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ACTUALLY THIS TIME IS DIFFERENT

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Actually This Time *Is* Different*

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Abstract

Episodes of extraordinary turbulence in global financial markets are examined during eight crises ranging from Asia in 1997-98 to the recent great recession of 2008-10. The analysis focuses on changes in the dependence structures of equity markets through correlation and coskewness to answer the question of whether the great recession is different to other crises in terms of shock transmission through contagion. The results show that 'this time is different' and that the great recession is truly a global financial crisis. Other US sourced crises do not affect other markets through contagion, and emerging market crises transmit unexpectedly.

Keywords: Contagion testing; Correlation; Coskewness; Asian crisis, Russian crisis, LTCM crisis, Brazil crisis, dot-com crisis, Argentinian crisis, sub-prime crisis, great recession, global financial crisis

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1 Introduction

The impressive body of work of Reinhart and Rogoff (2008a,b) historically analyses eight centuries of financial crises and conveys a simple message. Society convinces itself that in contrast to prior episodes in history, the prosperity that tends to precede crises is a permanent fixture of the economy. House and equity prices will increase into the foreseeable future, usually because of the competence of policy makers compared to the past, the view that economic fundamentals are sound, and that growth enhancing structural reforms and technological innovations will continue to be successful. This is what Reinhart and Rogoff refer to as the "This Time Is Different Syndrome". Then comes the crash.

This paper examines the syndrome of "This Time Is Different" from an alternative view point. The "crash" of eight crisis episodes is taken to establish in what sense "This Time Is Different" in terms of their international transmission during, rather than before, each episode. Countries with poor or similar fundamentals and even those with sound fundamentals suddenly worry that they too will be affected by the crisis and many take unprecedented steps to contain the transmission from the crisis markets to their own. Panic tends to set in amongst the financial and policy making communities as markets are not only linked through their normal mechanisms, but linkages that did not seem to exist before the crisis suddenly appear. These second type of linkages are referred to as contagion, and it is the nature of these little understood linkages that we seek to understand from a multi-crisis dimension. The work is also related to Dungey et al. (2009) in theme, but different in framework, which explores whether or not financial market crises are alike in equity and bond markets.

Contagion tests are about detecting sudden changes in dependence structures between markets which occur once a crisis is triggered. Early forms of contagion tests which intuitively convey its meaning are the correlation change tests of King and Wadhwani (1990) and Forbes and Rigobon (2002). After conditioning on economic relationships that exist in both of the non-crisis and crisis periods, a rising correlation of shocks between financial markets in the crisis period compared to the non-crisis period indicates that the nature of the transmission of shocks has changed and there is evidence of contagion. This idea is extended in Fry, Martin and Tang (2010) and applied here to examine contagion across markets through changes in higher order dependence structures such as coskewness. Contagion is defined as a significant change

in the dependence structures of asset returns during a crisis compared to a non-crisis period.

The tests developed in Fry, Martin and Tang (2010) draw on an idea from the univariate setting that the distribution of asset returns during crises can switch from negative to positive skewness as the preferences of risk averse agents change in a crisis period. In a crisis, agents prefer positive skewness and are apt to accept lower average returns in exchange (Ingersoll, 1990; Harvey and Siddique, 2000; Fry, Martin and Tang, 2010). Connecting markets as agents adjust their cross market risk preferences is the multivariate version of this relationship of coskewness. In essence, coskewness measures the correlation between the volatility of a source asset market and the average returns of a recipient market or vice versa. In a crisis, increasingly risk averse investors prefer positive to negative coskewness as investors seek to minimize their losses having conditioned on increased volatility. The coskewness contagion tests are related in spirit to the work in Yuan (2005) and Guidolin and Timmerman (2009) who focus on the role of skewness and/or kurtosis preferences in understanding asset prices given investor preferences or behavior.

Reinhart and Rogoff (2008a,b) document the "This Time Is Different" phenomena by focusing on sovereign debt crises, domestic debt crises, banking crises, inflation crises and exchange rate crises. The approach here is to focus on the international transmission of crises through daily equity market returns during eight crisis episodes. The equity market is chosen as it is relatively liquid in most countries and the duration of several crises is on the short side, making it difficult to capture in quarterly or other lower frequency transmission. It is also likely that the panic reflected in investor and policy maker behavior referred to earlier is a short term phenomenon. The macro-economic triggers of the eight crises though are drawn from the types investigated by Reinhart and Rogoff.

One important distinction that Reinhart and Rogoff make in their book is between a true global financial crisis and a severe financial crisis. Reinhart and Rogoff develop a metric of financial turbulence to quantitatively measure the severity of crises regionally and globally. In their definition of a global financial crisis, one of their criteria is that a global financial centre is also experiencing a severe crisis, with the idea that they are in the position to transmit crises through financial flows emanating through the centre. The framework of this paper is able to provide evidence on the existence of such a global financial crisis with four of the eight crises episodes being sourced in the US

market.[1] This transmission channel is also related to the centre and periphery concepts of Kaminsky and Reinhart (2003). Kaminsky and Reinhart (2003) argue that often the centre is a conduit of a crisis from one region to another without necessarily being impacted itself, and without being the trigger of the crisis *per se*. This paper provides some evidence on this effect by examining the transmission of contagion across four different crises sourced in emerging markets by finding that crises sourced in emerging markets often have unanticipated consequences particularly for developed markets.[2]

The main empirical finding with respect to the US sourced crises is that "This Time Is Different". The great recession in the period following the collapse of Lehman Brothers is more widespread in terms of the transmission of contagion compared to the US based and emerging market crises in the sample and is truly a global financial crisis. In contrast to the great recession, it is not the case that crises beginning in a major financial centre have important consequences for the rest of the world through the channels of contagion. The little contagion evident in the LTCM and dot-com crises suggests that shocks from a well integrated market do not result in surprise transmissions. This is not to say that there is no crisis transmission through normal dependence structures, but that there is no contagion.

The rest of this paper proceeds as follows. Section 2 provides the context in which the financial community and policy makers proclaim that "This Time Is Different". Section 3 specifies the contagion tests based on changes in correlation and coskewness and specifies the methods to control for interdependencies. Section 4 presents the crises and the empirical results, with Section 4.3 describing the sense in which "This Time Is Different" by examining the transmission channels of contagion for crises sourced in the US and in emerging markets. It then presents an index of crisis severity constructed for the great recession as it evolved through 2007 to 2010. Section 4.4 focuses on issues surrounding the dating of the crisis periods and the choice of the benchmark to compare the crisis period dynamics. Section 5 concludes.

[1] The US sourced crises correspond to the near collapse of the hedge fund Long Term Capital Management (LTCM), the collapse of the speculative bubble surrounding the dot-com industries, the sub-prime shock and the more severe phase of that crisis following the collapse of Lehman Brothers which is labeled the great recession.

[2] The emerging market crises are the Asian crisis, the Russian crisis, the Brazilian crisis and the Argentinian crisis.

2 This Time Is Different

As Reinhart and Rogoff well document, from an historical perspective, financial market crises are seemingly common place. Equity price data for the twelve countries of this paper are presented in Figure 1 from 1995 to 2010. The shaded areas on this diagram indicates periods of crises in some equity markets around the globe, with the crises originating in diverse regions including Asia, Russia, the US and Latin America. The crises include the Asian financial crisis of 1997-1998, the Russian and LTCM crises of 1998, the Brazilian devaluation of 1999, the dot-com crisis of 2000, the Argentinian crisis of 2001-2002, the sub-prime crisis of 2007-2008 and the great recession of 2008-2010.

Figure 1 shows how dramatically markets can plummet when a crisis occurs, and also illustrates the connectedness of equity markets as falls occur simultaneously. Yet anecdotally crises appear to take policy makers, financial and economic systems by surprise. Speculation during the Asian crisis in the US was that a recession was imminent and that American workers would lose their jobs (Galbraith, 1998). The Russian and LTCM crisis was concluded to be the "worst crisis ever" (Committee on the Global Financial System, 1999), and in the recent great recession it was expected that emerging countries would experience "sudden stops" (Blanchard, 2008).

In the midst of crises, uncertainty usually on the downside, pervades policy, financial and economic systems. Usually the leaders of most governments and policy organizations such as Central Banks and the IMF try to bring calm to markets through their measured statements. However, their actions such as dramatic, surprise interest rate cuts, often belie their beliefs of the seriousness. It is often media and financial commentators who express the crisis in terms of the panic ("This Time Is Different") experienced and emotional responses to crises reflected in plummeting indicators of consumer and business confidence (see Figure 2 for the US target Federal Funds Rate and indicators of consumer and business confidence). In hindsight, the drama of the media is sometimes just that, but in the midst of a crisis it is difficult to tell.

3 Contagion Tests

To formally analyze the extent that each crisis transmits from a source market to others through channels of contagion, three tests of financial market contagion are adopted. The tests are documented in detail in Fry, Martin and Tang (2010), and are

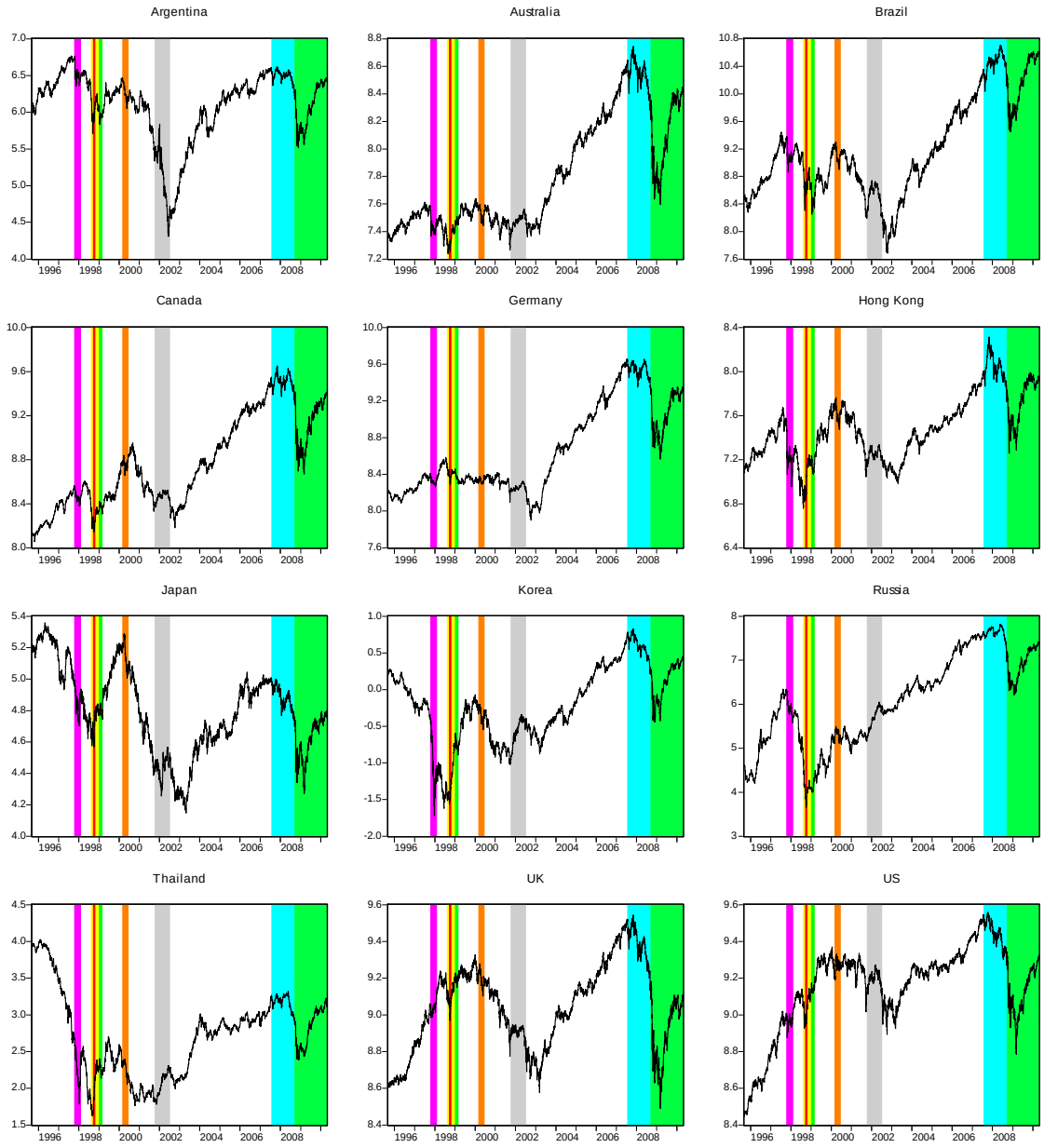

Figure 1: Daily equity prices (natural logs) - September 1, 1995-April 26, 2010. The shaded areas refer to episodes of crisis in international equity markets. These are (i) the Asian financial crisis (October 17, 1997 to January 30, 1998); (ii and iii) the Russian bond default and the LTCM crisis (Russia: August 17, 1998 to December 31, 1998; LTCM: September 23, 1998 to October 15, 1998); (iv) the Brazilian crisis (January 7, 1999 to February 25, 1999), (v) the dot-com crisis (February 28, 2000 to June 7, 2000); (vi) the Argentinian crisis (October 11, 2001 to June 30, 2002); (vii) the sub-prime crisis (July 26, 2007 to September 14, 2008); and (viii) the great recession (September 15, 2008 to April 26, 2010).

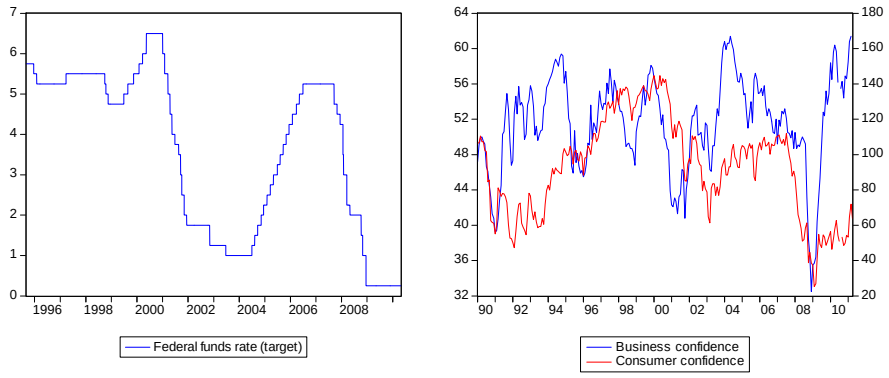

Figure 2: US Federal Funds Rate (target) and Consumer and Business Confidence Indexes. September 1, 1995 to April 26, 2010. Sources: FRED database and Trading Economics respecitively.

briefly summarized here. The underlying model used in motivating the tests builds on the portfolio model of risk of Harvey and Siddique (2000). Fry, Martin and Tang (2010) extend the mean-variance framework to account for the higher order dependence structures between assets discussed here. The expected excess return on assets is expressed in terms of risk prices which are a function of the risk preferences of investors, and risk quantities which are a function of higher order conditional moments including skewness and coskewness.

The statistical tests are derived in Fry, Martin and Tang (2010) from a family of bivariate distributions based on the generalized exponential distribution of Cobb, Koppstein and Chen (1983) and Lye and Martin (1993). In that framework, the bivariate normal distribution is extended to allow for dependence structures through higher order comoments with Lagrange Multiplier Tests derived as the basis of the tests for contagion. The first test of contagion is a correlation based test similar to that used in Forbes and Rigobon (2002) and refined in Fry, Martin and Tang (2010), which tests for changes in correlations across different sample periods. The second and third tests identify contagion as a significant change in (two alternative forms of) coskewness across markets during periods of financial market instability compared to normal times. The identification of contagion using each of these tests rests partly on the specification of a crisis source asset market denoted by i, while j represents the recipient market.

3.1 Interdependencies

The definition of contagion can be interpreted as comovements in asset returns not due to the cross market interdependencies that exist in all states s_t. As is standard in the contagion literature (see particularly the precedents set in Forbes and Rigobon, 2002) the data is adjusted in several dimensions to control for interdependencies and domestic economic conditions by estimating a VAR of the form

$$R_t = \phi(L) R_t + \Phi(L) F_t + z_t, \tag{1}$$

where R_t is the vector of returns of all equity markets in the sample, F_t contains other relevant observable economic data for all markets, $\phi(L)$ and $\Phi(L)$ are vectors of lags of p and q respectively, and z_t is the vector of residuals. Own market conditions and cross-market interdependencies in the data are controlled for through the combined effects of $\phi(L)$ and $\Phi(L)$. These parameters capture the transmission of shocks occurring through relationships that exist in all states of nature. It is the residuals of the VAR, (z_t), that are used as the returns in the calculation of the test statistics of contagion of Sections 3.2 and 3.3. To this end z_t is separated into non-crisis $(x_t | s_t = 0)$ and crisis $(y_t | s_t = 1)$ period data depending on an exogenous choice of state

$$s_t = \begin{cases} 0: & \text{non-crisis} \\ 1: & \text{crisis} \end{cases},$$

with sample sizes T_x and T_y respectively so that $z_t = \left(x_1, x_2, ..., x_{Tx}, y_1, y_2, ..., y_{T_y}\right)$.

3.2 Correlation Contagion Test

Correlation coefficients may be biased upwards because of increased volatility in asset returns in the source market during financial market crises. Forbes and Rigobon (2002) show how this bias can be removed using

$$\widehat{\nu}_{y|x_i} = \frac{\widehat{\rho}_y}{\sqrt{1 + \delta\left(1 - \widehat{\rho}_y^2\right)}}, \tag{2}$$

which adjusts the unconditional correlation coefficient $\left(\widehat{\rho}_y\right)$ of the crisis period between the source and recipient countries for heteroskedasticity. The denominator of the conditional correlation coefficient $\left(\widehat{\nu}_{y|x_i}\right)$ includes a term $\delta = \frac{s_{y,i}^2 - s_{x,i}^2}{s_{x,i}^2}$ which is the proportionate change in the volatility of returns in the source equity market i,

where $s^2_{x,i}$ and $s^2_{y,i}$ are the sample variances of equity returns in market i during the non-crisis and crisis periods.

The correlation test presented here is slightly different to that of Forbes and Rigobon (2002) as the data period is non-overlapping (Fry, Martin and Tang, 2010). The statistic for contagion (CR) based on the significance of a change in the adjusted crisis period correlation compared to a non-crisis period correlation ($\widehat{\rho}_x$) from i to j can be represented as[3]

$$CR(i \to j) = \left(\frac{\widehat{\nu}_{y|x_i} - \widehat{\rho}_x}{\sqrt{Var\left(\widehat{\nu}_{y|x_i} - \widehat{\rho}_x\right)}} \right)^2. \tag{3}$$

The null hypothesis of no contagion between two equity markets is

$$H_0 : \nu_{y|x_i} = \rho_x,$$

against the alternative hypothesis of contagion

$$H_1 : \nu_{y|x_i} \neq \rho_x.$$

Under the null hypothesis of no contagion, the correlation test of contagion is asymptotically distributed as $CR\left(i \to j\right) \xrightarrow{d} \chi^2_1$. The test here is a two sided test in contrast to Forbes and Rigobon (2002) to allow for a more general interpretation of contagion where contagion is considered to be any significant change in the dependence structures between the markets considered.

3.3 Coskewness Contagion Tests

Analogous to the correlation test for contagion, the coskewness tests for contagion from the source market i to the recipient market j seek a significant change in the

[3]The standard error in equation (3) is presented in Fry, Martin and Tang (2010), where

$$\begin{aligned}
Var\left(\widehat{\nu}_{y|x_i} - \widehat{\rho}_x\right) &= Var\left(\widehat{\nu}_{y|x_i}\right) + Var\left(\widehat{\rho}_x\right) - 2Cov\left(\widehat{\nu}_{y|x_i}, \widehat{\rho}_x\right) \\
Var\left(\widehat{\nu}_{y|x_i}\right) &= \frac{1}{2}\frac{(1+\delta)^2}{\left[1+\delta\left(1-\rho_y^2\right)\right]^3}\left[\frac{1}{T_y}\left(\left(2-\rho_y^2\right)\left(1-\rho_y^2\right)^2\right) + \frac{1}{T_x}\left(\rho_y^2\left(1-\rho_y^2\right)^2\right)\right] \\
Var\left(\widehat{\rho}_x\right) &= \frac{1}{T_x}\left(1-\rho_x^2\right)^2 \\
Cov\left(\widehat{\nu}_{y|x_i}, \widehat{\rho}_x\right) &= \frac{1}{2}\frac{1}{T_x}\frac{\rho_y\rho_x\left(1-\rho_y^2\right)\left(1-\rho_x^2\right)(1+\delta)}{\sqrt{\left[1+\delta\left(1-\rho_y^2\right)\right]^3}}.
\end{aligned}$$

distribution of the returns across a non-crisis and crisis period. Coskewness is a third moment and can take two forms. The first is denoted $\widehat{\psi}\left(r_i^1, r_j^2\right)$ and is given by

$$\widehat{\psi}\left(r_i^1, r_j^2\right) = \frac{1}{T}\sum_{t=1}^{T}\left(z_i - \widehat{\mu}_i\right)^1\left(z_j - \widehat{\mu}_j\right)^2. \tag{4}$$

This form of coskewness is a function of the relationship between the (demeaned) level of the equity returns of asset i $\left(z_i - \widehat{\mu}_i\right)^1$ and the volatility of the demeaned equity returns of market j, $\left(z_j - \widehat{\mu}_j\right)^2$.

The second form of coskewness is $\widehat{\psi}\left(r_i^2, r_j^1\right)$, where

$$\widehat{\psi}\left(r_i^2, r_j^1\right) = \frac{1}{T}\sum_{t=1}^{T}\left(z_i - \widehat{\mu}_i\right)^2\left(z_j - \widehat{\mu}_j\right)^1. \tag{5}$$

This form of coskewness is a function of the volatility of the (demeaned) equity returns of the source market i $\left(z_i - \widehat{\mu}_i\right)^2$ and the level of the (demeaned) equity market returns of z_j $\left(z_j - \widehat{\mu}_j\right)^1$, the recipient country.

The contagion tests looking for significant changes in the coskewness coefficients in a crisis $\left(\widehat{\psi}_y\right)$ compared to a non-crisis $\left(\widehat{\psi}_x\right)$ period are denoted CS_1 and CS_2 and are given by

$$CS_1\left(i \to j; r_i^1, r_j^2\right) = \left(\frac{\widehat{\psi}_y\left(r_i^1, r_j^2\right) - \widehat{\psi}_x\left(r_i^1, r_j^2\right)}{\sqrt{\frac{4\widehat{\nu}_{y|x_i}+2}{T_y} + \frac{4\widehat{\rho}_x^2+2}{T_x}}}\right)^2, \tag{6}$$

$$CS_2\left(i \to j; r_i^2, r_j^1\right) = \left(\frac{\widehat{\psi}_y\left(r_i^2, r_j^1\right) - \widehat{\psi}_x\left(r_i^2, r_j^1\right)}{\sqrt{\frac{4\widehat{\nu}_{y|x_i}+2}{T_y} + \frac{4\widehat{\rho}_x^2+2}{T_x}}}\right)^2, \tag{7}$$

where

$$\widehat{\psi}_y\left(r_i^m, r_j^n\right) = \frac{1}{T_y}\sum_{t=1}^{T_y}\left(\frac{y_{i,t} - \widehat{\mu}_{y_i}}{\widehat{\sigma}_{y_i}}\right)^m\left(\frac{y_{j,t} - \widehat{\mu}_{y_j}}{\widehat{\sigma}_{y_j}}\right)^n, \tag{8}$$

$$\widehat{\psi}_x\left(r_i^m, r_j^n\right) = \frac{1}{T_x}\sum_{t=1}^{T_x}\left(\frac{x_{i,t} - \widehat{\mu}_{x_i}}{\widehat{\sigma}_{x_i}}\right)^m\left(\frac{x_{j,t} - \widehat{\mu}_{x_j}}{\widehat{\sigma}_{x_j}}\right)^n. \tag{9}$$

The terms $\mu_{y_i}, \mu_{y_j}, \mu_{x_i}, \mu_{x_j}$ are the mean of the equity returns of market i and j in the crisis and non-crisis periods, and $\sigma_{y_i}, \sigma_{y_j}, \sigma_{x_i}, \sigma_{x_j}$ are the corresponding standard

errors. The differences in the tests are dependent on whether the equity market at the source of the crisis is expressed in accordance with the levels of the returns (the first coskewness test) or the squared returns (the second coskewness test) in computing coskewness.

The coskewness contagion tests are two sided tests, with the null and alternative hypotheses using statistic CS_1 and CS_2 given by

$$\begin{aligned} H_0 &: \psi_y(r_i^m, r_j^n) = \psi_x(r_i^m, r_j^n), \\ H_1 &: \psi_y(r_i^m, r_j^n) \neq \psi_x(r_i^m, r_j^n). \end{aligned}$$

Under the null hypothesis of no contagion, the coskewness test of contagion is asymptotically distributed as

$$CS_1\left(i \rightarrow j\right), CS_2\left(i \rightarrow j\right) \xrightarrow{d} \chi_1^2. \tag{10}$$

4 Eight Episodes of Crises

This section applies the three forms of contagion tests to equity markets in the eight most recent financial market crises. Prior to presenting the empirical results, this section presents the data and the dating and triggers of the crises, and then further explores issues surrounding the choice of non-crisis period and the dating of the crises.

4.1 The Data and Sample

The sample consists of daily equity price indices ($P_{k,t}$) expressed in US dollars collected for the $k = 12$ equity markets of Argentina, Australia, Brazil, Canada, Germany, Hong Kong, Japan, Russia, Korea, Thailand, the UK and the US. This choice of markets covers a selection of emerging markets, developed markets, regions, markets that are the trigger of a crisis and others who are not directly involved. The sample period begins September 1, 1995 and ends April 26, 2010, for a total of $T = 3822$ observations. Daily percentage equity returns ($R_{k,t}$) of the k^{th} market are calculated as

$$R_{k,t} = 100\left(ln(P_{k,t}) - ln(P_{k,t-1})\right). \tag{11}$$

Equation (1) is estimated to extract the data z_t net of interdependencies, with F_t containing the short term interest rates for the k markets.[4] A lag order of $p = 5$ in

[4] December 19 and 20 2006 are dummied out of the data for Thailand due to outliers

$\phi(L)$ is chosen using the results of the Aikaike Information and the Hannan-Quinn lag order selection criteria. The lag structure for $\Phi(L)$ is set at $q = 1$.[5] The interest rates in F_t are one of the few variables available at a daily frequency able to capture macroeconomic aspects of the economy which also affect equity markets. To control for time zone differences and following Forbes and Rigobon (2002), the data is adjusted by using the two day rolling average of returns. Following these data manipulations, the sample size is $T = 3815$ and the effective sample period is September 12, 1995 to April 26, 2010.

As a point of reference for understanding the properties of the non-crisis and crisis period data, Table 1 provides some preliminary statistics on the characteristics of the series on a univariate and multivariate basis. The crisis statistics are presented for the first 100 days of that crisis representing a sub-period of the most uncertainty.

The main points to note from these tables are that in the non-crisis period, all returns are positive compared to the crisis period where all are negative. All countries reported values of negative skewness apart from the US in the non-crisis period, while in the crisis period almost all countries reported positive skewness coefficients, or at least moved in that direction. This result confirms investors actively investing in risky assets and being prepared to accept the risk of large losses in return for higher returns in the non-crisis period. Also evident is the reversal of this relationship during the crisis period. In terms of the statistics measuring dependence across markets, the simple correlation coefficients of all countries with the US are much higher in the crisis period than in the non-crisis period, with the exception of that for Japan. Examination of the coskewness coefficients $\widehat{\psi}\left(r_i^1, r_j^2\right)$ and $\widehat{\psi}\left(r_i^2, r_j^1\right)$ of each country with the US also appear to change substantially across the non-crisis and crisis periods.

4.2 Dating and Triggers

As contagion tests are conditioned on a 'state' of nature s_t, the dating of the crisis periods is an essential component. Often there is no consensus to the dating of a crisis and this is clearly an area of future research (Kose, 2011). There is a body of work emerging where the dates of historical crises of different types are defined but this applies mainly to banking crises which is not necessarily applicable here, and they are not necessarily consistent across papers. See for examples Caprio et al. (2005), Laeven and Valencia (2008), Reinhart and Rogoff (2008b) and Reinhart (2010).

[5] Results of the lag specification tests are available on request.

Table 1:
Preliminary statistics for the (i) non-crisis period prior to the sub-prime crisis; and (ii) the first 100 days of the great recession.

	Mean	Min	Max	Std Dev	Skewness	Correlation	Coskew 1	Coskew 2
				(i) Non-crisis				
Arg.	0.155	-10.461	7.514	1.825	-0.321	0.243	-0.172	-0.077
Aus.	0.086	-3.785	3.883	0.985	-0.414	0.034	0.069	-0.222
Bra.	0.154	-8.572	12.728	2.156	-0.229	0.404	-0.227	-0.133
Can.	0.080	-4.857	3.907	0.952	-0.415	0.518	-0.046	0.128
Ger.	0.101	-5.016	4.492	1.036	-0.580	0.338	-0.123	-0.094
HK.	0.060	-4.224	4.049	0.979	-0.113	0.126	0.053	-0.189
Jap.	0.039	-6.509	4.248	1.312	-0.286	0.068	-0.010	-0.147
Kor.	0.096	-6.269	5.266	1.407	-0.381	0.096	-0.066	-0.337
Rus.	0.133	-10.605	9.619	1.712	-0.819	0.134	0.095	-0.091
Thai.	0.078	-16.064	9.673	1.392	-1.154	0.032	0.058	-0.249
UK	0.047	-5.309	5.570	1.070	-0.191	0.421	0.024	0.094
US	0.030	-4.751	6.155	0.933	0.312	1.000	0.312	0.312
				(ii) First 100 days of the great recession				
Arg.	-0.562	-12.864	10.882	4.247	-0.311	0.582	-0.367	-0.250
Aus.	-0.591	-16.002	8.509	4.673	-0.600	0.222	0.023	0.073
Bra.	-0.570	-17.963	16.857	6.325	0.064	0.715	0.181	0.208
Can.	-0.538	-13.789	9.925	4.487	-0.214	0.720	-0.256	-0.096
Ger.	-0.571	-11.326	11.887	4.012	0.392	0.530	0.186	0.076
HK.	-0.399	-13.589	13.404	4.147	0.375	0.386	0.527	0.478
Jap.	-0.259	-11.186	11.644	3.680	-0.032	0.011	0.177	-0.059
Kor.	-0.472	-14.691	15.695	4.723	0.124	0.227	0.199	0.118
Rus.	-0.961	-21.199	20.204	6.042	0.162	0.268	-0.113	-0.113
Thai.	-0.429	-11.599	7.849	3.020	-0.618	0.389	-0.156	0.094
UK	-0.511	-10.538	12.219	4.149	0.294	0.532	0.056	-0.013
US	-0.360	-8.201	10.508	3.439	0.323	1.000	0.323	0.323

Table 2:
Crisis and non-crisis period dates.

Crisis and non-crisis periods	Start of period	End of period	Obs.
	(i) Crisis period dates ($y_{n,t}$)		
Asia ($y_{1,t}$)	17 October 1997	30 January 1998	76
Russia ($y_{2,t}$)	17 August 1998	31 December 1998	99
LTCM ($y_{3,t}$)	23 September 1998	15 October 1998	17
Brazil ($y_{4,t}$)	7 January 1999	25 February 1999	36
Dot-com ($y_{5,t}$)	7 March 2000	7 June 2000	67
Argentina ($y_{6,t}$)	11 October 2001	30 June 2002	187
Sub-prime ($y_{7,t}$)	26 July 2007	14 September 2008	297
Great recession ($y_{8,t}$)	15 September 2008	26 April 2010	421
	(ii) Non-crisis period dates ($x_{m,t}$)		
Pre Asia ($x_{1,t}$)	12 September 1995	16 October 1997	548
Pre Russia, post Asia ($x_{2,t}$)	31 January 1998	14 August 1998	140
Pre Brazil, post Russia ($x_{3,t}$)	1 January 1999	6 January 1999	4
Pre Dot-com, post Brazil ($x_{4,t}$)	26 February 1999	6 March 2000	267
Pre Argentina, post Dot-com ($x_{5,t}$)	8 June 2000	10 October 2001	350
Pre Sub-prime/great recession, post Argentina ($x_{6,t}$)	7 January 2002	25 July 2007	1323

The Appendix contains a summary of papers written on one or more of the eight crises in equity markets that are considered here. It contains the market defined to be the crisis source, along with the dates that each author chose to represent the non-crisis and crisis periods. The datings chosen for the six non-crisis and eight crisis periods are drawn from the work in these tables, and are summarized in Table 2.

The principles of choosing the crisis dates are similar to Dungey et al. (2009) and are loosely that a trigger event marks the beginning of the crisis, and where possible, an event or a policy reform marks the end of a crisis. The rest of the paper will adopt the notation to distinguish the crises in the sample by x_m for the non-crisis periods, and y_n for the crisis periods, with $m = 1, ...6$ and $n = 1, ...8$ referring to non-crisis and crisis periods occurring throughout the sample.

The difficulties in defining a crisis period also apply to choosing the non-crisis ($x_{m,t}$)

period for comparison in the contagion tests. As is shown by the shading in Figure 1, crisis periods can be clustered close together making it difficult to choose a non-crisis period not contaminated by other extreme events. As this paper is focused on examining multiple crises in several regions, care is taken to select the non-crisis periods as well as the crisis periods to ensure that they are representative.

The principle in choosing the non-crisis periods is that where possible, the data in the non-crisis period preceding the crisis is used as the non-crisis data. This choice is based on information availability to the policy maker and portfolio decision makers in real time. As some crises run into each other in time, where a useful tranquil period directly prior to each crisis is not available, the most sensible pre-crisis data is used. Section 4.4 explores this issue further. The macroeconomic triggers for each crisis along with the dating of the non-crisis and crisis periods follow.

Asia The Asian crisis ($y_{1,t}$) is defined to extend from 20 October, 1997 to January 30, 1998 ($T_{1,y} = 76$). The trigger is the speculative attack on the Hong Kong currency and equity markets. It is common to use October 20 as the start date of the crisis, with the alternative corresponding to the devaluation of the Thai baht in July, 1997 (see Corsetti et al., 2005; Dungey, Fry and Martin, 2006; Forbes and Rigobon, 2002). As equity markets are the focus of this paper, the Hong Kong attack is the source here. The end date is generally consistent with several of the papers listed in the Appendix and is chosen to be the end of January to avoid clashing with the Russian crisis period. The pre-Asia non-crisis period ($x_{1,t}$) extends from 12 September, 1995 to 16 October, 1997.

Russia and LTCM The Russian crisis ($y_{2,t}$) begins on August 17, 1998 and ends December 31, 1998 ($T_{2,y} = 99$). The Russian Government deferred bond repayments on this date, marking the beginning of extreme asset market volatility. The majority of work on Russia summarized in the Appendix chooses the crisis period for Russia to be either early or mid August. The LTCM crisis ($y_{3,t}$) is linked to events in Russia and is nested within the Russian crisis period. The beginning coincides with the Federal Reserve of New York bailout of LTCM on September 23, 1998, and ends with the inter-FOMC interest rate cut on October 15 ($T_{3,y} = 17$). See Dungey et al. (2007) and Committee on the Global Financial System (1999). The pre-Asia non-crisis period ($x_{1,t}$) is used as it not clear that the turmoil in Asia really had subsided between

February and August 1998.

Brazil The trigger of the Brazilian crisis ($y_{4,t}$) is a currency devaluation. On January 15, 1999, the real was devalued, however, the start date of the crisis is taken to be January 7, 1999 as substantial foreign reserves were lost prior to that. The end of the crisis corresponds to a revised IMF program on February 25, 1999 which appeared to calm markets ($T_{4,y} = 36$). As the crisis in Brazil began just one week following the end of the Russian crisis, the pre-Asia non-crisis period ($x_{1,t}$) is also used.

Dot-com The dot-com crisis ($y_{5,t}$) occurring when the tech-stock bubble collapsed corresponds to that chosen in Dungey (2009) et al. and is based on visual inspection of the equity returns. A large component of that paper is sensitivity to the dating of crisis periods. The dot-com crisis extends from March 7, 2000 and ends June 7, 2000 ($T_{5,y} = 65$). This crisis is probably the least dramatic of the crises sourced in the US market with it mainly affecting one sector of the economy. However, at the time the real and transmitted effects were uncertain. The non-crisis period ($x_{4,t}$) extends from February 26, 1999 to March 6, 2000 and is between the Brazilian and dot-com crises.

Argentina Apart from the great recession, the Argentinian crisis ($y_{6,t}$) is longest in duration ($T_{6,y} = 187$). The trigger of the crisis is the introduction of the partial deposit freeze and capital controls (Cifarelli and Paladino, 2004), and the crisis is chosen to begin just prior to this on October 11, 2001. The end of the crisis is more difficult to date. Dungey et al. (2009) and Wälti and Weder (2008) use mid 2005 which coincides with Argentina's return to the voluntary bond market. However, this dating is more consistent with events in the bond market rather than equity markets. The bond market in Argentina remained in crisis for quite a long time compared to the crisis in the equity market. For the application here, the end date is taken to be June 30, 2002 and is determined by visual inspection. This period encompasses the collapse of the currency board in Argentina in 2002. See IMF (2003) for a comprehensive overview of the events in Argentina. The non-crisis period ($x_{5,t}$) extends from June 8, 2000 to October 10, 2001 and is between the dot-com and Argentinian crises.

Sub-prime and Great Recession The final two crises are the sub-prime crisis ($y_{7,t}$) and the great recession ($y_{8,t}$). Although these crises could be considered to be the

one event, they are separated because of the severity of the collapse of Lehman Brothers in September of 2008. The start date of the sub-prime crisis is chosen to coincide with heightened risk aversion and falls in liquidity from July 26, 2007 ($T_{7,t} = 297$). The great recession is still arguably underway but is defined to span from September 15, 2008 to April 26, 2010 when the data was collected ($T_{8,y} = 421$) days. The non-crisis period for both sub-prime and the great recession ($x_{6,t}$) extends from January 7, 2002 to July 25, 2007, between the Argentinian and sub-prime crises.

4.3 Contagion Channels During Crises

4.3.1 This Time Is Different

Table 3 presents the empirical results for the correlation and coskewness tests for the four crises with the source specified to be the US. Inspection of this table shows that the great recession is truly different to all other crises in the sample sourced in the US, and further comparing it to Table 4 which presents the results for the crises sourced in the emerging markets, the conclusion is the same.

The incidence of significant contagion is widespread through the great recession. Putting aside the sub-prime period, there are only two instances of contagion from the US market and these are from the LTCM crisis to the regional countries of Argentina and Brazil through the correlation channel (panel (i) of Table 3).[6] Less than three months later Brazil experienced its own crisis, suggesting already its vulnerability. There are no significant changes in the dependence structures during the dot-com period (panel (ii)), confirming that the dot-com crisis is contained to it's own sector.

Panel (iv) of Table 3 shows that during the great recession, all channels of contagion are clearly operating compared to the other crises sourced in the US. The majority of countries are also affected by more than one channel. The dependence structures based on the correlation coefficients change dramatically with evidence of contagion through this channel from the US equity market to more than half of the markets in the sample. Further, in almost all cases, contagion also transmits through at least one of the higher order coskewness channels. Most countries are affected by the $CS_1\left(i \to j; r_i^1, r_j^2\right)$ and the $CS_2\left(i \to j; r_i^2, r_j^1\right)$ channels. Japan and Thailand are only affected through the $CS_1\left(i \to j; r_i^1, r_j^2\right)$ channel and Germany through the $CS_2\left(i \to j; r_i^2, r_j^1\right)$ channel. Brazil and Korea are only affected by the correlation channel.

Comparison of the sub-prime period in panel (iii) of Table 3 with the great recession

[6] Note the use of the finite sample critical values determined in Appendix B.

Table 3:
Contagion from the US equity market (i) to recipient markets (j) during the (i) LTCM, (ii) dot-com, (iii) sub-prime, and (iv) great recession crises. CR is the correlation based contagion test in (3); The coskewness contagion test $CS_1\left(i \rightarrow j; r_i^1, r_j^2\right)$ measures coskewness in terms of the source market returns i and squared returns of markets j and is based on equation (6). The coskewness contagion test $CS_2\left(i \rightarrow j; r_i^2, r_j^1\right)$ measures coskewness in terms of the squared source market returns i and returns of markets j and is based on equation (7). pv denotes p-values with the 5% level of significance denoted by *.

Recip.	Contagion Tests											
(j)	CR	pv	CS_1	pv	CS_2	pv	CR	pv	CS_1	pv	CS_2	pv
	(i) Crisis: LTCM						(ii) Crisis: dot-com					
Arg.	18.97	0.00*	0.02	0.87	0.06	0.81	0.08	0.78	0.00	0.96	0.00	0.97
Aus..	0.15	0.70	0.50	0.48	0.30	0.58	3.56	0.06	0.17	0.68	4.86	0.03
Bra.	7.95	0.00*	0.01	0.90	0.05	0.82	2.52	0.11	1.06	0.30	0.01	0.92
Can.	0.02	0.89	0.26	0.61	0.01	0.94	1.97	0.16	0.43	0.51	1.84	0.18
Ger.	3.58	0.06	0.27	0.60	0.19	0.66	0.01	0.92	0.04	0.85	2.40	0.12
HK.	0.13	0.71	2.42	0.12	1.26	0.26	1.05	0.30	2.02	0.15	1.20	0.27
Jap.	0.52	0.47	0.00	0.96	1.81	0.18	0.68	0.41	0.78	0.38	0.27	0.60
Kor.	1.18	0.28	1.93	0.16	0.05	0.82	0.07	0.79	0.02	0.89	0.53	0.46
Rus.	3.13	0.08	0.10	0.76	1.64	0.20	3.14	0.08	0.00	0.99	1.41	0.24
Thai.	1.07	0.30	0.02	0.89	0.06	0.81	0.43	0.51	0.07	0.80	1.43	0.23
UK	0.09	0.76	0.05	0.82	0.03	0.87	0.28	0.60	0.72	0.40	0.05	0.82
	(iii) Crisis: sub-prime						(iv) Crisis: great recession					
Arg.	3.33	0.07	0.02	0.90	2.31	0.13	19.82	0.00*	8.70	0.00*	16.15	0.00*
Aus.	1.05	0.31	0.35	0.56	3.72	0.05	27.69	0.00*	8.02	0.00*	7.74	0.01*
Bra.	0.04	0.85	1.06	0.30	5.55	0.02*	7.24	0.01*	0.46	0.50	3.21	0.07
Can.	13.04	0.00*	9.19	0.00*	18.79	0.00*	1.74	0.19	28.94	0.00*	33.72	0.00*
Ger.	2.24	0.13	1.07	0.30	0.25	0.61	0.01	0.94	2.09	0.15	8.97	0.00*
HK.	0.53	0.47	0.28	0.59	0.01	0.94	13.76	0.00*	4.75	0.03*	6.42	0.01*
Jap.	4.41	0.04*	0.28	0.60	0.30	0.58	0.12	0.73	9.28	0.00*	1.29	0.26
Kor.	0.02	0.89	7.34	0.01*	7.18	0.01*	6.75	0.01*	3.54	0.06	0.74	0.39
Rus.	0.00	0.99	0.54	0.46	2.26	0.13	3.21	0.07	8.26	0.00*	11.00	0.00*
Thai.	0.72	0.40	0.11	0.74	8.52	0.00*	25.64	0.00*	11.35	0.00*	0.73	0.39
UK	3.28	0.07	1.71	0.19	0.03	0.87	3.08	0.08	17.59	0.00*	15.75	0.00*

in panel (iv) shows that the sub-prime crisis did not result in the transmission of contagion on a widespread scale. Only Canada is affected by all channels but is not affected by all channels in the great recession phase suggesting that it's linkages with the US reverted to normal quickly. Korea is affected through both coskewness channels and Brazil and Thailand through one of the coskewness channels. Japan is only affected through the correlation channel.

The evidence on the hypothesis that crises beginning in the major financial centre of the US have important consequences for the rest of world is not supported by examining the first three panels of Table 3. The result where there is little contagion from the US implies that the spillovers of the LTCM and dot-com crises to the other countries in the sample are well accounted for by normal interdependencies, and that transmission channels of shocks across countries have not changed for most countries during these crises. This is possibly an effect of the US being a large and efficient market, with linkages well understood and with arbitrage opportunities well exploited. This does not mean that the countries in the sample are unaffected by the US sourced crises, it just means that there is no change in the way that shocks transmit. That is, there is no contagion. However, the evidence supports Reinhart and Rogoff suggesting that the great recession is truly a global financial crisis, at least in the contagion sense, with linkages across markets not as well understood as previously thought. The evidence also supports that "This Time is Different".

4.3.2 An Index of Crisis Severity

To further explore the extent of the severity of the great recession over time, equally weighted indexes of crisis severity are constructed using the correlation and coskewness tests. Taking the non-crisis ($x_{6,t}$) period as fixed, the correlation and coskewness tests of contagion are calculated using a rolling 30 day window of returns through the sub-prime and great recession periods. An indicator variable is then constructed for each recipient country j which takes a value of 1 if the test statistic is significant at the 0.05 level of significance. Hence for the correlation tests,

$$I_{CR(i\rightarrow j),j,t} = \begin{cases} 1: & \text{p-value} \leq 0.05 \\ 0: & \text{otherwise} \end{cases}, \qquad j \neq i, \tag{12}$$

and for the coskewness tests using $CS1$ as an example,

$$I_{CS_1(i\rightarrow j),j,t} = \begin{cases} 1: & \text{p-value} \leq 0.05 \\ 0: & \text{otherwise} \end{cases}, \qquad j \neq i. \tag{13}$$

The index of crisis severity ($S_{CR}(i \to j)$) using the correlation test as an example is

$$S_{CR}(i \to j) = 100 \cdot \left(\frac{\sum_{j=1}^{11} I_{CR(i \to j),j,t}}{11} \right). \tag{14}$$

An overall index $S(i \to j)$ is also constructed by combining all channels

$$S(i \to j) = 100 \cdot \left(\frac{\sum_{j=1}^{11} I_{CR(i \to j),j,t} + \sum_{j=1}^{11} I_{CS_1(i \to j),j,t} + \sum_{j=1}^{11} I_{CS_2(i \to j),j,t}}{33} \right). \tag{15}$$

where $I_{CS_1(i \to j),j,t}$ and $I_{CS_2(i \to j),j,t}$ are the indexes of severity constructed from the respective coskewness tests.

Figure 3 presents the indexes described in equations (12) to (15). If the index takes a value of 0, then over the previous 30 days there is no evidence of contagion through a particular channel. If the index takes a value of 100 then all eleven countries are affected by contagion from the source which in this case is the US. The figures indicate that over the sub-prime and great recession periods, it is most likely to be the correlation based channel through which contagion operates, which is often the case being that most countries are affected through this channel. The CS_1 channel is likely to affect a small number of countries at any one time, while the CS_2 channel often affects no countries, but when this channel is operational, it tends to affect multiple countries, indicating that the changes in the transmission mechanisms of the crisis tends to be through the volatility of the US to the other countries once the correlation channel is accounted for.

The indexes for CS_1 and CS_2 reveal a rather sharp spike in September of 2008. For the CS_1 severity index 90% of countries are affected by contagion through that channel. The percentage is smaller for CS_2 but is still substantial with about 60% of countries affected. The dates of this spike range from (the 30 days up to) September 22, 2008 to September 29, 2008, and mark the aftermath of the collapse of Lehman brothers. The point to glean from these severity indexes is that it is important to focus not only on dependence structures through correlation relationships, but in times of severe crisis, the higher order dependence structures are also significant channels of contagion.

4.3.3 Emerging Market Sourced Crises

Half of the set of crises in the sample are sourced in emerging markets or regions including Hong Kong, Russia, Brazil and Argentina. There is no clear pattern across

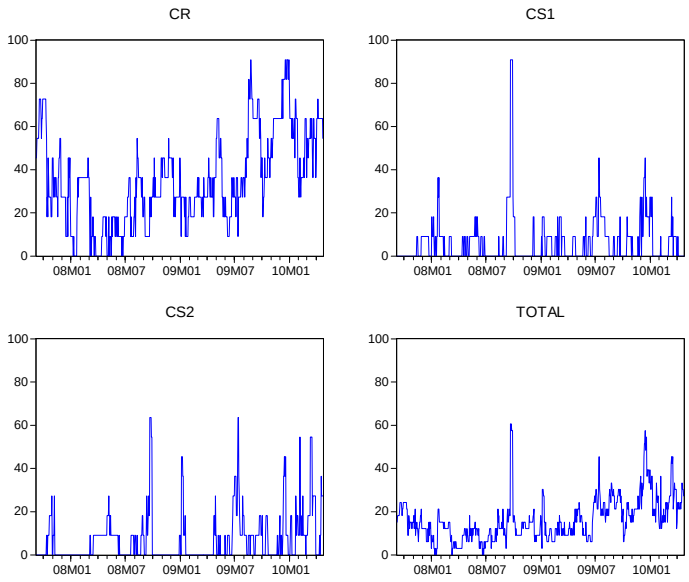

Figure 3: Indexes of the severity of contagion in financial markets through the (i) correlation channel (CR); (ii) the coskewness 1 channel (CS_1); and (iii) the coskewness ($CS2$) channel; and (iv) all channels ($Total$). These indexes represent the percentage of markets significantly affected by contagion at any point in time.

any of the crises, although it is notable that it is often the developed markets that are affected by the crises in the emerging markets. For example, Canada, the UK and the US are both affected through at least one channel in each crisis, while Australia and Germany are affected in three of the four crises. The UK and Canada are most often affected through the higher order channels of contagion rather than the correlation channels. In contrast to the US sourced crises it seems that the crisis event changes the dynamics of shock transmission between the emerging and developed countries, providing some evidence that often financial centres are affected by emerging market crises (Kaminsky and Reinhart, 2003), by potentially being cross-market conduits.

The results that the crisis in Argentina appears to show substantial evidence of contagion is at first pass unexpected. The correlation channel affects all markets except for Hong Kong, Japan, Korea and Thailand. There is also evidence that there is $CS_1\left(i \rightarrow j; r_i^1, r_j^2\right)$ contagion to Canada, and $CS_2\left(i \rightarrow j; r_i^2, r_j^1\right)$ contagion to Australia, Germany, Hong Kong, Russia, the UK and the US. These results may be driven by the fundamental changes occurring in Argentina during this crisis period rather than contagion. The collapse of the currency board in January 2002 permanently changed

Table 4:
Contagion from the emerging market crises (i) to recipient markets (j) during the (i) Asian, (ii) Russian, (iii) Brazilian and (iv) Argentinian crises. CR is the correlation based contagion test in (3); The coskewness contagion test $CS_1\left(i \to j; r_i^1, r_j^2\right)$ measures coskewness in terms of the source market returns i and squared returns of markets j and is based on equation (6). The coskewness contagion test $CS_2\left(i \to j; r_i^2, r_j^1\right)$ measures coskewness in terms of the squared source market returns i and returns of markets j and is based on equation (7). pv denotes p-values with the 5% level of significance denoted by *.

Recip.	Contagion Tests											
(j)	CR	pv	CS_1	pv	CS_2	pv	CR	pv	CS_1	pv	CS_2	pv
	(i) Crisis: Asia						(ii) Crisis: Russia					
Arg.	0.35	0.56	0.02	0.89	5.07	0.02*	5.38	0.02*	0.55	0.46	2.54	0.11
Aus.	0.23	0.63	0.07	0.79	0.73	0.39	10.89	0.00*	1.48	0.22	1.97	0.16
Bra.	0.81	0.37	2.04	0.15	3.54	0.06	1.46	0.23	2.89	0.09	3.55	0.06
Can.	0.22	0.64	6.66	0.01*	11.43	0.00*	21.86	0.00*	3.01	0.08	2.74	0.10
Ger.	0.72	0.40	0.05	0.83	0.14	0.70	16.56	0.00*	0.15	0.70	2.63	0.10
HK.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.06	0.80	1.04	0.31	0.05	0.82
Jap.	0.83	0.36	0.01	0.93	0.15	0.70	1.30	0.25	3.31	0.07	0.64	0.43
Kor.	0.53	0.47	0.17	0.68	0.19	0.67	3.50	0.06	0.93	0.34	0.72	0.40
Rus.	6.40	0.01*	1.15	0.28	0.32	0.57	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Thai.	2.13	0.14	0.19	0.66	0.77	0.38	0.14	0.71	0.04	0.85	0.59	0.44
UK	0.10	0.75	8.43	0.00*	1.04	0.31	26.68	0.00*	0.44	0.51	0.64	0.43
US	1.47	0.23	0.72	0.40	15.60	0.00*	4.44	0.04*	0.70	0.40	0.02	0.89
	(iii) Crisis: Brazil						(iv) Crisis: Argentina					
Arg.	0.06	0.80	8.16	0.00*	6.09	0.01*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Aus.	0.60	0.44	7.25	0.01*	10.20	0.00*	4.38	0.04*	0.26	0.61	4.28	0.04*
Bra.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	76.28	0.00*	2.35	0.13	1.36	0.24
Can.	1.85	0.17	8.99	0.00*	1.97	0.16	20.77	0.00*	3.87	0.05*	3.77	0.05
Ger.	8.29	0.00*	0.92	0.34	3.66	0.06	12.08	0.00*	0.01	0.94	9.36	0.00*
HK.	0.33	0.57	1.91	0.17	1.89	0.17	2.39	0.12	2.01	0.16	3.95	0.05*
Jap.	0.86	0.35	0.71	0.40	12.06	0.00*	0.30	0.58	1.62	0.20	0.28	0.59
Kor.	1.26	0.26	0.00	0.95	0.29	0.59	0.02	0.90	0.89	0.35	1.59	0.21
Rus.	1.64	0.20	1.30	0.25	0.18	0.67	10.92	0.00*	0.18	0.67	5.73	0.02*
Thai.	0.18	0.67	0.00	0.95	1.13	0.29	1.92	0.17	0.08	0.77	0.02	0.89
UK	0.18	0.67	9.63	0.00*	10.41	0.00*	25.42	0.00*	0.07	0.79	25.92	0.00*
US	7.66	0.01*	0.21	0.64	0.16	0.69	23.26	0.00*	1.14	0.29	15.55	0.00*

the relationship between the US and Argentina through the change in the currency arrangements, and hence is reflected in most of the other markets in the sample as well. This is not necessarily evidence of contagion, but will be reflected as contagion in these statistics, as even in a non-crisis period, the relationship between Argentina and the other markets change permanently.

4.4 One Post-Crisis is the Next Pre-Crisis

One of the biggest challenges and one often swept under the carpet in work on contagion is the dating of the non-crisis and crisis periods. The choices for the dating of the crises are explored in Section 4.2 and are more often commented on in the literature. However, when taken in historical context, one post-crisis period is the pre-crisis period of the next crisis. For this paper this creates several challenges, as it is sometimes the case that crisis periods run into each other. Hence it is not straightforward to choose the beginning of the non-crisis period. This section explores the sensitivity of the choice of the non-crisis and crisis periods by using all non-crisis period data available in the sample as the non-crisis period in 4.4.1, and by examining the behavior of contagion tests purely within a potential crisis period to date the end of a crisis in 4.4.2.

4.4.1 Using all Non-Crisis Data

The contagion tests for each crisis are re-run in this section by comparing each crisis period to the characteristics of the non-crisis data of the entire sample period. The non-crisis period consists of all data not considered to be in crisis

$$x_t = \{x_{1,t}, x_{2,t}, x_{3,t}, x_{4,t}, x_{5,t}, x_{6,t}\},$$

and consists of $T_x = 2168$ observations.

Only the results for the crises sourced in the US are presented to save space. The qualitative conclusions about each crisis are not necessarily similar when using the two approaches.[7] For the great recession the results are almost the same with contagion being found in three more cases in the higher order tests than when only pre-crisis data is used, and with contagion not being found twice in the latter model compared to the benchmark model. The LTCM crisis is identical to the earlier version. The most different results are in the dot-com crisis where the correlation channel is active to the

[7] The results are available on request, but are not presented here to conserve space.

developed countries in the sample. It is in the emerging market crises where the results differ most.

This robustness exercise points to the importance of choosing the right benchmark for analyzing contagion. It is clear the most of the US sourced crises and particularly the great recession are relatively robust across definitions of crisis periods. This supports the results of Section 4.3.1 examining contagion coming from the US, and may well indicate that there is little structural break in the transmission of financial market shocks occurring post-crisis periods for countries with the US. On the other hand, it is likely that the relationship of the emerging market economies with international financial markets fundamentally change after their own crises. Until a better method of dating crisis and non-crisis periods emerges, using pre-crisis data as the non-crisis benchmark seems to be the most logical way to proceed as this is the information that financial participants have when making decisions.

4.4.2 Within Crisis Contagion Testing

This section considers the transmission of contagion from an alternative viewpoint to aid in the dating of the end of a crisis, at least in terms of the operation of the contagion channels. The example of the great recession is used with a focus on the correlation tests given their importance by the severity of the crisis indexes of Section 4.3.2. Assuming that it is known that there is severe crisis transmission in the immediate aftermath of the trigger such as the collapse of Lehman Brothers, the correlation contagion test is conducted by comparing the initial phase of the crisis (defined here to be the crisis period, $y_t = y_{8,t}, t = 1, 2, ...30$) with a rolling window of 30 observations in the period following the initial shock to the end of the sample. The rolling window takes the role of the non-crisis period in each of the change in the correlation test statistics. That is, the non-crisis period for the first calculated test statistics is $x_t = y_{8,t}, t = 31, 32, ...60$.

Assuming that contagion exists in the height of the crisis, and the initial evidence indicates that contagion affects most of the financial system during this crisis, the hypothesis is that there will be a change in the dependence structures of markets once contagious transmission channels resolve themselves. As calm returns to financial markets, or at least as the dynamics of the financial market system either change or return to normal (albeit with higher volatility), the test statistics will become significant. This again represents a test of the null hypothesis of no change in the transmission channels

$$H_0 : \ \nu_{y|x_i} = \rho_x,$$

compared to the alternative of a statistically significant change in the transmission channels

$$H_1 : \ \nu_{y|x_i} \neq \rho_x.$$

Figure 4 presents the rolling correlation test p-values for each country and provides interesting insights into the dynamics of the crisis. The transmission channels of several countries over time appear to not change dramatically over the course of the crisis. Countries such as Hong Kong, Japan, Korea and Thailand, and to an extent Australia, all generally report high p-values (> 0.05) indicating that the transmission channels of the crisis do not change in comparison to the initial period of the crisis particularly much. These are all countries that were not affected by the most recent crisis in real terms.

Brazil, Germany and the UK exhibit similar p-value patterns. Inspection of the reported correlations after the initial shock indicates that the dynamics of the crisis do not change very much until around July 2009. The cross market dynamics of Argentina and Canada with respect to the US also seem to quickly separate in the period following the initial shock compared to the dynamics in the midst of the crisis.

5 Conclusions

This paper examined from a different perspective, Reinhart and Rogoff's (2008b) "This Time Is Different" syndrome. The "This Time Is Different" syndrome is that prior to economic crises that have occurred throughout history, society believes that prosperity will permanently continue because policy makers have mastered the management of the economy and technological innovations mean sustained growth. This paper addressed the syndrome of "This Time Is Different" from a within a crisis period perspective. During crises, even countries with sound fundamentals worry that they too will be affected and take steps to contain the transmission from the crisis markets as they worry that "This Time Is Different". Linkages with crisis markets that did not seem to exist before suddenly appear.

Eight crisis episodes from Asia in 1997-1998 to the great recession in 2008-2010 were examined to establish in what sense "This Time Is Different" in terms of the international transmission of crises through contagion during each episode. Contagion was defined as a significant change in the dependence structures of asset returns during a crisis compared to a non-crisis period, and included correlation based measures and

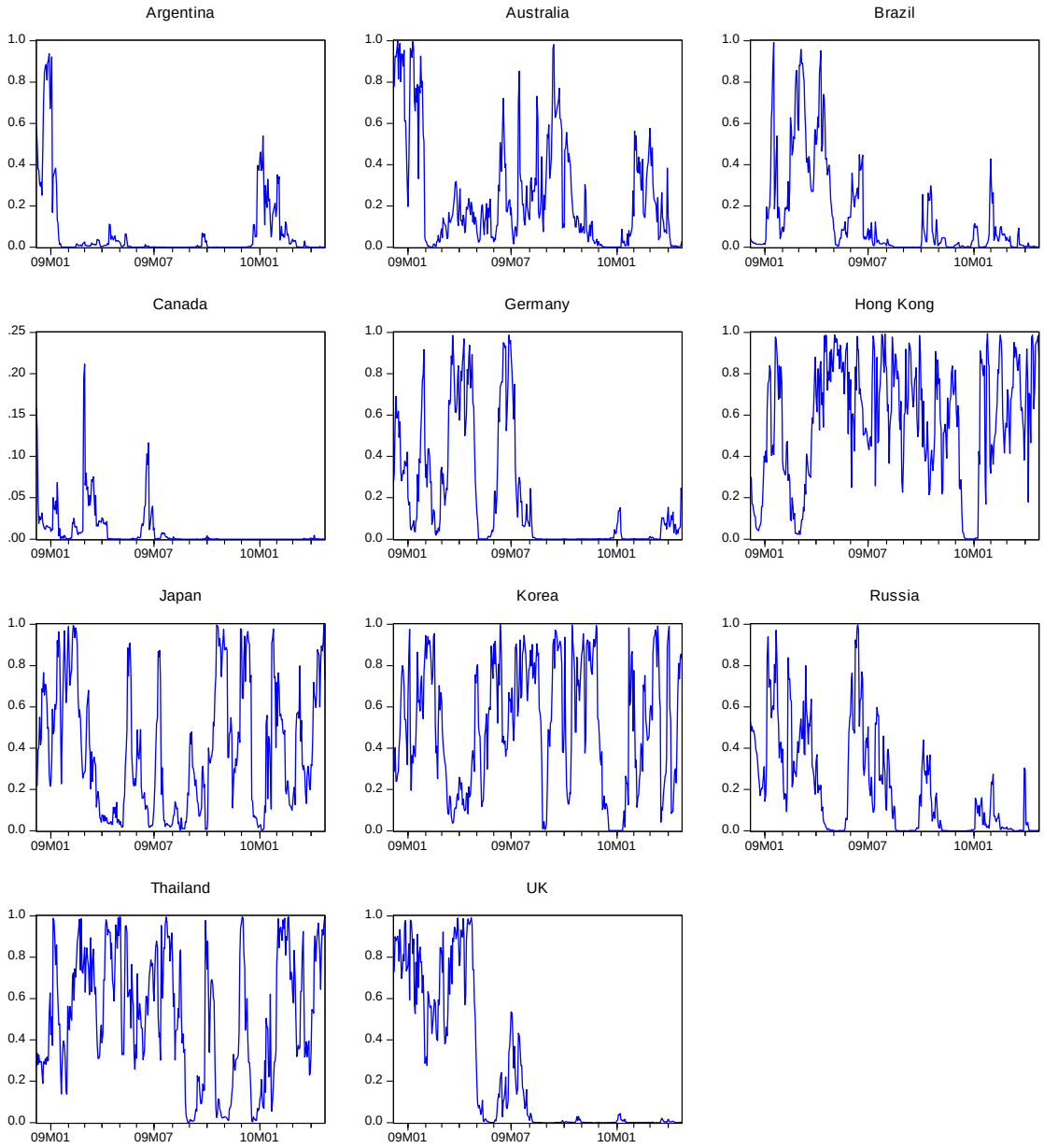

Figure 4: Within-crisis period rolling correlation test p-values during the great recession.

higher order dependence structures through coskewness (Fry, Martin and Tang, 2010).

The results showed that the great recession was actually different to any of the other crises of the past two decades with all transmission channels operating. Drawing on Reinhart and Rogoff (2008b), the paper also provided evidence that the great recession can be thought of as a global financial crisis rather than a severe financial crisis. However, it was not the case that the other US sourced crises were as systemic as the great recession. In almost all US sourced crises, there was virtually no evidence of contagion. It is possible that the well developed nature of the US market means that crises transmit through normal inter linkages rather than through new or altered channels, even during crises.

The emerging market sourced crises showed no clear pattern of transmission through contagion. However, often developed markets were affected by emerging market crises. In contrast to the US sourced crises it seemed that emerging market crises were reflected in a changed relationship between the emerging market and financial centres.

Some attention was devoted to choosing the benchmark such as a non-crisis period for comparison with the crisis data. The choice of benchmark proved to be just as difficult as the choice of crisis period. The correct dating of crises in conjunction with the correct dating of non-crisis periods is an area in which more rigorous research is needed.

Examining historically the crises in financial markets over the last decade raises the question of why are there so many financial market crises over this period? Financial market crises appear to take policy makers and market participants by surprise, yet Figure 1 shows how prevalent they really are. The lingering question is, in fact, are these crises related to each other? Do the policy responses bringing economies out of crises sow the seeds for the next one? For example, the low interest rates coming out of the dot-com crisis and the Greenspan put (Goodhart, 2008) appear to explain some of the sub-prime and great recession periods. Further research needs to focus on modelling these crises jointly through time with a view of explaining concurrent crises through the resolution of the previous ones. The current state of the global economy and the policy challenges yet to be overcome would hint that these questions are imperative.

A Summary of Crisis Dating in Selected Papers

The following tables provide an overview of literature on each crisis and their choice of source crisis asset markets, non-crisis date choices and crisis date choices.

Table A1: Summary of crisis dating in papers written on the Asian financial crisis.

Paper	Source	Non-crisis dates	Crisis dates	Notes
Forbes (2001)	TH	Not specified	Jun 30 97-Jul 6 97	Weekly
Dungey, Fry and Martin (2002)	HK	Jan 1 95-Oct 19 97	Oct 20 97-Dec 31 97	
Gelos and Sahay (2001)	TH	Feb 4 97-Jul 1 97	Jul 2 97-Jan 29 98	
Forbes and Rigobon (2002)	HK	Jan 1 96-Oct 16 97	Oct 17 97-Nov 16 97	
Jang and Sul (2002)	ID,KR,TH	Oct 1 96-May 31 97	Jun 1 97-Jan 31 98	
Baur (2003)	TH	Not specified	Jul 2 97-Sep 2 97	
	HK		Oct 17 97-Nov 17 97	
Billio and Pelizzon (2003)	HK	Jan 1 96-May 31 97	Jun 1 97-Jan 31 98	
Kaminsky, Reinhart and Vegh (2003)	V	n.a.	Jul 2 97	Start date only specified
Rigobon (2003)	HK	Jan 2 97-Jun 2 97	Oct 27 97-Nov 28 97	Weekly
	KR		Dec 1 97-Jan 30 98	
	TH		Jun 10 97-Aug 29 97	
Caporale, Cipollini and Spagnolo (2005)	HK	Jan 90-Sep 97	Oct 97-Jul 98	Weekly
	TH	Jan 90-May 97	Jun 97-Jul 98	
Collins and Gavron (2005)	TH	Jul 1 96-Jul 1 97	Jul 2 97-Aug 1 97	
Serwa and Bohl (2005)	HK	Sep 1 97-Oct 22 97	Oct 23 97-Nov 22 97	
	KR	Sep 17 97-Dec 14 97	Dec 15 97-Jan 12 98	
Chiang, Jeon and Li (2007)	HK	Jan 1 90-Oct 16 97	Oct 17 97-Mar 21 03	
	TH	Jan 1 90-Jul 1 97	Jul 2 97-Mar 21 03	
Baur and Fry (2009)	NS	Apr 30 97-May 1 97	May 2 97-May 29 98	
Laeven and Valencia (2008)	TH	n.a.	1997	Banking crisis
Essaadi, Jouini and Khallouli (2009)	TH	Jan 96-Dec 97	Jul 2 97-Dec 31 98	
Fry, Martin and Tang (2010)	HK	Jan 2 96-Oct 16 97	Oct 17 97-Jun 30 98	Real estate & equity
Kali and Reyes (2010)	TH	Jan 92–Dec 94	Jun 5 97-Jan 3 98	Weekly

Legend: HK - Hong Kong; ID - Indonesia; KR - Korea; TH Thailand; NS - Not specified; V - Various.

Table A2: Summary of crisis dating in papers written on the Russian and LTCM crises.

Paper	Source	Non-crisis dates	Crisis dates	Notes
		Crisis: Russia		
Gelos and Sahay (2001)	RU	Jul 16 98-Oct 15 98	Jan 31 98-Jul 15 98	Currency & equity returns
Rigobon (2003)	RU	Mar 2 98-Jun 1 98	Aug 3 98-Aug 31 98	
Kaminsky, Reinhart and Vegh (2003)	RU	n.a.	Aug 18 98	Start date only specified
AuYong, Gan and Treep. (2004)	V	Not specified	Aug 17 98-Jan 12 99	Exchange rates
Collins and Gavron (2005)	RU	Aug 16 97-Aug 16 98	Aug 17 98-Sep 16 98	
Serwa and Bohl (2005)	RU	Jun 6 98-Aug 5 98	Aug 6 98-Oct 5 98	
DFGM (2007)	RU	Jan 5 98-Jul 31 98	Aug 3 98-Dec 31 98	
Sojli (2007)	RU	Jan 1 97-Jul 31 98	Aug 10 98-Aug 31 98	
Laeven and Valencia (2008)	RU	n.a.	Jan 1 98-Dec 31 98	Banking, currency & debt crises
Reinhart and Rogoff (2008b)	RU	n.a.	Jan 1 98-Dec 31 98	Banking crisis
Saleem (2009)	RU	Jan 1 95-Jul 31 98	Aug 1 98-Dec 31 98	
DFGM and Tang (2009)	RU	All non-crisis data	Aug 17 98-Dec 31 98	Bond & equity returns
Kali and Reyes (2010)	RU	Jan 92–Dec 94	May 23 98-Jan 16 99	Weekly
		Crisis: LTCM		
Rigobon (2003)	LTCM	Mar 2 98-Jun 1 98	Aug 31 98-Oct 15 98	
Kaminsky, Reinhart and Vegh (2003)	LTCM	n.a.	Sep 2 98	Start date only specified
Kabir and Hassan (2005)	DUM	Jun 6 98-Sep 1 98	Sep 2 98-Sep 17 98	3 periods analyzed
			Sep 18 98-Sep 24 98	
			Sep 25 98-Oct 14 98	
DFGM and Tang (2009)	US	All non-crisis data	Sep 23 98-Oct 15 98	Bond and equity returns

Legend: DUM - dummy variable control for source; RU - Russia; NS - Not specified; V - Various;
DFGM - Dungey, Fry, Gonzalez-Hermosillo and Martin.

Table A3: Summary of crisis dating in papers written on the Brazilian, dot-com and Argentinian crises.

Paper	Source	Non-crisis dates	Crisis dates	Notes
		Crisis: Brazil		
Baig and Goldfajn (2000)	RU	Jan 1 97-May 30 97	Jan 1 98-Jun 30 99	Equity & bond returns
Kaminsky, Reinhart and Vegh (2003)	BR	n.a.	Feb 1 99	Start date only specified
Rigobon (2003)	BR	Mar 2 98-Jun 1 98	Oct 15 98-Nov 23 98	
Collins and Gavron (2005)	BR	Jan 12 98-Jan 12 99	Jan 13 99-Feb 12 99	
Serwa and Bohl (2005)	BR	Nov 1 98-Dec 31 98	Jan 1 99-Mar 1 99	
Laeven and Valencia (2008)	BR	n.a.	Jan 1 99-Dec 31 99	Currency crisis
DFGM and Tang (2009)	BR	All non-crisis data	Jan 7 99-Feb 25 99	Bond & equity returns
AuYong, Gan and Treep. (2004)	V	Not specified	Jan 13 99-Dec 31 99	Exchange rates
		Crisis: dot-com		
Hon, Strauss and Yong (2007)	US	Mar 10 99-Mar 10 00	Mar 13 00-Mar 12 01	
DFGM and Tang (2009)	US	All non-crisis data	Feb 28 00-Jun 7 00	Bond & equity returns
Munoz, Marquez and Chulia (2010)		Nov 22 97-Mar 9 00	Mar 10 00-Apr 9 00	
		Crisis: Argentina		
Boschi (2005)	AR	Jan 1 01-May 31 01	Dec 1 01-Nov 29 02	
Collins and Gavron (2005)	AR	Jul 3 00-Jul 2 01	Jul 3 01-Aug 2 01	
Serwa and Bohl (2005)	AR	Oct 13 01-Dec 12 01	Dec 27 2001-Feb 26 2002	
Laeven and Valencia (2008)	AR	n.a.	2001	
Reinhart and Rogoff (2008b)	AR	n.a.	Jan 1 01-Dec 31 01	
DFGM and Tang (2009)	AR	All non-crisis data	Oct 11 01-Mar 3 05	
Kali and Reyes (2010)	AR	Jan 92–Dec 94	Jun 2 01-Apr 6 02	

Legend: AR - Argentina; BR - Brazil; US - US; V - Various; DFGM - Dungey, Fry, Gonzalez-Hermosillo and Martin.

Table A4: Summary of crisis dating in papers written on the sub-prime crisis and the great recession.

Paper	Source	Non-crisis dates	Crisis dates	Notes
		Crisis: sub-prime		
Laeven and Valencia (2008)	US	n.a.	2007	
Reinhart and Rogoff (2008b)	US	n.a.	Jan 1 07-Dec 31 07	
DFGM and Tang (2009)	US	All non-crisis data	Jul 26 07-Dec 31 07	
Fry, Martin and Tang (2010)	US	Jan 2 07-Jul 25 07	Jul 26 07-Dec 25 07	
Horta, Mendes and Vieira (2010)	US	Jan 1 05-Jul 31 07	Aug 1 07-Apr 21 08	
Longstaff (2010)	CDO	Jan 1 06-Dec 31 06	Jan 1 07-Dec 31 07	
Munoz, Marquez and Chulia (2010)	V	Apr 10 00-Aug 14 07	Aug 15 07-Sep 14 07	
		Crisis: great recession		
Kim, Loretan and Remolona (2010)	CDO	Jan 05-Jul 07	Aug 07-Jan 09	
Longstaff (2010)	CDO	Jan 1 06-Dec 31 06	Jan 1 08-Dec 31 08	
Munoz, Marquez and Chulia (2010)	V	Apr 10 00-Aug 14 07	Sep 15 08-Oct 14 08	
Naoui, Liouane and Brahim (2010)	US	Jan 3 06-Jul 31 07	Aug 1 07-Feb 26 10	
Chudik and Fratzscher (2011)	US	Jan 1 05-Aug 6 07	Aug 7 07-Jul 31 09	

Legend: CDO - asset backed collateralized debt obligation market; US - US; V - Various; DFGM - Dungey, Fry, Gonzalez-Hermosillo and Martin.

B Finite Sample Properties

This section calculates the critical values for the three tests of contagion using a Monte Carlo experiment, with attention devoted to the duration of the crisis period T_y. Crisis periods vary in length but may be quite short raising the possibility of small sample issues. To calculate the critical values for each test statistic under the null hypothesis of no contagion, a series of random samples of non-crisis and crisis data are generated. The distribution of equity returns under the null hypothesis are assumed to be bivariate normal with zero mean and variance-covariance matrices V_x and V_y.

The variance-covariance matrices of the equity returns data in the sub-periods are set at

$$V_x = \begin{bmatrix} 2.29 & 0.45 \\ 0.45 & 2.40 \end{bmatrix}, \; V_y = \begin{bmatrix} 11 & 3.5 \\ 3.5 & 5.9 \end{bmatrix}.$$

V_x is set using the average non-crisis variance of the source and recipient returns, while the covariances are determined by taking the average of the covariances of all asset pairs in the non-crisis period. V_y is determined using crisis period data similarly. Under this parametrization, the correlations between the two assets are $\rho_x = 0.19$ and $\rho_y = 0.42$ respectively. The adjusted Forbes and Rigobon (2002) correlation coefficient is $v_y = 0.20$ which under the null of no contagion is close to the non-crisis value of ρ_x.

The critical values are obtained for CR, $CS_1$and CS_2 for values of T_y spanning

$$T_y = \{15, 30, 60, 90, 150, 200, 250, 350, 600, 700\}.$$

The non-crisis sample size is $T_x = 1472$ which is consistent with the number of observations in the non-crisis period in the sample.

The results of the Monte Carlo experiment using $100,000$ replications are contained in Table 5. As the crisis sample size increases, the distribution of equity returns tends to follow a χ^2_1 distribution. If $T_y \leq 30$, the test statistic tends to be biased and the critical values require adjusting following the first two rows of Table 5.

Table 5:
Comparison of critical values for the tests of contagion for crisis sample sizes. The non-crisis sample size is $T_x = 2168$. Based on $100,000$ replications.

	CR test			CS_1 test			CS_2 test		
Sig. level/ T_y	0.025	0.05	0.1	0.025	0.05	0.1	0.025	0.05	0.1
15	6.12	4.72	3.31	4.57	3.39	2.32	4.42	3.22	2.27
30	5.26	4.08	2.87	4.88	3.63	2.49	5.06	3.71	2.52
60	5.12	3.91	2.74	4.84	3.63	2.51	4.95	3.77	2.69
90	5.14	3.95	2.72	4.89	3.76	2.63	4.9	3.72	2.56
150	5.21	3.88	2.72	5.08	3.68	2.65	5.11	3.91	2.67
200	4.94	3.82	2.71	5.05	3.81	2.62	5.18	3.93	2.76
250	5.07	3.85	2.68	4.84	3.69	2.61	5.03	3.78	2.71
350	4.97	3.96	2.73	5.06	3.85	2.70	5.41	4.04	2.84
600	5.05	3.85	2.64	5.08	3.93	2.77	4.89	3.74	2.68
700	5.21	3.97	2.73	4.94	3.79	2.73	4.81	3.73	2.66

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