



SCHOOL OF ECONOMICS AND FINANCE

Discussion Paper 2010-12

Financial Crises in Asia: Concordance by Asset Market or Country?

Mardi Dungey, Jan P.A.M. Jacobs and Lestano

ISSN 1443-8593
ISBN : 978-1-86295-605-6

Financial crises in Asia: concordance by asset market or country?

Mardi Dungey^{a,d}, Jan P.A.M. Jacobs^{b,d*} and Lestano^c

^a University of Tasmania and CFAP, University of Cambridge

^b University of Groningen and CIRANO

^c Atma Jaya Catholic University, Jakarta, Indonesia

^d CAMA, Australian National University

This version: November 2010

Abstract

This paper investigates the extent of concordance in financial crises by both asset market and country in six Asian countries over the period 1970–2002. To that purpose we adapt a concordance index to deal with the typically low incidence of financial crises in both bivariate and multivariate settings. We find that in the Asian countries financial crises spread across markets over geographic borders rather than between markets within countries.

Keywords: Asia, financial crisis, contagion, synchronisation, concordance indices

JEL-code: F31, F47

*Corresponding author: Jan P.A.M. Jacobs, Faculty of Economics and Business, University of Groningen, PO Box 800, 9700 AV Groningen, The Netherlands, Tel.: +31 50 363 3681, Email: j.p.a.m.jacobs@rug.nl.

1 Introduction

A direct consequence of the Asian financial crises of 1998 was to focus attention on the root causes of the transmission of financial crises, particularly where that transmission occurred across geographical boundaries and was not in response to real economic linkages such as trade. One response was a substantial literature suggesting policy reform in international financial architecture, with the intent of limiting cross border transmissions; for example Eichengreen (2002) and Eichengreen, Kletzer and Mody (2003) review proposals, although the most recent discussions have centred on sharing cross-border information, see BIS (2010: recommendation 7). Others have dissented from this view, arguing that the underlying cause of transmission is fundamental economic weaknesses or financial fragility in the recipient economies; see Goldstein, Kaminsky and Reinhart (2000), Karolyi (2003) and Athukorala and Warr (2002) for the case of Asia specifically, and more generally Reinhart and Rogoff (2009).¹ More recently, Joyce and Nabar (2009) show that for emerging markets a strong banking sector promotes resilience against the effects of crises. Clearly which of these views dominates will have a substantial impact on the policy advice offered to countries faced with infection from a crisis elsewhere. Domestic weaknesses can be best remedied with national policies, but deficiencies in the international financial system which promote undue transmission of shocks may require an orchestrated international effort; see Brunnermeier et al (2009).

¹These arguments are also clearly made in the first generation literature of financial crises; see Flood and Marion (1999) for an overview.

Asia was the star pupil of emerging economies success until the East Asian crisis of 1997-1998, with relatively high growth, high return on investment and improving standards of living. This reputation changed abruptly in 1997. However, it is not clear that all was rosy prior to the crisis. A number of authors point to relatively strong fundamentals in Asian economies in the mid-1990s, for example, Furnam and Stiglitz (1998) for Asia in general and Kenward (1999) for Indonesia, while Athukorala and Warr (2002) conclude the opposite. In a paper which predates the crisis, Sachs, Tornell and Velasco (1996) soften their conclusions on the relationships between crises and fundamentals drawing on Latin American data *precisely* because of evidence of weak Asian fundamentals and institutional structure without the presence of a crisis.

To examine the relative importance of the different possible transmission mechanisms in the case of Asia we formally construct measures of the concordance between financial crises in the region. By concordance we mean the contemporaneous occurrence of crises in different markets. The hypothesis we put forward is that if financial crises are primarily associated with inappropriate domestic fundamentals or institutional structures the results should show strong concordance between crises in different asset markets in the same country—that is a preponderance of twin crisis periods. Alternatively, if the international linkages are stronger, perhaps due to some failing in the international financial architecture, then strong concordance should occur between crises in the same market across geographical borders.

This paper specifically considers the evidence as to whether contemporaneous crises in currencies and banking sectors are likely to be independent

events either within economies or across geographic borders. The first step in this agenda is to measure the degree of independence between crises, formalising the approach of counting numbers of co-occurrences undertaken by Kaminsky and Reinhart (1999) for example. This leads to the adaption of the concordance index of Harding and Pagan (2002, 2005) for business cycles to account for the low incidence events, christened the turbulent periods index. Additionally we extend the concordance indices to the multivariate case. These indices are used in tests of independent occurrence of multiple contemporaneous crises.

The concordance indices are applied to monthly bivariate indices of currency and banking crises for six Asian economies over the period January 1970 to December 2002. The results suggest that when two or more crises occur concurrently they are unlikely to be coincidental. In the bivariate indices we find that the Asian sample can be characterised as having spread across markets over geographic borders rather than between markets within countries. The multivariate indices and tests reinforce this view.

The paper proceeds as follows. Section 2 develops a bivariate concordance index appropriate to relatively rarely occurring financial crises. Multivariate extensions and their properties are outlined. Tests for whether independent crisis events are truly being observed are explained in Section 3. The concordance index and tests are then applied to Asian data in Section 4. Section 5 concludes.

2 Measuring synchronisation

2.1 Bivariate crises

Let a financial crisis be represented by the binary variable S_{it} , where $i = nm$, which takes the value one if a crisis occurs in country n and market m in period t and zero otherwise. Synchronisation can be expressed in terms of means and correlation. Two series are perfectly (positively) synchronised if they have equal means and the correlation coefficients equals one.

An alternate way of viewing the concordance between series is simply to ‘count’ the number of times the variables S_{xt} and S_{yt} are in various combinations of states. In a bivariate setting the total observations in the sample (T) consist of the number of simultaneous crises periods ($\#(1, 1)$), the number of periods with a single crisis ($\#(1) \equiv \#(1, 0) + \#(0, 1)$) and the number of tranquil periods ($\#(0, 0)$), or

$$T \equiv \#(1, 1) + \#(1) + \#(0, 0). \quad (1)$$

One possible concordance index is then given by

$$\hat{I}_t = \frac{\#(1, 1) + \#(0, 0)}{T} = 1 - \frac{\#(1)}{T}, \quad (2)$$

as suggested by Harding and Pagan (2002, 2005) for business cycles. However, this measure is focussed on samples which are relatively symmetric in the terminology of Kedem (1980), that is where the mean is around 0.5. In financial crisis indicator variables this is not the case, due to the low inci-

dence of financial crises and the preponderance of zeros in the sample. Hence we adopt the turbulent periods concordance index which focusses attention on the number of periods of contemporaneous crisis as a proportion of all periods which experience a crisis. This can be expressed as

$$\hat{I}^{tp} = \frac{\#(1, 1)}{T - \#(0, 0)} = 1 - \frac{\#(1)}{T - \#(0, 0)}, \quad (3)$$

where we assume that there is at least one crisis in our sample, *i.e.*, $T - \#(0) \neq 0$. Note that these indices can also be expressed in terms of the estimated means $\hat{\mu}_{S_x}$, $\hat{\mu}_{S_y}$, and the estimated correlation coefficient $\hat{\rho}_S$ between S_{xt} and S_{yt} . See Dungey, Jacobs and Lestano (2010) for graphical illustrations.

2.2 Multivariate synchronisation

Consider the case of concordance in the context of multiple financial crises across m financial markets and n countries, giving a total of nm potential crises indices. To measure the joint occurrence of Z or more crises occurring at time t consider this as the number of 1s which occur, and denote as $(\#1 \geq Z)$. So, the multivariate equivalent of the bivariate counting identity (1) becomes

$$T \equiv (\#1 \geq Z) + (\#1 < Z) + \#(0), \quad (4)$$

where $\#(0)$ denotes the number of tranquil periods.

The multivariate forms of the indices can be defined analogously to the bivariate ones. The multivariate turbulent-periods concordance index of in-

terest in the low incidence binary data gives the simultaneous crises as a proportion of all crisis periods as

$$\hat{I}^{tp} = \frac{(\#1 \geq Z)}{T - \#(0)} = 1 - \frac{(\#1 < Z)}{T - \#(0)}. \quad (5)$$

3 Testing synchronisation

Concordance indices for various crisis series can be calculated as outlined in the previous section. However, we are also interested as to whether an observed concordance index exceeds a critical value, indicating that the two or multiple crises are no longer occurring coincidentally. This section outlines how those critical values can be calculated.

To obtain critical values for concordance indices, tests of independence in a contingency table can be applied. For an introduction to testing independence in contingency tables see Agresti (2002). Table 1 shows the contingency table of bivariate crises where n is similar to T in identity (1).

Table 1: Contingency table of bivariate crises

	Crisis A	No crisis A	Row sums
Crisis B	$n_{11} = \#(1, 1)$	$n_{12} = \#(1, 0)$	$n_{1.} = n\mu_{S_B}$
No crisis B	$n_{21} = \#(0, 1)$	$n_{22} = \#(0, 0)$	$n_{2.} = n(1 - \mu_{S_B})$
Column sums	$n_{.1} = n\mu_{S_A}$	$n_{.2} = n(1 - \mu_{S_A})$	n

Below we apply Fisher's exact test in most cases, which proceeds as follows. The probability of observing the outcomes in the table when all

marginal frequencies, i.e., column and row sums, are fixed is equal to

$$\begin{aligned}
P_1 &= P\{n_{ij}|n, n_{1.}, n_{.1}\} = \frac{P\{n_{ij}|n, n_{1.}\}}{P\{n_{.1}|n\}} \\
&= \frac{n_{1.}!n_{.1}!n_{2.}!n_{.2}!}{n!n_{11}!n_{12}!n_{21}!n_{22}!}.
\end{aligned} \tag{6}$$

Since the row and column sums are fixed, only one of the n_{ij} can vary independently. Without loss of generality, we take this to be n_{11} . We can use this expression to construct an exact test by calculating the probabilities of any given configuration of frequencies and summing these over the tail of the distribution of n_{11} . Alternately the test can be used to calculate the number of simultaneous crises observations required to obtain a rejection of the null hypothesis of independence.

Corresponding critical values for the concordance indices and correlation coefficients can be calculated directly from the critical value of the simultaneous crises n_{11} , the incidences of the crises and the number of observations. For the concordance indices this follows directly from Equations (2) and (3). The critical value of the correlation coefficient of two binary crisis series can be calculated by putting simultaneous ones at the beginning of both series, followed by the additional ones for the first series and zeros for the other, and the additional ones for the second series and zeros for the first, completed by zeros for the remainder of the observations.

An equivalent exact independence test for the multivariate case is not readily apparent. Instead we report simulated critical values for the number of observations with Z or more joint occurrence of crises, where $Z = 2, \dots, Z^*(\equiv \max Z)$. In our illustration below Z^* equals (6 countries \times 3

types of crises =) 18. In each replication we build a new matrix of observations on crises dummies with the same properties as the originally observed data set. The crises means give the exact number of draws from a uniform (0,1) distribution; these are converted into numbers for the ones in the crisis dummies. The numbers in this matrix are summed: we calculate the number of tranquil periods, single crisis periods, periods with two or more simultaneous crises, three or more, etc. We use 10,000 replications to generate the distribution of these totals and 95% critical values. Converting these critical values for the totals into critical values for the multivariate concordance indices is again straightforward from Equation (5).

4 Concordance in six Asian countries, 1970–2002

4.1 Measuring and dating financial crises

At least three types of financial crises are distinguished in existing literature: currency crises, banking crises and foreign debt crises. A number of methods, including statistical criteria and event studies, have been suggested to classify, measure and date financial crises. See for example the overview in Jacobs, Kuper and Lestano (2005).

Currency crises are often dated on the basis of events, such as a devaluation or float of a currency as in a number of studies of the Asian financial crisis dated from the float of the Thai baht, or by using some form of threshold in an exchange market pressure index, as originated by Eichengreen, Rose and

Wyplosz (1995, 1996), or more recently determined endogenously in Abiad (2003) using Markov switching. These dating schemes are all sample dependent.

In this paper, we identify currency crises in East Asia using the exchange market pressure approach of Kaminsky, Lizondo and Reinhart (1998) and Kaminsky and Reinhart (1999, 2000). They define the exchange market pressure index as:

$$EMPI_{i,t} = \frac{\Delta e_{i,t}}{e_{i,t}} - \frac{\sigma_e}{\sigma_r} \frac{\Delta r_{i,t}}{r_{i,t}} \quad (7)$$

where $EMPI_{i,t}$ is the exchange rate market pressure index for country i in period t , $e_{i,t}$ the units of country i 's currency per US dollars in period t , σ_e the standard deviation of the relative change in the exchange rate ($\Delta e_{i,t}/e_{i,t}$), $r_{i,t}$ gross foreign reserves of country i in period t and σ_r the standard deviation of the relative change in the reserves ($\Delta r_{i,t}/r_{i,t}$).

To avoid the problem that currency crises are associated with high inflation, the sample is split into periods with hyperinflation and low inflation; separate indices are constructed for each subsample. A period of currency crisis is identified when the index exceeds some upper bound:

$$\text{Crisis} = \begin{cases} 1 & \text{if } EMPI_{i,t} > \beta\sigma_{EMPI} + \mu_{EMPI} \\ 0 & \text{otherwise,} \end{cases}$$

where σ_{EMPI} equals the sample standard deviation of $EMPI$ and μ_{EMPI} is the sample mean of $EMPI$. The threshold to define a currency crisis is set to three standard deviations above the mean.²

²This method is not the only one used in the existing literature for dating crises; other possibilities include ad hoc dates, Forbes and Rigobon (2002), Dungey and Martin (2004),

Banking crises are even more difficult to define than currency crises. Here we use the definition and dates provided by Kaminsky and Reinhart (1999).³ In their chronology banking crises begin with events which point to either bank runs that lead to closure, merger or take overs by the public sector of one or more financial institutions or large scale government bailouts. The end of crises is marked by the cessation of government assistance. In addition to the Kaminsky and Reinhart (1999) data we augment the sample period and countries covered to include Singapore and South Korea. Our additions to their dating rely on correspondence with central banks, IMF country reports and various financial publications as documented in Lestano, Jacobs and Kuper (2003).

The literature on debt crises is extensive and also incorporates a number of potential definitions with which to identify an observed debt crisis. Typically, the incidence of a debt crisis is interpreted as a debt rescheduling agreement or negotiation, arrears (amounts past due and unpaid) on principal repayments or interest payments and an upper-tranche IMF agreement.⁴ Here we constructed the debt crisis index based on debt rescheduling events, where debt default occurs when a country pursues commercial bank rescheduling with commercial borrowers as defined by the IMF and the World Bank. Commercial borrowers are defined as those developing countries for

thresholds on volatility, Frankel and Rose (1996), identification with outliers, Favero and Giavazzi (2002), or tails of distributions, Bae, Karolyi and Stulz (2003), Pozo and Amuedo-Dorantes (2003).

³Other literature which dates banking crises includes Caprio and Klingebiel (1996), Lindgren, Garcia and Saal (1996) and Dermirgüç-Kunt and Detragiache (1997).

⁴For example Berg and Sachs (1988), Lee (1991), Balkan (1992), Lanoie and Lemarbre (1996) and Marchesi (2003) define a debt crisis as debt rescheduling. McFadden *et al.* (1985) and Hajivassiliou (1989,1994) incorporate a wider range of the elements listed.

which at least one third of foreign borrowing is from private sector creditors. We also include debt problems that led to rescheduling of the official debt in the Paris Club,⁵ debt equity swap and voluntary buybacks and use the list of debt rescheduling events recorded by the World Bank, Global Development Finance and World Debt Table in various issues.

Table 2: Distribution of financial crises: 1970-2002 numbers (proportion of total observations)

	Currency crises	Banking crises	Debt crises
Indonesia	9 (2.3%)	12 (3.0%)	5 (1.3%)
Malaysia	10 (2.5%)	7 (1.8%)	0 (0.0%)
Philippines	12 (3.0%)	8 (2.0%)	14 (3.5%)
South Korea	7 (1.8%)	12 (3.0%)	1 (0.3%)
Singapore	11 (2.8%)	2 (0.5%)	0 (0.0%)
Thailand	9 (2.3%)	10 (2.5%)	0 (0.0%)
All countries	58 (2.4%)	51 (2.2%)	20 (0.8%)

Each of these three crisis indicators has in common that they provide zero-one indices of the form explored in the first section of this paper. Table 2 summarizes the distribution of the financial crises over the countries in our sample of six Asian countries. Currency crises are distributed more or less evenly over the six countries. Banking crises are relative rare for Singapore,

⁵The Paris Club is an informal group of official creditors (19 countries) whose role is to find co-ordinated and sustainable solutions to the payment difficulties experienced by debtor nations. Paris Club creditors agree to rescheduling debts due to them. Rescheduling is a means of providing a country with debt relief through a postponement and, in the case of concessional rescheduling, a reduction in debt service obligations (see <http://www.clubdeparis.org/en/>).

a country with a more advanced banking system. Debt crises occur most frequently in Philippines, followed by Indonesia.

4.2 Bivariate concordance outcomes

This section presents a selection of the bivariate concordance outcomes calculated for the data given above, along with tests based on the null of independence of the crises, *i.e.*, the crises are coincidental only. We begin with the latter.

Table 3 reports the results for the tests of independence in the bivariate examples. The upper triangle of the table contains the observed number of incidences of each of the potential crisis combinations, for example the number of times that a banking and currency crisis occurred simultaneously for Indonesia is 2 in this sample. The lower triangle records the minimum number of occurrences of joint crises which are not independent based on the exact Fisher test at the 5 percent significance level. The crisis combinations which reject independence are indicated with an asterisk in the upper triangle.

Table 4 constructs the bivariate turbulent period concordance indices for the currency and banking crises case. The upper triangular part of each panel gives the concordance indicator and the lower triangle the correlation matrix between the indicators. An asterisk again indicates a significant rejection (at the 5% level) of the null hypothesis of independence based on the exact Fisher test outcomes listed in Table 3. There are no cases of simultaneous debt crises in the East Asian sample so that the turbulent crisis index is zero

Table 3: Bivariate tests

	Indonesia			Malaysia			Philippines			South Korea			Singapore			Thailand			Total single crisis
	CC	BC	DC	CC	BC	DC	CC	BC	DC	CC	BC	DC	CC	BC	DC	CC	BC	DC	
Indonesia	CC	2*	1	3*	1	-	1	1	0	0	1	1*	4*	0	-	3*	0	-	9
	BC	2	1	3*	0	-	2*	2*	0	2*	4*	0	3*	1	-	4*	2*	-	12
	DC	2	2	0	2*	-	0	0	0	0	0	0	0	0	-	0	0	-	5
Malaysia	CC	2	2	2	0	-	3*	0	0	1	2*	1*	4*	0	-	4*	0	-	10
	BC	2	2	2	2	-	0	1	0	0	2*	0	0	0	-	0	1	-	7
	DC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Philippines	CC	2	2	2	2	-	2	0	1	1	1	0	1	0	-	2*	0	-	12
	BC	2	2	2	2	-	2	0	0	0	2*	0	1	0	-	0	0	-	8
	DC	2	3	2	2	-	3	2	2	0	0	0	0	0	-	0	0	-	14
South Korea	CC	2	2	2	2	-	2	2	2	2	0	0	1	0	-	3*	0	-	7
	BC	2	2	2	2	-	2	2	3	2	0	0	1	2*	-	2*	2*	-	12
	DC	1	2	1	1	-	1	1	1	1	1	0	1	0	-	1*	0	-	1
Singapore	CC	2	2	2	2	-	2	2	3	2	2	1	2	0	-	5*	0	-	11
	BC	1	2	1	1	-	2	1	2	1	2	1	2	2	-	0	1*	-	2
	DC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Thailand	CC	2	2	2	2	-	2	2	2	2	2	1	2	1	-	2	0	-	9
	BC	2	2	2	2	-	2	2	2	2	2	1	2	1	-	2	1	-	10
	DC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0

Note: Upper triangle gives the observed number of concurrent crises for each category, lower triangle gives the lowest number of simultaneous crises for which the null hypothesis of independence is rejected at the 5 percent level, * indicates a significant rejection of independence at the 5 percent level.

in each case. In the case of Malaysia and Singapore the currency crises concordance index is 0.24, indicating the relatively low probability of both these countries' currency markets being in crisis at the same time. Unsurprisingly the concordance index is highest in these tables for pairs of countries involving Thailand, since Thailand is usually regarded as the source of the shock for the East Asian crisis of 1997-1998.

Combinations of the crises which reject the null of independence result in several findings. First, there is some support for the role of the Thai currency crisis as the 'trigger' event for the other currency crises in the region, with significant associations between the Thai currency crisis and that for each other country. Second, the Indonesian banking crisis is associated with both its own currency crisis and a broad range of banking and currency crises in other countries. Third, the South Korean banking crisis is associated with banking crises in each of the other countries. Finally the debt crises are generally less associated with other crises in this sample, the exception being the Indonesian debt crisis is associated with the Malaysian currency crisis.

Other combinations of bivariate tests are also easily constructed.⁶ For example we can construct concordance indices for the possibility of a banking crisis in one country being associated with a currency crisis in another. The results of such an exercise produce positive turbulent period concordance indices for the case of Indonesian banking crises and currency crises in other countries, but otherwise generally a zero index.

The most interesting of these results is the incidence of so-called twin

⁶These tables are available from the authors on request, but are omitted in the interest of saving space.

Table 4: Turbulent-periods concordance index and correlation of bivariate crises

	Indonesia	Malaysia	Philippines	South Korea	Singapore	Thailand
<i>Currency crises</i>						
Indonesia		0.19*	0.05	0.00	0.25*	0.20*
Malaysia	0.30*		0.16*	0.06	0.24*	0.27*
Philippines	0.07	0.25*		0.06	0.05	0.11*
South Korea	-0.02	0.10	0.09		0.06	0.23*
Singapore	0.39*	0.36*	0.06	0.09		0.33*
Thailand	0.32*	0.41*	0.17*	0.37*	0.49*	
<i>Banking crises</i>						
Indonesia		0.00	0.11*	0.20*	0.08	0.10*
Malaysia	-0.02		0.07	0.12*	0.00	0.06
Philippines	0.18*	0.12		0.11*	0.00	0.00
South Korea	0.31*	0.20*	0.18*		0.17*	0.10*
Singapore	0.20	-0.01	-0.01	0.40*		0.09*
Thailand	0.16*	0.10	-0.02	0.16*	0.22*	

Note: Correlations below the diagonal and turbulent-periods concordance indices above the diagonal. The * denotes a significant rejection of the hypothesis of independence at the 5% level, see Table 3.

crises, that is concurrent banking and currency crises, which are more frequent in the modern age than previously according to Bordo and Eichengreen (2000); see also Reinhart and Rogoff (2009). In addition, Bordo *et al.* (2001) calculate that twin crises are twice as costly as currency crises and four times more costly than banking crises in terms of output loss.⁷ Table 5 shows the concordance indices for twin crises across the different countries. The turbulent periods concordance indices for the countries considered for twin crises is low for all but Indonesia.

⁷Bordo *et al.* (2001) express some surprise at the relatively smaller size of the loss of banking crises compared with currency crises, but find this result over a number of sample periods. Their surprise stems from comparisons with alternative literature, such as canvassed in Goldstein, Kaminsky and Reinhart (2000) which rank the costs of banking crises as above currency crises. Reinhart and Rogoff (2010:p.230) give an average GDP per capita decline of -9.3% for historical banking crises, but also note the unusual upward trajectory of GDP growth for emerging economies following earlier crises on p.263.

Table 5: Twin crisis

turbulent-periods concordance index	
Indonesia	0.11
Malaysia	0.00
Philippines	0.00
South Korea	0.00
Singapore	0.00
Thailand	0.00

The results in this section indicate that the financial crises in different markets and countries are not driven by links within the country—that is the joint occurrence of any pair of currency, banking or debt crises within a country does not generally reject the null of independence. One exception to this is between banking and currency crises in Indonesia, but surprisingly not in Thailand and Malaysia. This reinforces the finding that the crises in Asia are primarily driven by international market linkages rather than individual countries (of course we have not included an equity market crisis here which may change this picture and would be a useful extension). To further investigate the linkages between the markets and countries we now consider the construction and testing of the multivariate concordance indices.

4.3 Multivariate concordance indices

Table 6 reports the multivariate concordance indices for the group of crises which involves all three types of crisis and all countries. Each row reports the concordance index for the stated number of common crises occurring across these categories shown in the first column. For example, the first row

reports the concordance index for at least two concurrent crises in either of banking, debt or currency markets across the six economies sampled. A total of 22 time periods are identified which fulfill that criteria, giving a turbulent-periods index of 0.31.

The final column of Table 6 reports the test of the null hypothesis of independence amongst the crises, where the null hypothesis is that all types of crisis are independent across all countries in the sample. Beginning with the higher number of concurrent samples in Table 6, the first panel records a critical frequency of 3 and 1 for the categories of at least 3 and at least 4 crises, respectively. The appropriate interpretation is that no occurrence of 5 or 6 concurrent crises can be considered to be mere coincidence. These cases are related. As the number of concurrent crises recorded is reduced, the frequency with which this may occur is logically higher. For instance, the category of at least 3 crises can occur 3 times before the null hypothesis of independence is rejected. In the total sample, it occurs 11 times, and rejects the null. For the most encompassing of the concurrent crises, at least 2 crises, the critical value indicates that up to 21 instances of concurrent crises may occur completely coincidentally, which is fewer than the 25 observed in the sample.

To further explore these results, we consider the multivariate concordance indices and tests of independence across banking and currency crises alone. We do not consider debt crises as they were of insufficient incidence to generate interesting results. The currency crisis results are given in the middle panel of Table 6 and the banking crisis results in the lower panel of that table. In each case, at all frequencies the null hypothesis of independence

is rejected. That is, concurrent banking crises or concurrent currency crises across countries are not coincidental. This adds further to the evidence collected from the bivariate results, suggesting that the Asian crises spread primarily through the asset markets across countries, rather than within the countries themselves.

Table 6: Concordance index and independence tests of multivariate financial crises in Asian economies

	Concordance index	Observations	Critical value
<i>Across countries–across crises type</i>			
At least 2 crises	0.31	25	21
At least 3 crises	0.14	11	3
At least 4 crises	0.07	6	1
At least 5 crises	0.05	4	0
At least 6 crises	0.02	2	0
Crises observations ($T - \#(0)$)			81
<i>Across countries–currency crises type</i>			
At least 2 crises	0.30	11	7
At least 3 crises	0.16	6	4
At least 4 crises	0.08	3	2
At least 5 crises	0.03	1	1
Crises observations ($T - \#(0)$)			37
<i>Across countries–banking crises type</i>			
At least 2 crises	0.37	13	3
At least 3 crises	0.06	2	2
At least 4 crises	0.03	1	1
Total crises ($T - \#(0)$)			35

Note: The critical value gives the minimum number of observations for the case at hand that rejects the null hypothesis of multivariate independence at the 5% level.

The occurrences of at least Z , $Z = 1, \dots, 6$ crises in the top panel may differ from the sum of the corresponding numbers of currency crises in the middle panel and banking crises in the bottom panel, since for example a dual currency crises may occur simultaneously with a bank or a debt crisis.

The results suggest that when two or more crises occur concurrently, they are unlikely to be coincidental. In our sample, there were 129 crises, 57% of them were associated with concurrent crises in other markets or countries and 43% were isolated to a single market in a particular country. Pairing the crisis data in Table 3 provided 91 instances of dual crises, between currency, banking and debt markets across our sample countries, 73 of those pairs rejected the null hypothesis of independent occurrence of the events, suggesting that the majority of the crises were related. The multivariate tests reinforced this view, rejecting the null of independent crises when more than 2 occurred simultaneously across all the crisis types, and at a slightly higher frequency in each of the three crisis categories.⁸

4.4 Policy Lessons

Policy makers are correct to be concerned about the occurrence of a crisis. However, knowing which crises are going to spread out is as yet unresolved. Isolating the characteristics of what makes a particular crisis spread, or alternatively what makes other markets vulnerable to spread from other crises remains an important issue, and is the focus of work on indicators of financial fragility such as associated with Goldstein, Kaminsky and Reinhart (2000) and more recently Rose and Spiegel (2010). Unfortunately this literature has not been particularly successful to date, with the relatively poor performance of these indicators documented in Berg and Pattillo (1999a,b) and Edison (2003). The problem lies with the heterogeneity of the crises; it seems no two

⁸The differences between the bivariate and multivariate outcomes stress the need for an encompassing model incorporating different assets and country linkages; see for example Hartmann, Straetmans and de Vries. (2004)

crises are ever the same. However, it is important we do know that crisis situations will tend to exacerbate other weaknesses in the economy and financial system, increasing the possibility of crises in other markets and countries, which is reflected in the rejection of the independence tests above.

5 Conclusion

In order to examine whether contemporaneous currency and banking crises in Asia for the period of 1970–2002 can be characterised as coincidental this paper developed a concordance index for the case of low incidence events and extended the analysis to incorporate the concept of multivariate concordance. The application to East Asian data revealed that concurrent crises were unlikely to occur independently in this sample, and demonstrated the richer story which emerges through the use of the new multivariate index.

The results of the empirical analysis suggest that currency (banking) crises in Asia were primarily transmitted across geographical borders to the currency (banking) sector in other countries, rather than primarily transmitting within a country and forming twin crises. The dominance of cross border over cross market condition is consistent with measurements of currency and equity market contagion in Dungey and Martin (2007). These results suggest a potential role for international financial architectural reform in mitigating the transmission of crises, although this is contingent on the extent of potential vulnerability through weak fundamentals. Further work on recent crises will reveal whether the results of cross border transmissions of crises generally dominate cross asset market transmissions.

Acknowledgements

Dungey acknowledges funding from ARC Grant DP0343418, Jacobs acknowledges support from the Research School SOM, University of Groningen. The present version of the paper has benefited from comments following many seminars. Some revisions were accomplished during the second author's visit to the University of Tasmania, Hobart, whose kind hospitality is gratefully accomplished.

References

- Abiad, A. (2003), “Early warning systems: A survey and a regime-switching approach”, *IMF Working Paper* 32, International Monetary Fund, Washington, D.C.
- Agresti, A. (2002), *Categorical data analysis*, Wiley Series in Probability and Statistics, John Wiley & Sons, Inc., Hoboken, NJ.
- Athukorala, P.-C. and P. Warr (2002), “Vulnerability to a currency crisis: lessons from the Asian experience”, *World Economy*, **25**, 33–57.
- Bae, K.-H., G.A. Karolyi, and R. Stulz (2003), “A new approach to measuring financial contagion”, *Review of Financial Studies*, **16**(3), 717–763.
- Balkan, E. M. (1992), “Political instability, country risk and probability of default”, *Applied Economics*, **24**(9), 999–1008.
- Bank for International Settlements (2010), “Report and recommendations of the cross-border bank resolution group”, Technical report, Bank for International Settlements, Committee on Banking Supervision, Basel, Switzerland.
- Berg, A. and C. Pattillo (1999a), “Predicting currency crises: the indicators approach and an alternative”, *Journal of International Money and Finance*, **18**(4), 561–586.
- Berg, A. and C. Pattillo (1999b), “What caused the Asian crises: An early warning system approach”, *Economic Notes*, **28**(3), 285–334.

- Berg, A. and J. Sachs (1988), “The debt crisis structural explanations of country performance”, *Journal of Development Economics*, **29**(3), 271–306.
- Bordo, M.D and B. Eichengreen (2000), “Is the crisis problem growing more severe?”, paper presented at a Sveriges Riksbank conference on ‘Asset prices and monetary policy’, Stockholm , 16-17 June.
- Bordo, M.D., B. Eichengreen, D. Klingebiel, and M.S. Martinez-Peria (2001), “Is the crisis problem growing more severe?”, *Economic Policy*, **16**, 53–82.
- Brunnermeier, M., A. Crockett, C. Goodhart, A. Persaud, and H. Shin. (2009), “The fundamental principles of financial regulation”, Geneva Reports on the World Economy 11, ICMB and CEPR, Geneva, Switzerland.
- Caprio, G. and D. Klingebiel (1996), “Bank insolvencies: cross-country experience”, *Policy Research Working Paper* 1620, World Bank, Washington, D.C.
- Dermirgüç-Kunt, A. and E. Detragiache (1997), “The determinants of banking crises in developing and developed countries”, *IMF Working Paper* 106, International Monetary Fund, Washington, D.C.
- Dungey, M., J.P.A.M. Jacobs, and Lestano (2010), “Synchronisation of financial crises”, *SOM Research Report #* 10002, Systems, Organisations and Management, Groningen.
- Dungey, M. and V.L. Martin (2004), “A multifactor model of exchange rates with unanticipated shocks: measuring contagion in the East Asian currency crisis”, *Journal of Emerging Market Finance*, **3**, 305–330.

- Dungey, M. and V.L. Martin (2007), “Unravelling financial market linkages during crises”, *Journal of Applied Econometrics*, **22**, 89–119.
- Edison, H.J. (2003), “Do indicators of financial crisis work? An evaluation of an Early Warning System”, *International Journal of Finance and Economics*, **8**, 11–53.
- Eichengreen, B., K. Kletzer, and A. Mody (2003), “Crisis resolution: next steps”, *NBER Working Paper* 10095, National Bureau of Economic Research, Cambridge, MA.
- Eichengreen, B., A.K. Rose, and C. Wyplosz (1995), “Exchange rate mayhem: the antecedents and aftermath of speculative attacks”, *Economic Policy*, **21**, 251–312.
- Eichengreen, B., A.K. Rose, and C. Wyplosz (1996), “Contagious currency crises: first tests”, *Scandinavian Journal of Economics*, **98**(4), 463–484.
- Eichengreen, Barry (2002), *Financial crises and what to do about them*, Oxford University Press, Oxford, UK.
- Favero, C.A. and F. Giavazzi (2002), “International propagation of financial shocks non-linear? evidence from the ERM”, *Journal of International Economics*, **57**(1), 231–246.
- Flood, A. and N. Marion (1999), “Perspectives on the recent currency crisis literature”, *International Journal of Finance and Economics*, **4**, 1–26.
- Forbes, K.J. and R. Rigobon (2002), “No contagion, only interdependence: measuring stock market comovements”, *Journal of Finance*, **57**(5), 2223–2261.

- Frankel, J.A. and A.K. Rose (1996), “Currency crashes in emerging markets: an empirical treatment”, *Journal of International Economics*, **41**(3-4), 351–366.
- Furnam, J. and J.E. Stiglitz (1998), “Economic crises: Evidence and insights from east Asia”, *Brookings Papers on Economic Activity*, **2**, 1–135.
- Goldstein, M., G. Kaminsky, and C. Reinhart (2000), *Assessing financial vulnerability: an early warning system for emerging markets*, Institute for International Economics, Washington, D.C.
- Hajivassiliou, V.A. (1989), “Do the secondary markets believe in life after debt?”, *Cowles Foundation Discussion Paper* 911, Yale University, New Haven.
- Hajivassiliou, V.A. (1994), “A simulation estimation analysis of the external debt crises of developing countries”, *Journal of Applied Econometrics*, **9**(2), 109–131.
- Harding, D. and A.R. Pagan (2002), “Dissecting the cycle: a methodological investigation”, *Journal of Monetary Economics*, **49**(2), 365–381.
- Harding, D. and A.R. Pagan (2006), “Synchronisation of cycles”, *Journal of Econometrics*, **132**, 59–79.
- Hartmann, P., S. Straetmans, and C.G. de Vries (2004), “Asset market linkages in crisis periods”, *Review of Economics and Statistics*, **86**(1), 313–326.
- Jacobs, J.P.A.M., G.H. Kuper, and Lestano (2005), “Identifying financial crises”, in M. Dungey and D.N. Tambakis, editors, *Identifying Interna-*

- tional Financial Contagion: Progress and Challenges*, Oxford University Press, New York.
- Joyce, J.P. and M. Nabar (2009), “Sudden stops, banking crises and investment collapses in emerging markets”, *Journal of Development Economics*, **90**, 314–322.
- Kaminsky, G.L., S. Lizondo, and C.M. Reinhart (1998), “Leading indicators of currency crisis”, *IMF Staff Papers* 45/1, International Monetary Fund, Washington, D.C.
- Kaminsky, G.L. and C.M. Reinhart (1999), “The twin crises: the causes of banking and balance-of-payments problems”, *American Economic Review*, **89**(3), 473–500.
- Kaminsky, G.L. and C.M. Reinhart (2000), “On crises, contagion, and confusion”, *Journal of International Economics*, **51**(1), 145–168.
- Karolyi, G. (2003), “Does international financial contagion really exist?”, *International Finance*, **6**(2), 179–199.
- Kenward, L.R. (1999), “Assessing vulnerability to financial crisis: evidence from Indonesia”, *Bulletin of Indonesian Studies*, **35**, 71–95.
- Lanoie, P. and S. Lemarbre (1996), “Three approaches to predict the timing and quantity of LDC debt rescheduling”, *Applied Economics*, **28**(2), 241–246.
- Lee, S.H. (1991), “Ability and willingness to service debt as explanation for commercial and official rescheduling cases”, *Journal of Banking and Finance*, **15**(1), 5–27.

- Lestano, J.P.A.M. Jacobs, and G.H. Kuper (2003), “Indicators of financial crises do work! An early-warning system for six Asian countries”, *CCSO Working Paper* No. 13, Department of Economics, University of Groningen, The Netherlands.
- Lindgren, C.-J., G. Garcia, and M.I. Saal (1996), *Bank Soundness and Macroeconomic Management*, International Monetary Fund, Washington, D.C.
- Marchesi, S. (2003), “Adoption of an IMF programme and debt rescheduling”, *Journal of Development Economics*, **70**(2), 403–423.
- McFadden, D., R. Eckaus, G. Fader, V. Hajivassiliou, and S. O’Connell (1985), “Is there life after debt? An econometric analysis of the creditworthiness of developing countries”, in G. Smith and J. Cuddington, editors, *International Debt and the Developing Countries*, The World Bank, Washington , D.C., 179–209.
- Pozo, S. and C. Amuedo-Dorantes (2003), “Statistical distributions and the identification of currency crises”, *Journal of International Money and Finance*, **22**(4), 591–609.
- Reinhart, C.M. and K.S. Rogoff (2009), *This time is different: Eight centuries of financial folly*, Princeton University Press, Princeton, US.
- Rose, A. and M. Spiegel (2010), “Cross-country causes and consequences of the 2008 crisis: Early Warning”, *NBER Working Paper* 1537, National Bureau of Economic Research, Cambridge, MA.
- Sachs, J.D., A. Tornell, and Velasco A. (1996), “Financial crises in emerging markets: the lessons from 1995”, *Brookings Papers on Economic Activity*, **1**, 147–215.

School of Economics and Finance Discussion Papers

2010-01	Economic Assessment of the Gunns Pulp Mill 2004-2008, Graeme Wells
2010-02	From Trade-to-Trade in US Treasuries, Mardi Dungey, Olan Henry and Michael McKenzie
2010-03	Detecting Contagion with Correlation: Volatility and Timing Matter, Mardi Dungey and Abdullah Yalama
2010-04	Non-Linear Pricing with Homogeneous Customers and Limited Unbundling, Hugh Sibly
2010-05	Assessing the Impact of Worker Compensation Premiums on Employment in Tasmania, Paul Blacklow
2010-06	Cojumping: Evidence from the US Treasury Bond and Futures Markets, Mardi Dungey and Lyudmyla Hvozdyk
2010-07	Modelling the Time Between Trades in the After-Hours Electronic Equity Futures Market, Mardi Dungey, Nagaratnam Jeyasreedharan and Tuo Li
2010-08	Decomposing the Price Effects on the Cost of Living for Australian Households, Paul Blacklow
2010-09	Menus of Linear Contracts in Procurement with Type-Dependent Reservation Utility, Shane B. Evans
2010-10	Franchise Contracts with Ex Post Limited Liability, Shane B. Evans
2010-11	Innovation Contracts with Leakage Through Licensing, Shane B. Evans
2012-12	Financial Crises in Asia: Concordance by Asset Market or Country?, Mardi Dungey, Jan P.A.M. Jacobs and Lestano
2008-01	Calorie Intake in Female-Headed and Male Headed Households in Vietnam, Elkana Ngwenya
2008-02	Determinants of Calorie Intake in Widowhood in Vietnam, Elkana Ngwenya
2008-03	Quality Versus Quantity in Vertically Differentiated Products Under Non-Linear Pricing, Hugh Sibly
2008-04	A Taxonomy of Monopolistic Pricing, Ann Marsden and Hugh Sibly
2008-05	Vertical Product Differentiation with Linear Pricing, Hugh Sibly
2008-06	Teaching Aggregate Demand and Supply Models, Graeme Wells
2008-07	Demographic Demand Systems with Application to Equivalence Scales Estimation and Inequality Analysis: The Australian Evidence", Paul Blacklow, Aaron Nicholas and Ranjan Ray
2008-08	Yet Another Autoregressive Duration Model: The ACDD Model, Nagaratnam Jeyasreedharan, David E Allen and Joey Wenling Yang
2008-09	Substitution Between Public and Private Consumption in Australian States, Anna Brown and Graeme Wells

Copies of the above mentioned papers and a list of previous years' papers are available from our home site at <http://www.utas.edu.au/ecofin>