

# A Comparison of Seven Crises

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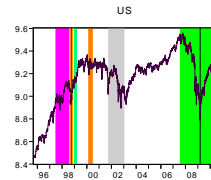
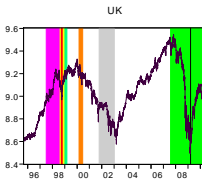
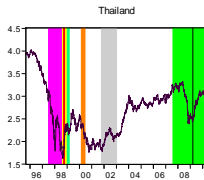
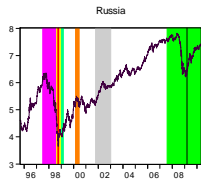
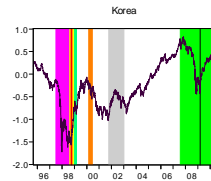
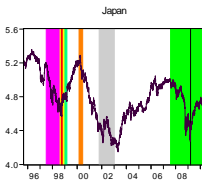
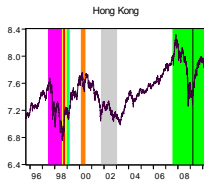
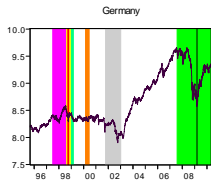
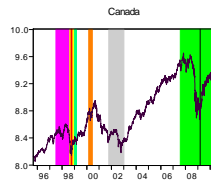
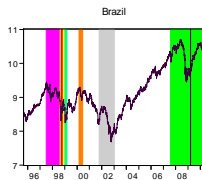
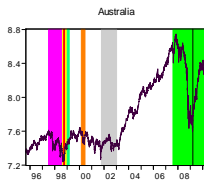
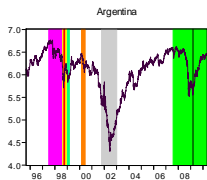
- Financial market crises are common place
  - diverse markets
  - connectedness of markets as fall simultaneously
  - take financial and economic systems by surprise
- Policy/regulatory structures affected by nature of market comovements
  - based on normal relationships
  - contagion
- New class of tests for contagion applied to last seven financial market crises
  - changes in distribution of comoments

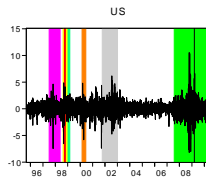
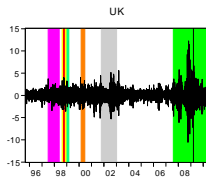
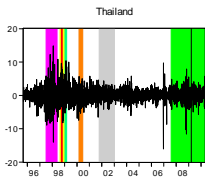
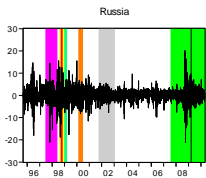
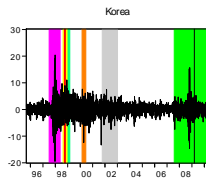
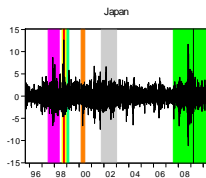
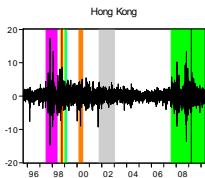
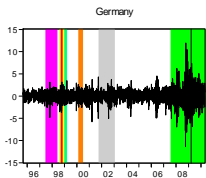
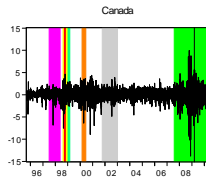
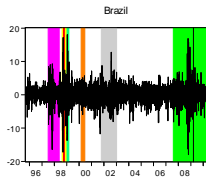
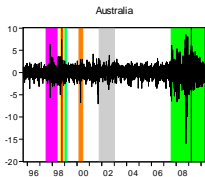
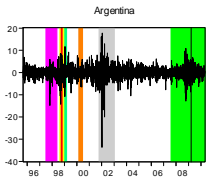
# Transmission of Financial Crises and Contagion



A Latent Factor Approach

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Brenda González-Hermosillo · Vance L. Martin





# Moments in a non and crisis period

Daily equity returns for Germany and the US before and during the GFC

Market	Non		Crisis		Non		Crisis	
	Mean		Std dev.		Non		Crisis	
Germany	0.06	-0.04	0.96	2.38				
US	0.03	-0.03	0.93	1.75				

# Moments in a non and crisis period

- Often distributions of asset returns are negatively skewed
  - risk and return tradeoff - higher risk of large losses, but possibility of large returns
- In a crisis, distribution of asset returns during crises can switch from negative to positive skewness
  - increasingly risk averse agents prefer positive to negative skewness
  - agents accept lower average returns in exchange for positive skewness

# Moments in a non and crisis period

Daily equity returns for Germany and the US before and during the GFC

Market	Non		Crisis		Non		Crisis	
	Mean		Std dev.		Skew.			
Germany	0.06	-0.04	0.96	2.38	-0.55	0.00		
US	0.03	-0.03	0.93	1.75	-0.57	0.09		



# Contagion testing through coskewness

- Crisis transmission and contagion is about dependence structures between asset markets, and changes in dependence structures between asset markets
- Dependence structure here:
  - correlation
  - coskewness - multivariate version of skewness
- Coskewness
  - volatility in one market affects the mean of another market
  - mean of one market affects the volatility of another market
  - agents adjust cross market risk preferences from negative to positive coskewness
- Contagion
  - significant changes in the moments of the distribution of equity returns such as correlation or coskewness

# Moments in a non and crisis period

Daily equity returns for Germany and the US before and during the GFC

Market	Non	Crisis	Non	Crisis	Non	Crisis
	Mean		Std dev.		Skew.	
Germany	0.06	-0.04	0.96	2.38	-0.55	0.00
US	0.03	-0.03	0.93	1.75	-0.57	0.09
	Corr					
Germany & US	0.23	0.50				

# Moments in a non and crisis period

Daily equity returns for Germany and the US before and during the GFC

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	Mean		Std dev.		Skew.	
Germany	0.06	-0.04	0.96	2.38	-0.55	0.00
US	0.03	-0.03	0.93	1.75	-0.57	0.09
	Corr		Coskew1 <sup>(a)</sup>		Coskew2 <sup>(b)</sup>	
Germany & US	0.23	0.50	-0.13	-0.07	-0.27	-0.18

(a) Coskewness between equity returns of Germany and squared equity returns of the US

(b) Coskewness between squared equity returns of Germany and equity returns of the US

## Some notation

- $x_t$  non crisis data
- $y_t$  crisis data
- $T_x$  and  $T_y$  non crisis and crisis sample sizes
- $i$  source asset market
- $j$  recipient market.

# Correlation contagion testing

- Compares correlations during a non-crisis and crisis period
- The crisis period correlation coefficient adjusted for heteroskedasticity is given by

$$\hat{v}_{y|x_i} = \frac{\hat{\rho}_y}{\sqrt{1 + \delta (1 - \hat{\rho}_y^2)}}, \quad (1)$$

- $\delta = \frac{s_{y,i}^2 - s_{x,i}^2}{s_{x,i}^2}$  : the proportionate change in the volatility of returns in the source equity market  $i$

- Test for contagion from  $i$  (a source market) to  $j$  (a recipient market)

$$CR(i \rightarrow j) = \left( \frac{\hat{v}_{y|x_i} - \hat{\rho}_x}{\sqrt{\text{Var}(\hat{v}_{y|x_i} - \hat{\rho}_x)}} \right)^2, \quad (2)$$

- Standard error in (2) derives from the asymptotic distribution of the estimated correlation coefficient

# Correlation contagion testing

- Two sided test
- Null hypothesis

$$H_0 : \hat{v}_{y|x_i} = \rho_x$$

- Alternative hypothesis

$$H_1 : \hat{v}_{y|x_i} \neq \rho_x$$

- Asymptotically distributed as

$$CR(i \rightarrow j) \xrightarrow{d} \chi_1^2$$

- Coskewness 1

$$\hat{\psi}_x(r_i^1, r_j^2) = \frac{1}{T} \sum_{t=1}^T (x_i - \hat{\mu}_i)^1 (x_j - \hat{\mu}_j)^2 \quad (3)$$

- Level of the source market ( $x_i$ ) returns  $(x_i - \hat{\mu}_i)^1$
- Variance of the recipient market ( $x_j$ ) returns  $(x_j - \hat{\mu}_j)^2$



- Coskewness 2

$$\hat{\psi}_x(r_i^2, r_j^1) = \frac{1}{T} \sum_{t=1}^T (x_i - \hat{\mu}_i)^2 (x_j - \hat{\mu}_j)^1 \quad (4)$$

- Variance of the source market ( $x_i$ ) returns  $(x_i - \hat{\mu}_i)^2$
- Level of the recipient market ( $x_j$ ) returns  $(x_j - \hat{\mu}_j)^1$

- Test for contagion from  $i$  (a source market) to  $j$  (a recipient market)

$$CS_1(i \rightarrow j; r_i^1, r_j^2) = \left( \frac{\hat{\psi}_y(r_i^1, r_j^2) - \hat{\psi}_x(r_i^1, r_j^2)}{\sqrt{\frac{4\hat{v}_{y|x_i} + 2}{T_y} + \frac{4\hat{\rho}_x^2 + 2}{T_x}}} \right)^2 \quad (5)$$

$$\hat{\psi}_y(r_i^m, r_j^n) = \frac{1}{T_y} \sum_{t=1}^{T_y} \left( \frac{y_{i,t} - \hat{\mu}_{y_i}}{\hat{\sigma}_{y_i}} \right)^m \left( \frac{y_{j,t} - \hat{\mu}_{y_j}}{\hat{\sigma}_{y_j}} \right)^n, \quad (6)$$

$$\hat{\psi}_x(r_i^m, r_j^n) = \frac{1}{T_x} \sum_{t=1}^{T_x} \left( \frac{x_{i,t} - \hat{\mu}_{x_i}}{\hat{\sigma}_{x_i}} \right)^m \left( \frac{x_{j,t} - \hat{\mu}_{x_j}}{\hat{\sigma}_{x_j}} \right)^n. \quad (7)$$

$$CS_2 (i \rightarrow j; r_i^2, r_j^1) = \left( \frac{\hat{\psi}_y (r_i^2, r_j^1) - \hat{\psi}_x (r_i^2, r_j^1)}{\sqrt{\frac{4\hat{v}_{y|x_i} + 2}{T_y} + \frac{4\hat{\rho}_x^2 + 2}{T_x}}} \right)^2, \quad (8)$$

# Coskewness contagion testing

- Hypotheses using  $CS_1$  are

$$H_0 : \psi_y(r_i^1, r_j^2) = \psi_x(r_i^1, r_j^2),$$

$$H_1 : \psi_y(r_i^1, r_j^2) \neq \psi_x(r_i^1, r_j^2).$$

- Hypotheses using  $CS_2$  are

$$H_0 : \psi_y(r_i^2, r_j^1) = \psi_x(r_i^2, r_j^1),$$

$$H_1 : \psi_y(r_i^2, r_j^1) \neq \psi_x(r_i^2, r_j^1),$$

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

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

- Daily equity price indices ( $P_{i,t}$ ) in US dollars for 12 equity markets
- Argentina, Australia, Brazil, Canada, Germany, Hong Kong, Japan, Russia, Korea, Thailand, UK, US
- Sample period:
  - September 1, 1995 to April 27, 2010,
  - $T = 3822$  observations

- Daily percentage equity returns of the  $i^{th}$  market

$$R_{i,t} = 100 (\ln(P_{i,t}) - \ln(P_{i,t-1})).$$

- Data filtered using a VAR(1)

- Asia
  - October 20, 1997 to May 18, 1998
  - $T_y = 151$
  - Source: Hong Kong (speculative attack)
- Russia
  - August 17, 1998 to December 31, 1998
  - $T_y = 99$  observations
  - Source: Russian (Government deferral of bond repayments)
- LTCM
  - September 23, 1998 to October 15, 1998
  - $T_y = 17$
  - Source: US (linked to the Russian crisis)

- Brazil
  - January 7, 1999 to February 25, 1999
  - $T_y = 36$
  - Source: Brazil - (loss of reserves and devaluation of the real)
- Dot com
  - February 28, 2000 to June 7, 2000
  - $T_y = 73$
  - Source: US
- Argentina
  - October 11, 2001 to December 31, 2002
  - $T_y = 317$
  - Source: Argentina (introduction of the partial deposit freeze and capital controls)

- GFC
  - July 26, 2007 to April 27, 2010
  - $T_y = 718$
  - Source: US (prior to the collapse of AIG)



# Non-crisis period dating

- The non-crisis period ( $x_t$ ) consists of all data in the sample that is not in crisis
- $T_x = 2168$  observations

# Contagion channels during crises

## Non crisis period statistics

	Mean	Minimum	Maximum	Std Dev	Skewness
Argentina	0.04	-14.81	9.18	1.90	-0.39
Australia	0.05	-7.01	6.38	1.02	-0.37
Brazil	0.12	-16.42	9.85	2.11	-0.36
Canada	0.05	-8.93	4.40	1.00	-0.97
Germany	0.06	-5.79	4.49	0.96	-0.55
Hong Kong	0.05	-14.71	17.27	1.46	0.22
Japan	0.01	-6.14	6.70	1.41	0.04
Korea	0.03	-9.95	9.70	1.83	-0.10
Russia	0.11	-21.10	15.55	2.73	-0.47
Thailand	-0.03	-16.06	10.80	1.78	-0.35
UK	0.04	-4.87	5.57	0.96	-0.11
US	0.03	-7.45	4.60	0.93	-0.57

- Mostly negative skewness

# Contagion channels during crises

## Crisis period statistics - Asia

		Mean	Min	Max	Std Dev	Skew
Asia	Argentina	-0.03	-6.13	4.80	2.03	-0.56
	Australia	0.01	-3.13	3.58	1.25	0.13
	Brazil	0.07	-10.89	7.81	2.56	-0.86
	Canada	0.02	-2.80	1.71	0.94	-0.58
	Germany	0.09	-2.20	2.07	0.90	-0.16
	Hong Kong	-0.12	-9.07	13.41	2.80	0.75
	Japan	-0.19	-6.67	8.69	2.51	0.33
	Korea	-0.24	-15.47	20.43	5.88	0.28
	Russia	-0.50	-15.49	6.89	3.81	-0.81
	Thailand	-0.34	-14.07	14.82	4.25	0.87
	UK	0.10	-2.44	2.62	1.03	-0.04
	US	0.09	-2.89	2.51	0.91	-0.20

- Evidence of positive skewness - mainly regional

# Contagion channels during crises

Crisis period statistics - Brazil

		Mean	Min	Max	Std Dev	Skew
Brazil	Argentina	-0.32	-10.80	11.64	3.70	0.29
	Australia	0.01	-2.54	1.83	1.04	-0.43
	Brazil	-0.93	-13.75	18.02	6.52	0.65
	Canada	-0.24	-2.61	2.46	1.26	0.16
	Germany	-0.23	-1.93	1.35	0.85	-0.14
	Hong Kong	-0.45	-4.15	2.99	1.83	-0.10
	Japan	0.11	-2.30	2.76	1.36	0.08
	Korea	-0.97	-5.65	7.00	2.76	0.84
	Russia	0.43	-7.83	7.12	3.36	0.00
	Thailand	-0.69	-5.33	10.41	2.73	2.05
	UK	-0.23	-2.57	1.81	1.15	0.23
	US	-0.05	-2.48	2.38	1.22	0.16

- Evidence of positive skewness, mainly regional

## Dependence in the non crisis period - correlations

	Arg.	Brazil	HK	Russia	US
Argentina	1.00	0.49	0.12	0.17	0.36
Australia	0.14	0.20	0.45	0.20	0.11
Brazil	0.49	1.00	0.17	0.20	0.44
Canada	0.34	0.42	0.21	0.22	0.51
Germany	0.20	0.28	0.28	0.25	0.23
Hong Kong	0.12	0.17	1.00	0.30	0.09
Japan	0.09	0.15	0.40	0.14	0.05
Korea	0.11	0.15	0.42	0.18	0.10
Russia	0.17	0.20	0.30	1.00	0.13
Thailand	0.13	0.15	0.33	0.19	0.05
UK	0.24	0.33	0.29	0.25	0.36
US	0.36	0.44	0.09	0.13	1.00

- Correlations strongest across regions

# Dependence in the non crisis period - coskewness 1

	Arg	Brazil	HK	Russia	US
	Coskewness 1 $\hat{\psi}_x(r_i^1, r_j^2)$				
Argentina	-0.39	-0.38	-0.20	-0.15	-0.28
Australia	-0.11	-0.13	-0.13	-0.20	-0.17
Brazil	-0.41	-0.36	-0.21	-0.18	-0.24
Canada	-0.49	-0.44	-0.14	-0.22	-0.38
Germany	-0.11	-0.23	-0.32	-0.28	-0.13
Hong Kong	-0.05	-0.18	0.22	-0.09	0.20
Japan	-0.05	-0.04	-0.05	-0.11	-0.07
Korea	-0.05	-0.11	-0.18	-0.17	-0.06
Russia	-0.09	-0.03	-0.31	-0.47	0.04
Thailand	0.12	0.06	0.00	-0.06	0.09
UK	-0.06	-0.08	-0.17	-0.08	0.00
US	-0.30	-0.14	-0.39	-0.23	-0.57

- Mostly negative, but for the US some positive

## Dependence in the non crisis period - coskewness 2

	Arg	Brazil	HK	Russia	US
	Coskewness $2 \hat{\psi}_x (r_i^2, r_j^1)$				
Argentina	-0.39	-0.41	-0.05	-0.09	-0.30
Australia	-0.14	-0.27	-0.07	-0.29	-0.52
Brazil	-0.38	-0.36	-0.18	-0.03	-0.14
Canada	-0.32	-0.30	0.12	-0.07	-0.32
Germany	-0.13	-0.30	-0.18	-0.27	-0.27
Hong Kong	-0.20	-0.21	0.22	-0.31	-0.39
Japan	-0.07	-0.13	-0.09	-0.16	-0.22
Korea	-0.27	-0.24	-0.20	-0.27	-0.33
Russia	-0.15	-0.18	-0.09	-0.47	-0.23
Thailand	0.03	-0.07	-0.36	-0.27	-0.22
UK	-0.14	-0.17	-0.01	-0.08	0.03
US	-0.28	-0.24	0.20	0.04	-0.57

- When reverse coskew, all negative for the US (US volatility corresponds with -ve returns)

# Dependence in the crisis periods

- Evidence that the correlation coefficients rise substantially
- Coskewness statistics also appear to change in magnitude and sign
- Difficult to analyze these statistics during this period given the increases in volatility



# Summary of results

	Asia				Russia				Brazil				Argentina		
	CR	CS1	CS2		CR	CS1	CS2		CR	CS1	CS2		CR	CS1	CS2
Arg		■		Arg				Arg		■	■	Aust	■		
Aust				Aust			■	Aust		■		Brz	■	■	
Brz		■		Brz				Can	■	■	■	Can			
Can			■	Can		■	■	Ger	■			Ger	■		
Ger				Ger	■			HK				HK	■		■
Jap	■			HK	■			Jap	■		■	Jap			
Kor	■		■	Jap		■		Kor				Kor			
Rus				Kor		■		Rus				Rus	■		■
Thai	■		■	Thai	■			Thai				Thai	■		
UK	■			UK				UK		■	■	UK	■	■	
US		■		US				US	■			US	■		

	LTCM				Dotcom				GFC		
	CR	CS1	CS2		CR	CS1	CS2		CR	CS1	CS2
Arg	■								■	■	
Aust							■		■	■	
Brz	■								■	■	
Can					■		■		■	■	
Ger					■				■	■	
HK					■				■	■	
Jap					■				■	■	
Kor					■				■	■	
Rus					■				■	■	
Thai					■				■	■	
UK					■				■	■	
US					■		■		■	■	

- GFC truly different to all other crises
- All channels of contagion are operating
- Almost all countries are affected by more than one channel
- Correlation dependence structures change dramatically
  - contagion to all except for Canada, Japan and the UK
- Coskewness dependence structures change dramatically
  - only Australia through  $CS_1 (i \rightarrow j; r_i^1, r_j^2)$  and Brazil and Germany through both channels do not change.

# Crises in major financial centres

	LTCM				Dotcom				GFC		
	FR	CS1	CS2		FR	CS1	CS2		FR	CS1	CS2
Arg	0.00	0.83	0.77		0.98	0.22	0.08		0.04	0.00	0.00
Aust	0.35	0.70	0.69		0.26	0.77	0.00		0.00	0.31	0.00
Brz	0.05	0.68	0.89		0.12	0.52	0.24		0.02	0.89	0.51
Can	0.96	0.49	0.58		0.00	0.29	0.03		0.31	0.00	0.00
Ger	0.63	0.11	0.51		0.00	0.20	0.16		0.00	0.25	0.96
HK	0.69	0.61	0.45		0.04	0.22	0.36		0.00	0.00	0.00
Jap	0.83	0.33	0.31		0.04	0.53	0.19		0.86	0.00	0.00
Kor	0.25	0.09	0.51		0.57	0.16	0.25		0.00	0.00	0.00
Rus	0.55	0.17	0.86		0.04	0.75	0.44		0.01	0.00	0.02
Thai	0.75	0.32	0.77		0.33	0.36	0.35		0.00	0.03	0.01
UK	0.19	0.95	0.63		0.00	0.47	0.05		0.44	0.01	0.00

- LTCM little evidence of contagion - interdependence.
- Dotcom crisis affects mainly the developed countries
  - Aust., Canada and the UK were the only countries through  $CS_2 (i \rightarrow j; r_i^2, r_j^1)$
  - No cases through the  $CS_1 (i \rightarrow j; r_i^1, r_j^2)$

# Crises in emerging markets

	Asia				Russia				Brazil		
	CR	CS1	CS2		FR	CS1	CS2		FR	CS1	CS2
Arg	0.21	0.01	0.26	Arg	0.69	0.36	0.07	Arg	0.50	0.00	0.00
Aust	0.38	0.07	0.18	Aust	0.15	0.86	0.05	Aust	0.99	0.12	0.00
Brz	0.08	0.03	0.77	Brz	0.35	0.76	0.07	Can	0.00	0.00	0.00
Can	0.42	0.07	0.00	Can	0.19	0.00	0.01	Ger	0.00	0.71	0.61
Ger	0.43	0.61	0.95	Ger	0.04	0.67	0.35	HK	0.16	0.98	0.33
Jap	0.00	0.33	0.03	HK	0.02	0.47	0.11	Jap	0.03	0.07	0.01
Kor	0.00	0.30	0.02	Jap	0.69	0.03	0.58	Kor	0.62	0.60	0.06
Rus	0.71	0.22	0.18	Kor	0.83	0.00	0.74	Rus	0.03	0.27	0.25
Thai	0.00	0.54	0.04	Thai	0.01	0.60	0.32	Thai	0.07	0.76	0.97
UK	0.03	0.87	0.07	UK	0.49	0.53	0.23	UK	0.12	0.00	0.00
US	0.72	0.00	0.06	US	0.88	0.29	0.16	US	0.00	0.67	0.14

- Similar pattern across most of these emerging market sourced crises
  - two thirds of the countries are affected through one channel only, with no channel dominating
- More than 1 channel needs to be considered

# Crises in emerging markets

- Countries with strong regional linkages are affected through correlation
- Countries less likely to have linkages are more likely to show contagion through the higher order channels
- Asia:
  - Correlation based channel is active for Japan, Korea, Thailand and UK
  - Argentina, Brazil, Canada and the US are affected through  $CS_1 (i \rightarrow j; r_i^1, r_j^2)$  or  $CS_2 (i \rightarrow j; r_i^2, r_j^1)$
- Russia
  - Germany and Hong Kong are also affected by Russia through correlation channel
  - Germany strong banking linkages
  - HKMA intervened in the Hong Kong equity market to support the currency board in August of 1998
  - Australia, Canada, Japan and Korea affected through higher order channels

# Crises in emerging markets

	Asia				Russia				Brazil		
	CR	CS1	CS2		FR	CS1	CS2		FR	CS1	CS2
Arg	0.21	0.01	0.26	Arg	0.69	0.36	0.07	Arg	0.50	0.00	0.00
Aust	0.38	0.07	0.18	Aust	0.15	0.86	0.05	Aust	0.99	0.12	0.00
Brz	0.08	0.03	0.77	Brz	0.35	0.76	0.07	Can	0.00	0.00	0.00
Can	0.42	0.07	0.00	Can	0.19	0.00	0.01	Ger	0.00	0.71	0.61
Ger	0.43	0.61	0.95	Ger	0.04	0.67	0.35	HK	0.16	0.98	0.33
Jap	0.00	0.33	0.03	HK	0.02	0.47	0.11	Jap	0.03	0.07	0.01
Kor	0.00	0.30	0.02	Jap	0.69	0.03	0.58	Kor	0.62	0.60	0.06
Rus	0.71	0.22	0.18	Kor	0.83	0.00	0.74	Rus	0.03	0.27	0.25
Thai	0.00	0.54	0.04	Thai	0.01	0.60	0.32	Thai	0.07	0.76	0.97
UK	0.03	0.87	0.07	UK	0.49	0.53	0.23	UK	0.12	0.00	0.00
US	0.72	0.00	0.06	US	0.88	0.29	0.16	US	0.00	0.67	0.14

# Argentina

	Argentina		
	FR	CS1	CS2
Aust	0.00	0.82	0.01
Brz	0.00	0.00	0.07
Can	0.00	0.00	0.48
Ger	0.00	0.22	0.35
HK	0.02	0.92	0.10
Jap	0.33	0.50	0.90
Kor	0.29	0.33	0.01
Rus	0.00	0.56	0.31
Thai	0.00	0.24	0.14
UK	0.00	0.19	0.34
US	0.00	0.00	0.64

# Conclusions

- Examined the transmission of contagion across equity markets in seven financial crises
- Contagion: significant changes in the moments of the distribution of equity returns such as correlation or coskewness
- GFC truly different to any of the other crises of the past two decades
- Some US based crises - virtually no evidence of contagion suggesting crises transmit through normal linkages usually
- The emerging market crises channels of contagion transmitted were equally active
- More than just the correlation based channel should be examined during when analyzing crises
- Markets expected not to have linkages with the source country were more likely to be affected through the higher order channels