Bond Spreads, Market Integration and Contagion in the 2007-2008 Crisis

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What to Study

- **Market linkages** are becoming increasingly important in the international environment.
- In particular, **linkages in financial markets** receive more attention during financial crisis as **decision makers** in markets become keener to receive available information across markets.
- The recent financial crisis of 2007-2008 is mainly a **crisis in debt markets**.
- We study the nature of market integration and linkages around the period of recent financial crisis by **analyzing bond spreads** during the period.

Yield Spreads, Factor Model

- **Yield spreads** of bonds represent **relative attractiveness** of the bonds, which is affected by profitability, default risk, and liquidity.
- These determinants of bond values are closely related to **market connectedness and integration**.
- A complicated multivariate specification would be needed to consider such multiple economy bond spreads. Problems of **specification sensitivity and curse of dimensionality** are entailed.
- Instead, we use a **latent factor model**, which makes it possible to **decompose volatility** of bond spreads to various components with interpretable identification.
- The latent factor approach also has the advantage of quantifying effects **contagion effects** of shocks across markets.

Factors in Factor Model

- **Four potential factors** are considered that influence bond spreads: the world factor, the regional factor, the country-specific factor, and the U.S. risk factor.
- The first, second and fourth factors are common factors. The third factor is country specific.
- In the crisis period the world factor are classified into the U.S. risk factor and the other part.
- The regional factor reflects common events and market integration in each region, which cause movements of markets in the same direction, e.g. period of Asian economic crisis

Advantage of Latent Factor Model

- The latent factor model helps **avoid modeling of a specific structure**, absorbing it in latent factors.
- This approach not only reduces the dimension of parameters but also avoids the problem of model misspecification.
- A number of authors use the latent factor model to analyze financial markets. Diebold and Nerlove (1989), Ng, Engle, and Rothschild (1992), Mahieu and Schotman (1994), King, Sentana, and Wadhwani (1994), and Forbes and Rigobon (2002), Gregory and Watts (1995), Dungey, Martin and Pagan (2000), Kose, Otrok, and Whiteman (2003).

Data

- Data from 9 countries are used: 3 Latin American countries (Argentina, Brazil, and Mexico), 3 Asian countries (Indonesia, Korea, and Philippines), and 3 developed countries (Japan, UK, and US).
- Daily observations of spreads on bond yields from December 1, 2006 to March 31, 2010.
- For six emerging economies (Latin America and Asia) the long-term sovereign bonds are used. For developed economies the long-term BBB corporate bonds are used.

Results

- For most countries, the **level and volatility** of bond spreads have shown an overall increase during the financial crisis.
- The absolute value of **correlation** of bond spreads has increased in most cases during the crisis.
- **Contagion emerges** quite substantially from the U.S. shock during the crisis.
- Contagion from the U.S. shock has **global-level effects** on most of the considered emerging economies.
- **Mixed effects of regional factors** are shown, with similarities and differences across regions and countries.

The Model

- Let $r_{i,t}$ be the bond yield of the i-th market at time t and $r_{0,t}$ be the bond yield of a comparable risk free benchmark.
- The bond spread of the i-th market is $s_{i,t} = r_{i,t} - r_{0,t}$. $s_{i,t}$, is risk premium over a risk-free counterpart.
- Let w_t, R_t^A, R_t^L, and $u_{1,t}$ be, respectively, the world, the Asia, the Latin America, and country specific factors.
- Then, we have a latent fact model for Δs_t:

$$\Delta s_{i,t} = \lambda_i w_t + \gamma^{i,A} R_t^A + \gamma^{i,L} R_t^L + \sigma_i u_{i,t}, \tag{1}$$

  where λ_i, $\gamma^{i,A}$, $\gamma^{i,L}$, σ_i are factor loadings,
- whose variances are normalized to be unity.
- Assume that all the factors are independent of each other: $E[w_t, R_t^k] = 0$ for $k = A, L$, $E[R_t^A R_t^L] = 0$, $E[u_{i,t}u_{j,t}] = 0$ for $i \neq j$, $E[u_{i,t}w_t] = 0$ for $i = 0, 1, \cdots, N$ and $E[u_{i,t}R_t^k] = 0$ for $i = 0, 1, \cdots, N$ and $k = A, L$.

ARCH for Disturbance Process

- Assume that the disturbance processes are distributed as Gaussian processes with the autoregressive conditional heteroskedasticity (ARCH) in the conditional variance:

$$\begin{aligned} f_{j,t} &= v_{j,t}, \\ v_{j,t} &\sim N(0, \sigma^2_{j,t}), \text{ and} \\ \sigma^2_{j,t} &= (1-\alpha_j) + \alpha_j \sigma^2_{j,t-1}. \end{aligned} \tag{2}$$

  where $j = 1, 2, 3$ and $\{f_{1,t}, f_{2,t}, f_{3,t}\} = \{w_t, R^A_t, R^L_t\}$.

  Used by Diebold and Nerlove (1989), Engle, Ng and Rothschild (1990), Kim and Park (2004), Dungey et. al. (2000) and Dungey et. al. (2011).

Augmentation: Including the U.S. Risk Factor

- Augment the model (1) by including the U.S. factor $u_{us,t}$ for the period of crisis (via the indicator I_t):

  $$\Delta s_{i,t} = \lambda_i w_t + \gamma^{i,A} R_t^A + \gamma^{i,L} R_t^L + \sigma_i u_{i,t} + \zeta_i I_t u_{us,t}, \qquad (3)$$

  The strength of contagion from the U.S. market are controlled by ζ_i; $I_t = 1$ for the crisis period.
- $\zeta_{us} = 0$, implying that the U.S. risk factor for the U.S. is included in the idiosyncratic shock of the U.S.
- The U.S. risk factor is distinct from the world factor: The former presents only in the crisis period while the latter presents in the whole period.

Evaluation of the Contribution of Each Factor

- The variance of $\Delta s_{i,t}$ can be decomposed as

$$\begin{aligned} Var(\Delta s_{i,t}) = \quad & Var(\lambda_i w_t) + Var(\gamma_i^A R_t^A) + Var(\gamma_i^L R_t^L) \qquad (4) \\ & + Var(\zeta_i I_t u_{us,t}) + Var(u_{i,t}). \qquad (5) \end{aligned}$$

- The contribution of each factor to the volatility of the bond spread variation is, then, defined as:

$$\begin{aligned} \text{Contribution of the world factor} &= \frac{\lambda_i^2}{Var(\Delta s_{i,t})}, \\ \text{Contribution of the regional factor} &= \frac{(\gamma_i^k)^2}{Var(\Delta s_{i,t})}, \\ \text{Contribution of the idiosyncratic factor} &= \frac{\sigma_i^2}{Var(\Delta s_{i,t})}. \\ \text{Contribution of the contagion factor} &= \frac{\zeta_i^2 I_t}{Var(\Delta s_{i,t})}. \qquad (6) \end{aligned}$$

where $Var(\Delta s_{i,t}) = \lambda_i^2 + (\gamma_i^A)^2 + (\gamma_i^L)^2 + \zeta_i^2 + \sigma_i^2$.

Estimation Method (1)

- We use a simulation-based indirect inference method proposed by Gourieroux et al. (1993).
- Denote by $M = M(\theta)$ a given model. Suppose a direct estimation method such as the maximum likelihood method or the method of moments is not tractable for M.
- In this case we consider an approximate model M^a that is more tractable than M. We call M^a an instrumental model for the estimation of θ.
- The instrumental model is characterized by a vector of parameters θ^a, $M^a = M^a(\theta^a)$.

Estimation Method (2)

- Let $X_T(\theta) \equiv \{x_t(\theta)\}_{t=1}^{T}$ be a sequence of observed data and $\hat{\theta}_T^a = \hat{\theta}^a(X_T(\theta))$ be an estimator of θ^a based on $X_T(\theta)$.
- Denote by $X_{sT}(\theta) \equiv \{x_t^s(\theta)\}_{t=1}^{T}$ a sequence of simulated data from the model M conditional on the parameter θ for $s = 1, \ldots, S$.
- Let $\hat{\theta}_{sT}^a = \hat{\theta}^a(X_{sT}(\theta))$ be an estimator of θ^a based on $X_{sT}(\theta)$.
- The indirect estimator of θ, $\hat{\theta}_{ST}$, is defined as

$$\hat{\theta}_{ST}(W) = \arg\min_{\theta} \left[\hat{\theta}_T^a - \frac{1}{S}\sum_{s=1}^{S} \hat{\theta}_{sT}^a(\theta)\right]' W \left[\hat{\theta}_T^a - \frac{1}{S}\sum_{s=1}^{S} \hat{\theta}_{sT}^a(\theta)\right] \qquad (7$$

where W is a weighting matrix.

Estimation Method (3)

- In the estimation process we use the Kalman filter as the likelihood function of an approximate model.
- The state-space model for the Kalman filter is represented as follows:

$$\begin{aligned} &\text{(Observation equation)} & \Delta s_t &= \Gamma f_t + \sigma u_t, \\ &\text{(State equation)} & f_{j,t} &= \sqrt{(1-\alpha^j) + \alpha^j f_{j,t-1}^2}\,\eta_{j,t}. \end{aligned} \tag{8}$$

  where $\Gamma = \{\lambda, \gamma^A, \gamma^L\}$ and $\alpha = \{\alpha^w, \alpha^A, \alpha^L\}$. $\eta_{j,t}$ is the i.i.d. standard normal process and is independent of u_t.

- Although the state equation is nonlinear, we can apply the Kalman filter to have an updated f_t from f_{t-1}.

Empirical Results: Descriptive Statistics

- The mean and standard error of spread series for most countries experienced large increases in the crisis period.
- Correlations of the bond spread increase in the period of crisis, reflecting risk spillover effects. (Table 3.1)
- To check persistence of spread series we have tested the unit root null. The null is not rejected at 5% test for the spread of all countries. (Table 3.2)
- The persistence and instability of bond spreads, implied in the unit root hypothesis, are well expected during the period of 2007-2008 financial crisis.
- We use the first difference of bond spreads, Δs_t, to remove the unit root in s_t.
- Δs_t exhibits common time-varying volatility (Figure 3.1), which can be properly modelled by ARCH.

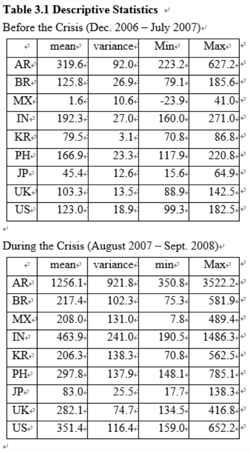


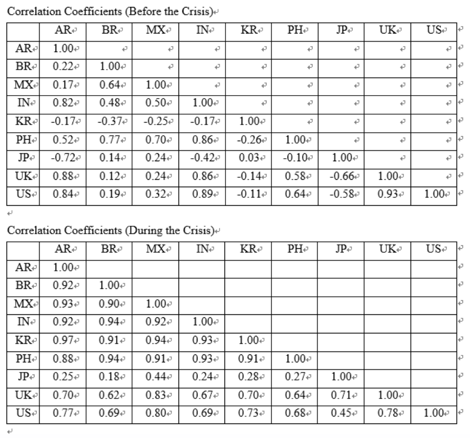
Table 3.1 Descriptive Statistics

Before the Crisis (Dec. 2006 – July 2007)

	mean	variance	Min	Max
AR	319.6	92.0	223.2	627.2
BR	125.8	26.9	79.1	185.6
MX	1.6	10.6	-23.9	41.0
IN	192.3	27.0	160.0	271.0
KR	79.5	3.1	70.8	86.8
PH	166.9	23.3	117.9	220.8
JP	45.4	12.6	15.6	64.9
UK	103.3	13.5	88.9	142.5
US	123.0	18.9	99.3	182.5

During the Crisis (August 2007 – Sept. 2008)

	mean	variance	min	Max
AR	1256.1	921.8	350.8	3522.2
BR	217.4	102.3	75.3	581.9
MX	208.0	131.0	7.8	489.4
IN	463.9	241.0	190.5	1486.3
KR	206.3	138.3	70.8	562.5
PH	297.8	137.9	148.1	785.1
JP	83.0	25.5	17.7	138.3
UK	282.1	74.7	134.5	416.8
US	351.4	116.4	159.0	652.2



Correlation Coefficients (Before the Crisis)

	AR	BR	MX	IN	KR	PH	JP	UK	US
AR	1.00								
BR	0.22	1.00							
MX	0.17	0.64	1.00						
IN	0.82	0.48	0.50	1.00					
KR	-0.17	-0.37	-0.25	-0.17	1.00				
PH	0.52	0.77	0.70	0.86	-0.26	1.00			
JP	-0.72	0.14	0.24	-0.42	0.03	-0.10	1.00		
UK	0.88	0.12	0.24	0.86	-0.14	0.58	-0.66	1.00	
US	0.84	0.19	0.32	0.89	-0.11	0.64	-0.58	0.93	1.00

Correlation Coefficients (During the Crisis)

	AR	BR	MX	IN	KR	PH	JP	UK	US
AR	1.00								
BR	0.92	1.00							
MX	0.93	0.90	1.00						
IN	0.92	0.94	0.92	1.00					
KR	0.97	0.91	0.94	0.93	1.00				
PH	0.88	0.94	0.91	0.93	0.91	1.00			
JP	0.25	0.18	0.44	0.24	0.28	0.27	1.00		
UK	0.70	0.62	0.83	0.67	0.70	0.64	0.71	1.00	
US	0.77	0.69	0.80	0.69	0.73	0.68	0.45	0.78	1.00

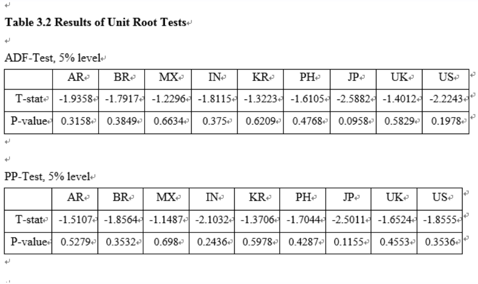


Table 3.2 Results of Unit Root Tests

ADF-Test, 5% level

	AR	BR	MX	IN	KR	PH	JP	UK	US
T-stat	-1.9358	-1.7917	-1.2296	-1.8115	-1.3223	-1.6105	-2.5882	-1.4012	-2.2243
P-value	0.3158	0.3849	0.6634	0.375	0.6209	0.4768	0.0958	0.5829	0.1978

PP-Test, 5% level

	AR	BR	MX	IN	KR	PH	JP	UK	US
T-stat	-1.5107	-1.8564	-1.1487	-2.1032	-1.3706	-1.7044	-2.5011	-1.6524	-1.8555
P-value	0.5279	0.3532	0.698	0.2436	0.5978	0.4287	0.1155	0.4553	0.3536

Empirical Results: Main Findings (1)

- The world factor has certain amount of effects on the volatility of Δs_t for most emerging economies. This implies that the emerging economies are mostly integrated into the global market.
- Contagion effects of the U.S. shock emerge quite substantially for all the considered emerging economies.
- Contagion from the U.S. shock has global-level effects on all the considered emerging economies although the degree of influence is different across different countries and regions.

Table 3.4 Variance Decomposition

Non-Crisis Period

	world	Latin	Asia	idiosync
AR	77.7%	16.3%	—	6.0%
BR	18.0%	70.0%	—	12.0%
MX	9.8%	25.1%	—	65.1%
IN	7.9%	—	17.9%	74.2%
KR	0.0%	—	3.8%	96.2%
PH	11.1%	—	64.0%	24.9%
JP	0.7%	—	—	99.3%
UK	1.0%	—	—	99.0%
US	11.8%	—	—	88.2%

Crisis Period

	world	Latin	Asia	idiosync	U.S. risk
AR	12.1%	2.5%	—	0.9%	84.5%
BR	14.6%	56.9%	—	9.7%	18.7%
MX	8.5%	21.8%	—	56.5%	13.1%
IN	6.1%	—	13.9%	57.4%	22.6%
KR	0.0%	—	3.7%	92.0%	4.4%
PH	8.6%	—	49.7%	19.3%	22.4%
JP	0.7%	—	—	98.4%	0.9%
UK	1.0%	—	—	98.5%	0.5%
US	11.8%	—	—	88.2%	—

Empirical Results: Main Findings (2)

- Clear regional effects are shown which, however, are mixed with similarities and differences across regions and countries. In the crisis period, the world-wide contagion effects together with the world factor outweigh the regional factor for majority of the considered emerging economies.
- Strong effects of country specific factors are shown in Korea as well as Japan, the UK, and the US.

Conclusions

- We analyzed bond spreads of nine countries in the period from December 1, 2006 to March 31, 2010 to see how much markets are integrated and how the 2007-2008 crisis affects the international market.
- The analysis is based on an augmented latent factor model.
- Our empirical results have several interesting implications.
- The analysis is mainly for the effects of the U.S. shock and did not include the effects of the recent EU crisis following the U.S. shock.
- With different sets of countries and different identification schemes with respect to regions and periods of contagions we may have some different results.