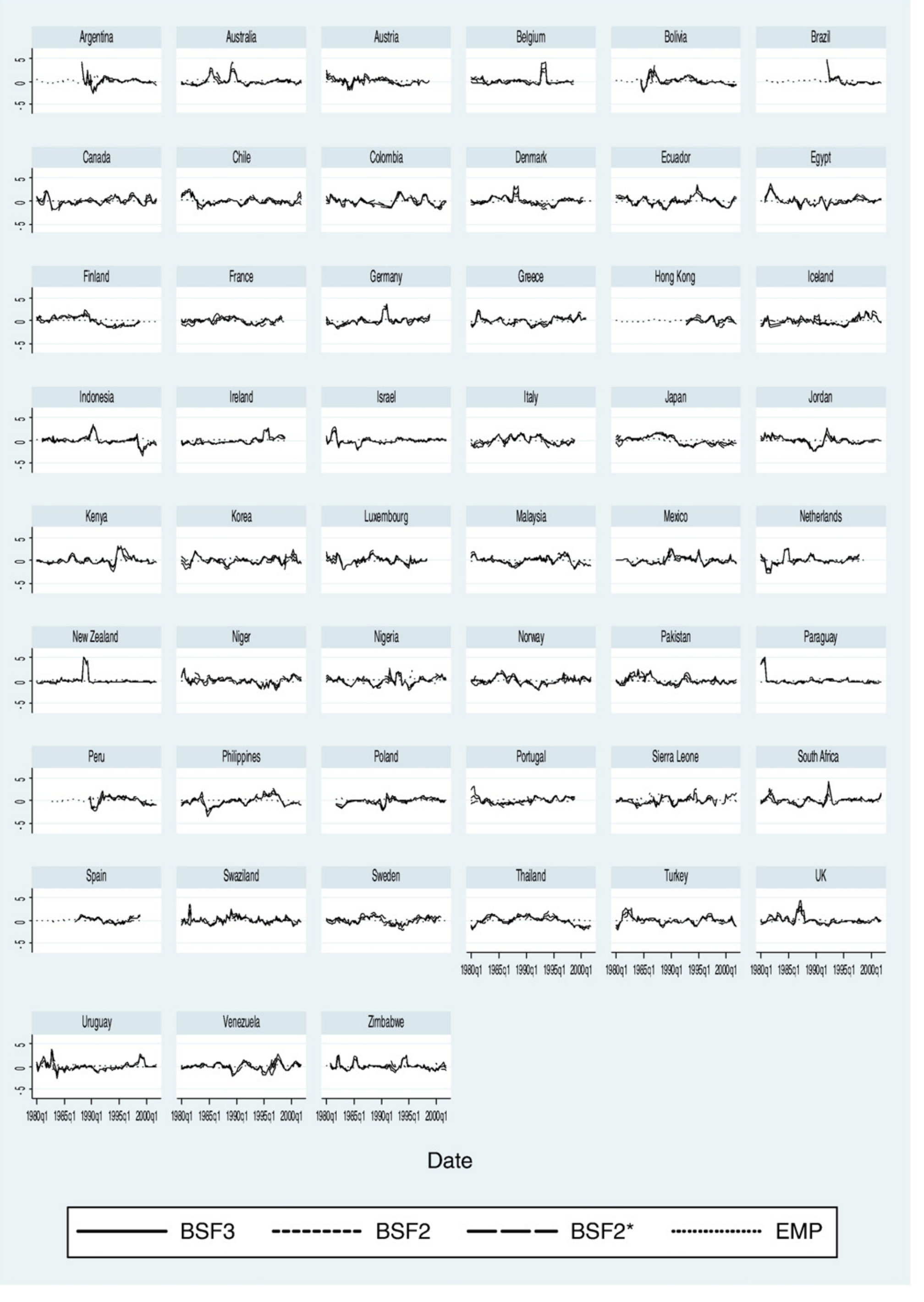

Fig. 1. BSF and EMP for all countries.

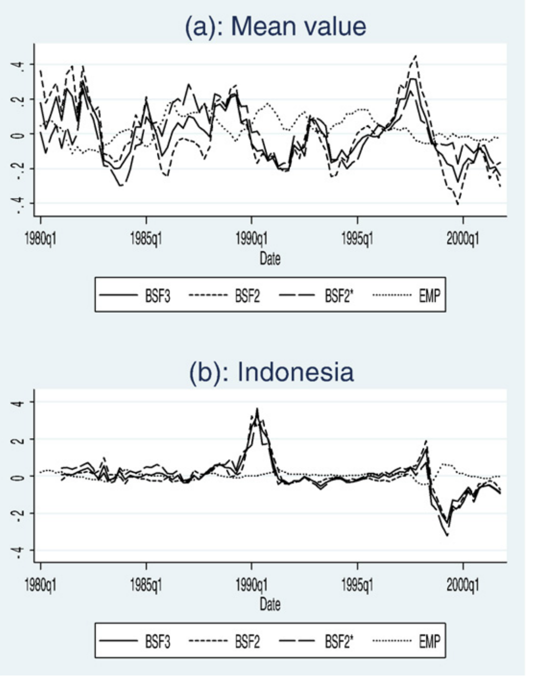

Fig. 2. EMP and BSF.

from our sample, and hence a country with a negative BSF3 and a positive BSF2* suggests that the decrease in foreign liabilities may be the cause of the banks' fragility in Austria, Bolivia, Chile, Colombia, Hong Kong, Iceland, Italy, Kenya, Paraguay, Peru, Turkey and Venezuela.

Fig. 1 plots the mean values of BSF3, BSF2, BSF2* and EMP, respectively, for the 51 countries. Because the plots are small and messy, we plot their average at the top of Fig. 2. The fluctuations in the first three plots appear similar but the variation in BSF2 is larger after 1998. Three peaks occur in EMP, which are around

Table 2
Correlation coefficients among BSF3, BSF2, and BSF2*

	BSF3	BSF2	BSF2*
All countries			
BSF3	1.000		
BSF2	0.9224	1.000	
BSF2*	0.9105	0.7337	1.000
Industrial countries			
BSF3	1.000		
BSF2	0.9206	1.000	
BSF2*	0.9096	0.7220	1.000
Developing countries			
BSF3	1.000		
BSF2	0.9238	1.000	
BSF2*	0.9111	0.7420	1.000

1986, 1991 and 1995. At the bottom of Fig. 2, we take Indonesia as an example to describe our four series. During the years preceding the Asian financial crisis, Indonesia had huge foreign exchange reserves and a good banking sector. The BSF3, BSF2, and BSF2* indices are seen to fluctuate around zero as shown in panel (b) of Fig. 2. This implies that Indonesia seemed far from banking fragility before July 1997. At the end of 1997, nevertheless, there was a significant decrease in EMP due to the huge depreciation of the Indonesian rupiah, followed by a substantial fall in the banking sector fragility indices.

Table 2 reports the correlation matrix between the three BSF measures. When all countries are used, the correlation between BSF3 and BSF2 is 0.9224, it is 0.9105 between BSF3 and BSF2* and it is 0.7337 between BSF2 and BSF2*. When industrial countries are used, the correlation coefficient between BSF3 and BSF2 is

Table 3
Panel Granger causality test — all countries

Lag length	BSF3		BSF2		BSF2*	
	1	2	1	2	1	2
Dependent variable: $\Delta BSF_{i,t}$						
Constant	0.183 (0.017)**	−0.064 (0.527)	0.167 (0.035)**	−0.039 (0.722)	0.178 (0.069)*	−0.109 (0.303)
$\Delta BSF_{i,t-1}$	0.767 (0.000)***	0.821 (0.000)***	0.749 (0.000)***	0.772 (0.000)***	0.784 (0.000)***	0.854 (0.000)***
$\Delta BSF_{i,t-2}$		−0.098 (0.001)***	(0.000)***	−0.043 (0.214)		−0.119 (0.000)***
$\Delta EMP_{i,t-1}$	0.417 (0.001)***	0.285 (0.018)**	0.446 (0.002)***	0.349 (0.012)**	0.427 (0.004)***	0.325 (0.027)**
$\Delta EMP_{i,t-2}$		0.112 (0.178)		0.146 (0.012)**		0.114 (0.276)
No. of countries	51	51	51	51	51	51
No. of observations	3762	3691	3762	3691	3762	3691
RSS	1255.16	1288.75	1522.59	1537.32	1691.10	1741.44
H0: No causality ($\Delta EMP_{i,t-j}$)						
Wald statistic	10.51 (0.001)***	15.38 (0.000)***	9.195 (0.002)***	15.94 (0.000)***	8.194 (0.004)***	21.65 (0.000)***
Dependent variable: $\Delta EMP_{i,t}$						
Constant	−0.007 (0.608)	−0.036 (0.009)***	−0.007 (0.593)	−0.036 (0.009)***	−0.004 (0.748)	−0.039 (0.005)***
$\Delta BSF_{i,t-1}$	−0.027 (0.004)***	−0.025 (0.004)***	0.565 (0.000)***	−0.026 (0.000)***	0.565 (0.000)***	−0.011 (0.129)
$\Delta BSF_{i,t-2}$		0.002 (0.739)	(0.092)*	0.010 (0.205)		−0.012 (0.092)*
$\Delta EMP_{i,t-1}$	0.571 (0.000)***	0.599 (0.000)***	−0.027 (0.001)***	0.597 (0.000)***	−0.013 (0.063)*	0.630 (0.000)***
$\Delta EMP_{i,t-2}$		−0.107 (0.026)**		−0.104 (0.035)**		−0.129 (0.011)**
No. of countries	51	51	51	51	51	51
No. of observations	3762	3691	3762	3691	3762	3691
RSS	92.89	97.53	92.44	94.29	93.87	100.03
H0: No causality ($\Delta BSF_{i,t-j}$)						
Wald statistic	8.834 (0.004)***	9.078 (0.011)**	11.99 (0.001)***	13.75 (0.001)***	3.463 (0.063)*	6.789 (0.034)**

Notes:
The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels.
Time dummies are included in all equations, but are not reported here.
The *p*-values (the standard errors are robust to heteroskedasticity) are reported in parentheses.
The Wald statistic is asymptotically distributed as $\chi^2(k)$ under the noncausality hypothesis, where k is the number of coefficients estimated.

Table 4
Panel Granger causality test — industrial countries

Lag length	BSF3		BSF2		BSF2*	
	1	2	1	2	1	2
Dependent variable: $\Delta BSF_{i,t}$						
Constant	0.194	0.019	0.172	0.098	0.115	−0.087
	(0.033)**	(0.838)	(0.104)	(0.896)	(0.192)	(0.524)
$\Delta BSF_{i,t-1}$	0.723	0.820	0.739	0.830	0.733	0.814
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
$\Delta BSF_{i,t-2}$		−0.172		−0.159		−0.150
		(0.000)***		(0.000)***		(0.000)***
$\Delta EMP_{i,t-1}$	0.409	0.279	0.388	0.226	0.625	0.468
	(0.063)*	(0.231)	(0.034)**	(0.245)	(0.037)**	(0.144)
$\Delta EMP_{i,t-2}$		0.091		0.145		0.032
		(0.740)		(0.514)		(0.921)
No. of countries	21	21	21	21	21	21
No. of observations	1547	1516	1547	1516	1547	1516
RSS	429.04	469.64	436.12	466.83	661.51	713.66
H0: No causality ($\Delta EMP_{i,t-j}$)						
Wald statistic	3.454	4.091	4.501	5.037	4.362	4.389
	(0.063)*	(0.129)	(0.034)**	(0.081)*	(0.037)**	(0.111)
Dependent variable: $\Delta EMP_{i,t}$						
Constant	−0.020	−0.033	−0.021	−0.031	−0.019	−0.035
	(0.332)	(0.194)	(0.310)	(0.212)	(0.000)***	(0.172)
$\Delta BSF_{i,t-1}$	−0.005	−0.006	−0.008	−0.037	−0.0003	0.002
	(0.363)	(0.325)	(0.096)*	(0.046)**	(0.933)	(0.693)
$\Delta BSF_{i,t-2}$		0.007		0.015		−0.002
		(0.877)		(0.019)**		(0.619)
$\Delta EMP_{i,t-1}$	0.716	0.790	0.714	0.788	0.719	0.792
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
$\Delta EMP_{i,t-2}$		0.131		−0.126		−0.134
		(0.026)**		(0.001)***		(0.000)***
No. of countries	21	21	21	21	21	21
No. of observations	1547	1516	1547	1516	1547	1516
RSS	11.36	12.10	11.33	12.03	11.41	12.16
H0: No causality ($\Delta BSF_{i,t-j}$)						
Wald statistic	0.830	1.880	2.779	5.677	0.007	0.284
	(0.362)	(0.391)	(0.096)*	(0.059)*	(0.900)	(0.868)

Note: See Table 3.

0.9206, is 0.9096 between BSF3 and BSF2*, and is 0.722 between BSF2 and BSF2*. When developing countries are used, the correlation coefficients do not change too much. Thus, while the correlation coefficients are high, they still differ from each other.

5. Estimation results

5.1. Panel Granger causality

Table 3 reports the estimated results of Eq. (2) using all countries. Two dependent variables are tested where the top one uses BSF3, BSF2 and BSF2* as the dependent variable and the bottom one uses EMP as the dependent variable. Lag lengths, 1 and 2, are alternatively tried for each estimation.[11] In the top panel,

[11] The lag length selection should be based on statistical methods, such as Akaike Information Criteria. However, because in the GMM estimation on panel data the large lag length results in a substantial loss of sample size, we restrict our maximum lag length to two.

Table 5
Panel Granger causality test — developing countries

Lag length	BSF3		BSF2		BSF2*	
	1	2	1	2	1	2
Dependent variable: $\Delta BSF_{i,t}$						
Constant	0.161 (0.830)	−0.158 (0.373)	0.162 (0.150)	−0.194 (0.299)	0.218 (0.211)	−0.132 (0.406)
$\Delta BSF_{i,t-1}$	0.742 (0.000)***	0.773 (0.000)***	0.705 (0.000)***	0.708 (0.000)***	0.762 (0.000)***	0.837 (0.000)***
$\Delta BSF_{i,t-2}$		−0.052 (0.224)		−0.001 (0.990)		−0.107 (0.023)**
$\Delta EMP_{i,t-1}$	0.399 (0.001)***	0.285 (0.016)**	0.413 (0.003)***	0.307 (0.013)**	0.388 (0.008)***	0.278 (0.065)*
$\Delta EMP_{i,t-2}$		0.175 (0.035)**		0.203 (0.059)*		0.208 (0.053)*
No. of countries	30	30	30	30	30	30
No. of observations	2215	2175	2215	2175	2215	2175
RSS	763.15	756.40	997.76	991.45	951.78	962.76
H0: No causality ($\Delta EMP_{i,t-j}$)						
Wald statistic	10.25 (0.001)***	14.88 (0.001)***	8.791 (0.003)***	13.50 (0.059)**	6.993 (0.008)***	18.78 (0.000)***
Dependent variable: $\Delta EMP_{i,t}$						
Constant	0.005 (0.828)	−0.039 (0.004)***	0.003 (0.881)	−0.040 (0.003)***	0.005 (0.810)	−0.041 (0.002)***
$\Delta BSF_{i,t-1}$	−0.042 (0.001)***	−0.038 (0.001)***	−0.041 (0.000)***	−0.037 (0.000)***	−0.022 (0.016)**	−0.010 (0.059)*
$\Delta BSF_{i,t-2}$		−0.002 (0.877)		0.005 (0.586)		−0.178 (0.107)
$\Delta EMP_{i,t-1}$	0.518 (0.000)***	0.566 (0.000)***	0.507 (0.000)***	0.562 (0.000)***	0.519 (0.000)***	0.589 (0.000)***
$\Delta EMP_{i,t-2}$		−0.115 (0.026)**		−0.114 (0.032)**		−0.138 (0.014)**
No. of countries	30	30	30	30	30	30
No. of observations	2215	2175	2215	2175	2215	2175
RSS	77.56	80.36	77.11	80.25	78.99	84.63
H0: No causality ($\Delta BSF_{i,t-j}$)						
Wald statistic	10.81 (0.001)***	13.44 (0.001)***	15.07 (0.000)***	20.16 (0.000)***	5.842 (0.016)**	9.343 (0.009)***

Note: See Table 3.

when BSF3 is used as the dependent variable, the Wald tests are found to be 10.51 and 15.38 for lag length = 1 and 2, respectively. Both are significant at even the 1% level. Thus, the null that EMP does not Granger cause BSF3 is rejected regardless of the lag lengths. The results are robust when different definitions of banking fragilities are used. The null is still rejected when BSF2 and BSF2* are employed as dependent variables. Thus, EMP Granger causes BSF when all countries are used.

When EMP is used as the dependent variable, as reported in the bottom panel, the Wald tests are 8.334 and 9.078 for the null of the zero coefficients on $BSF3_{i,t-1}$, and on $BSF3_{i,t-1}$ and $BSF3_{i,t-2}$, respectively. Hence, the null that BSF does not Granger cause EMP is also rejected regardless of the lag lengths. The null is rejected again when BSF2 and BSF2* are used as explanatory variables. In short, the results demonstrate a bilateral causality between exchange market pressure and banking sector fragility.

The results change slightly when only industrial countries are used. Table 4's top panel demonstrates that EMP Granger causes BSF2 but does not Granger cause BSF3 and BSF2* when the lag length is equal to 2. The bottom panel shows similar results in that BSF2 Granger causes EMP, but it is not the case that BSF3 and BSF2* Granger cause EMP. Accordingly, using the industrial countries data, the bilateral causation is found between EMP and BSF2 but no lead-lag relationship between EMP and BSF3 is found, or between EMP and

Table 6
Panel threshold Granger causality test — currency fragility

	Dependent variable: BSF					
	Currency fragility regime	Non-currency fragility regime	Currency fragility regime	Non-currency fragility regime	Currency fragility regime	Non-currency fragility regime
	ΔBSF3		ΔBSF2		ΔBSF2*	
Constant	−0.030 (0.000)***	0.001 (0.008)***	−0.030 (0.000)***	0.003 (0.000)***	−0.017 (0.025)**	−0.0001 (0.779)
$\Delta BSF_{i,t-1}$	0.500 (0.000)***	0.595 (0.000)***	0.288 (0.000)***	0.463 (0.000)***	0.560 (0.000)***	0.618 (0.000)***
$\Delta BSF_{i,t-2}$	0.201 (0.000)***	0.161 (0.000)***	0.309 (0.000)***	0.271 (0.000)***	0.137 (0.000)***	0.108 (0.000)***
$\Delta EMP_{i,t-1}$	0.377 (0.001)***	0.224 (0.000)***	0.275 (0.030)**	0.016 (0.735)	0.417 (0.001)***	0.413 (0.000)***
$\Delta EMP_{i,t-2}$	0.576 (0.000)***	0.332 (0.000)***	0.808 (0.000)***	0.519 (0.000)***	0.275 (0.044)**	0.084 (0.115)
No. of countries	51	51	51	51	51	51
No. of observations	445	3289	445	3289	445	3289
H0: No causality ($\Delta EMP_{i,t-j}$)						
Wald statistic	89.94 (0.000)***	246.96 (0.000)***	94.60 (0.000)***	212.11 (0.000)***	43.97 (0.000)***	181.07 (0.000)***

Note: See Table 3.

BSF2*. This is probably because the real foreign liabilities of banks tend to be affected by actual or potential depreciation in the domestic currency. In the industrial countries, investors are fully aware of this. When the exchange rate depreciation is included in BSF2, together with LEND, EMP and BSF2 are prone to being affected each other.

Table 7
Panel threshold Granger causality test — banking fragility

	Dependent variable: EMP					
	Banking fragility regime	Non-banking fragility regime	Banking fragility regime	Non-banking fragility regime	Banking fragility regime	Non-banking fragility regime
	ΔBSF3		ΔBSF2		ΔBSF2*	
Constant	0.006 (0.000)***	−0.002 (0.000)***	0.010 (0.000)***	−0.004 (0.000)***	0.007 (0.000)***	−0.002 (0.000)***
$\Delta BSF_{i,t-1}$	−0.048 (0.000)***	−0.022 (0.000)***	−0.064 (0.000)***	−0.036 (0.000)***	−0.010 (0.291)	0.006 (0.055)*
$\Delta BSF_{i,t-2}$	0.014 (0.209)	0.003 (0.000)***	0.055 (0.000)***	0.012 (0.001)***	−0.022 (0.027)***	−0.016 (0.000)***
$\Delta EMP_{i,t-1}$	0.477 (0.001)***	0.525 (0.000)***	0.772 (0.000)***	0.719 (0.000)***	0.594 (0.000)***	0.558 (0.000)***
$\Delta EMP_{i,t-2}$	−0.006 (0.814)	0.034 (0.000)***	−0.129 (0.000)***	−0.122 (0.000)***	−0.206 (0.000)***	−0.208 (0.000)***
No. of countries	51	51	51	51	51	51
No. of observations	807	2880	916	2771	887	2884
H0: No causality ($\Delta BSF_{i,t-j}$)						
Wald statistic	89.94 (0.000)***	77.46 (0.000)***	41.74 (0.000)***	138.18 (0.000)***	12.68 (0.002)***	37.07 (0.000)***

Note: See Table 3.

Table 8
Panel threshold Granger causality test — double fragility

	Dependent variable: BSF					
	Banking and currency fragility regime	Non-bank. and non-curr. fragility regime	Banking and currency fragility regime	Non-bank. and non-curr. fragility regime	Banking and currency fragility regime	Non-bank. and non-curr. fragility regime
	ΔBSF3		ΔBSF2		ΔBSF2*	
Constant	−0.129 (0.000)***	0.006 (0.000)***	−0.122 (0.000)***	0.010 (0.000)***	−0.017 (0.025)**	−0.0001 (0.779)
$\Delta BSF_{i,t-1}$	0.188 (0.011)**	0.547 (0.000)***	−0.015 (0.782)	0.453 (0.000)***	0.560 (0.000)***	0.618 (0.000)***
$\Delta BSF_{i,t-2}$	0.188 (0.092)*	0.074 (0.000)***	0.079 (0.194)	0.135 (0.000)***	0.137 (0.000)***	0.108 (0.000)***
$\Delta EMP_{i,t-1}$	0.410 (0.002)***	0.461 (0.000)***	0.230 (0.057)*	0.569 (0.000)***	0.417 (0.001)***	0.413 (0.000)***
$\Delta EMP_{i,t-2}$	0.473 (0.001)***	−0.241 (0.000)***	0.473 (0.539)	−0.348 (0.000)***	0.275 (0.044)**	0.084 (0.115)
No. of countries	40	51	45	51	43	51
No. of observations	131	2556	156	2472	134	2522
H0: No causality ($\Delta EMP_{i,t-j}$)						
Wald statistic	32.50 (0.000)***	137.20 (0.000)***	6.40 (0.041)**	172.71 (0.000)***	43.97 (0.000)***	181.07 (0.000)***

Note: See Table 3.

Table 5 presents the results using developing countries only. In the top panel of the table, when the dependent variables BSF3, BSF2 and BSF2* are employed, similar bilateral causalities are found to those presented in Table 3. Alternatively, in the bottom panel of the table, when dependent variable ΔEMP is

Table 9
Panel threshold Granger causality test — double fragilities

	Dependent variable: EMP					
	Banking and currency fragility regime	Non-bank. and non-curr. fragility regime	Banking and currency fragility regime	Non-bank. and non-curr. fragility regime	Banking and currency fragility regime	Non-bank. and non-curr. fragility regime
	ΔBSF3		ΔBSF2		ΔBSF2*	
Constant	0.022 (0.154)	−0.004 (0.000)***	0.039 (0.014)** (0.000)***	−0.005	0.007 (0.000)***	−0.002 (0.000)***
$\Delta BSF_{i,t-1}$	−0.133 (0.012)**	−0.003 (0.926)	−0.051 (0.198)	−0.023 (0.000)***	−0.010 (0.291)	0.006 (0.055)*
$\Delta BSF_{i,t-2}$	−0.010 (0.842)	0.002 (0.573)	0.036 (0.404)	0.014 (0.000)***	−0.022 (0.027)**	−0.016 (0.000)***
$\Delta EMP_{i,t-1}$	0.013 (0.887)	0.491 (0.000)***	0.271 (0.002)***	0.720 (0.000)***	0.594 (0.000)***	0.558 (0.000)***
$\Delta EMP_{i,t-2}$	0.369 (0.000)***	0.094 (0.000)***	0.378 (0.000)***	−0.034 (0.000)***	−0.206 (0.000)***	−0.208 (0.000)***
No. of countries	40	51	45	51	43	51
No. of observations	128	2556	153	2485	132	2533
H0: No causality ($\Delta BSF_{i,t-j}$)						
Wald statistic	6.570 (0.037)**	0.700 (0.704)	12.68 (0.002)***	37.07 (0.000)***	12.68 (0.002)***	37.07 (0.000)***

Note: See Table 3.

Table 10
Robustness test for panel Granger causality test — all countries

Lag length	BSF3		BSF2		BSF2*	
	1	2	1	2	1	2
Dependent variable: $\Delta BSF_{i,t}$						
Constant	−0.011	0.323	−0.025	0.233	−0.049	0.373
	(0.830)	(0.000)***	(0.460)	(0.002)***	(0.460)	(0.000)***
$\Delta BSF_{i,t-1}$	0.667	0.667	0.687	0.680	0.656	0.654
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
$\Delta BSF_{i,t-2}$		−0.034		−0.025		−0.020
		(0.194)		(0.435)		(0.462)
$\Delta EMP_{i,t-1}$	0.605	0.488	0.698	0.560	0.576	0.495
	(0.000)***	(0.000)***	(0.000)***	(0.001)***	(0.001)***	(0.005)***
$\Delta EMP_{i,t-2}$		0.150		0.270		0.078
		(0.096)*		(0.036)**		(0.318)
No. of countries	51	51	51	51	51	51
No. of observations	3762	3691	3762	3691	3762	3691
RSS	1894.36	1882.46	2204.36	2163.90	2515.26	2494.40
H0: No causality ($\Delta EMP_{i,t-j}$)						
Wald statistic	17.86	29.56	22.49	42.44	10.60	16.23
	(0.000)***	(0.000)***	(0.000)***	(0.026)**	(0.001)***	(0.000)***
Dependent variable: $\Delta EMP_{i,t}$						
Constant	−0.004	−0.040	−0.003	−0.039	−0.004	−0.039
	(0.735)	(0.006)***	(0.809)	(0.007)***	(0.785)	(0.005)***
$\Delta BSF_{i,t-1}$	−0.035	−0.023	−0.038	−0.026	−0.021	−0.010
	(0.000)***	(0.001)***	(0.000)***	(0.000)***	(0.002)***	(0.056)***
$\Delta BSF_{i,t-2}$		−0.022		−0.015		−0.025
		(0.003)**		(0.005)***		(0.001)***
$\Delta EMP_{i,t-1}$	0.562	0.602	0.551		0.582	0.623
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
$\Delta EMP_{i,t-2}$		−0.122		−0.122		−0.125
		(0.018)**		(0.019)**		(0.014)**
No. of countries	51	51	51	51	51	51
No. of observations	3762	3691	3762	3691	3762	3691
RSS	93.82	97.35	93.03	96.84	95.47	99.29
H0: No causality ($\Delta BSF_{i,t-j}$)						
Wald statistic	214.40	14.52	21.92	17.58	9.570	11.75
	(0.000)***	(0.001)***	(0.000)***	(0.000)***	(0.002)***	(0.003)***

Note: See Table 3.

employed as a dependent variable, similar results but also stronger results are found just as the Wald statistics are larger and more significant than those shown in Table 3.

5.2. Panel threshold Granger causality

Table 6 presents the estimated results using BSF as the dependent variable under both currency and non-currency fragility regimes, where the currency fragility regime is based on $1.5\times\sigma_{EMP}$. It is surprising to find that the null of no causality is rejected regardless of the regimes and regardless of the proxies for banking fragilities. Accordingly, EMP Granger causes BSF in both regimes. In short, currency fragilities lead banking fragilities, which is the opposite of the results found in the literature.

Table 7, which reports a similar test to that in Table 5, uses EMP as the dependent variable under both banking and non-banking fragility regimes. The null is also rejected for all three proxies for BSF, suggesting that BSF Granger causes EMP. Hence the banking fragilities lead the currency fragilities. These results, together with the results reported in Table 5, show that bilateral causality is found for both fragilities.

Tables 8 and 9 take the double thresholds into account, using BSF and EMP as the dependent variable, respectively. This model has the endogenous threshold problem mentioned above. However, our results are robust in the case of different specifications, since the results are similar to those reported in Tables 6 and 7. Thus, the existence of a bilateral relationship between banking and currency fragilities cannot be rejected.

Table 10 contains a robust testing using a slightly different definition of BSF. We use the deviations from an average of previous 4-quarter data for LEND, FOR, and DEP to compute the change in these three variables. The robustness of the regression results was tested by using a different measure of change in LEND, FOR, and DEP.[12] The estimated results are reported in Table 10 and are very similar to those in Table 3. Other estimations are also attempted and the results change little from those reported in Tables 3–9.[13] Accordingly, our results are robust for different constructions of BSF.

6. Conclusion

A panel dynamic model both with and without a threshold is specified to reexamine the lead-lag relationship between banking and currency fragilities. We employ banking sector fragility and exchange market pressure as the proxies, respectively. Furthermore, three proxies for the banking sector fragility are created. Our 51 sample countries include 21 industrial and 30 developing countries.

When the panel dynamic model without a threshold is used, bilateral causality is found between the two fragilities using all of the sample countries. Using only industrial country data, bilateral causation is found only between EMP and BSF2, but no relationship is found between BSF3 and EMP, or between BSF2* and EMP. When industrial countries are employed, stronger bilateral causality is found between banking fragilities and currency fragilities.

When the panel threshold dynamic model is used, the results overwhelmingly suggest that bilateral causality exists. Thus our conclusion differs from past studies in that banking fragilities typically lead currency fragilities. When fragilities are considered, bilateral causality is favored to some extent.

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[12] We thank an anonymous referee for the suggestion.

[13] Due to the limitation of space, we do not report here all regressions of the robustness test. Other regression results are available upon request.

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