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Empirical dynamics of emerging financial markets during the global mortgage crisis ☆

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Abstract

Focusing on five major emerging markets, I investigate the interactions between credit default swap premiums, foreign exchange rates, local currency government bond spreads, and national stock market returns over the period 4/2/2007 to 8/27/2009. Empirical analysis indicates that bond markets, along with foreign exchange markets, were very dominant in the price discovery process during a common distressed period.

JEL classification: G14; G15; F30; F31; F36

Keywords: Price discovery; Emerging markets; Local currency government bond; Credit default swap; Stock market; Foreign exchange market

1. Introduction

Which markets provide the most accurate and timely assessment of macroeconomic risks? Does the flow of information have a common path across emerging financial markets? There is a large body of literature examining the informational discoveries in the corporate world as well as in the sovereign context (Blanco, Brennan, & Marsh, 2005; Forte & Lovreta, 2013; Forte & Pena, 2009; Giannikos, Guirguis, & Suen, 2013; Narayan, Sharma, & Thuraisamy, 2014; Ngene, Hassan, & Alam, 2014; Nowak, Andritzky, Jobst, & Tamirisa, 2011). Even though there are many studies (Cakan, Doytch, & Upadhyaya, 2014) focusing on emerging markets (EM), very few (Ertugrul, & Ozturk, 2013) brought foreign exchange (FX) and local currency government bond (LCB) markets into spotlight. Especially, the interaction of Credit Default Swaps (CDS) and stock markets were rarely assessed together with the LCB and FX markets. This study aims to accomplish this task.

The reason behind bringing FX and LCB markets to light is simple; they are the building blocks in determining the overall risk level of a sovereign (Eichengreen, Hausmann, & Panizza, 2002). Using the novel ideas of Merton (1974) on the firms' capital structure and option pricing theory, Gray, Merton, & Bodie (2007) show that the local currency liabilities (domestic debt and monetary base) function as the "equity-like" portion of the sovereign balance sheet, whereas the foreign currency liabilities (external debt) function as a "distress barrier" on the road to default. Here one can easily see that local currency bonds and exchange rate parities are the starting points to such default probability calculations (Aktug, 2014).

Accordingly, local currency denominated government bonds are emphasized rather than US Dollar (USD) or Euro (EUR) denominated bonds in empirical analysis. Most of the corporate studies use USD or EUR denominated bonds (Blanco et al., 2005; Forte & Pena, 2009; Zhu, 2006). About

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the EM studies, some authors use JP Morgan's EMBI+ or EMBIG spreads (Chan-Lau & Kim, 2004), and some use USD denominated bond yields provided by JP Morgan (Adler & Song, 2010) or extracted from Bloomberg (Ammer & Cai, 2007).[1]

The use of LCB markets is very new in the price discovery literature and the advantage is that these markets are larger and more liquid (Peiris, 2010) compared to foreign currency denominated bond (FCB) markets.[2] In addition, using JP Morgan's EMBI+ or EMBIG data has some shortcomings such as the variation in maturity structure over time, and unclear composition of instruments that go into index calculation (i.e. Brady Bonds, collateral enhancements, loans).[3]

Currency markets are the largest and the most active financial markets, and the easiest and cheapest to trade. Liquidity of these markets can also be attributed to the 24-h-trading day. Currency markets can also help international investors in diversifying their portfolios, thus achieving mean-variance efficiency (Campbell, Mederios, & Viceira, 2010).

In addition to the LCB and FX markets, I include the national stock markets and the newly developing sovereign CDS markets to provide a comprehensive analysis of emerging financial markets.[4] Sovereign risk, defined as the ability and willingness of a government to pay back its debt, has also a direct impact on macroeconomic risks via government's interaction with private sector. Therefore the performance of the private sector, or the performance of a country's stock market, is very sensitive to the finances of governments (Gray et al., 2007; Ngene, 2014) and should be included in such a study.

Finally, sovereign Credit Default Swaps (CDS) have also become very popular tools to hedge country risk, or to bet against the health of a country's economy. A CDS is simply an insurance policy[5] which pays out when a government or a company defaults on its debt. The liquidity and ease of trading in CDS markets make them very attractive for financial institutions and investors (Augustin, 2014). Consequently, since sovereign risk is closely monitored in all the four markets mentioned above (Broner, 2010), it is important to provide a complete analysis to discover which markets deliver the news faster.

The Fundamental Theorem of Arbitrage-Free Pricing (Cornuejols & Tutuncu, 2007) suggests that all the derivatives of an underlying asset have an intertemporal (linear or nonlinear) relationship among each other. From this point of view, the capacity and willingness of a sovereign to payback its debt, can be thought as the underlying asset, and all the secondary markets; stock, bond, currency, and CDS, can be considered as the derivatives tied to this asset.

Accordingly, I examine how various emerging financial markets interact with each other in delivering the news over the 2007—2009 global mortgage crisis period. Specifically, I test the comparable speed of CDS, FX, LCB, and stock markets in delivering the news. My analysis fills some of the missing gaps in the literature, and provides a snapshot for the major emerging markets, namely Brazil, China, Indonesia, Mexico, and Turkey.[6] Understanding the empirical dynamics among these financial markets can be quite important for trading, investment, and risk management purposes (Campbell et al., 2010; Jorion, 2009).

Besides various noticeable findings, I have four novel contributions. First, I show that LCB markets are very active in the price discovery process, especially when the market fear is high. This finding departs from the corporate studies which favor the leading role of CDS and stock markets over bond markets (Forte & Pena, 2009; Narayan et al., 2014). Second, I find that FX markets also have an important presence in time-series analysis. FX and LCB markets have been rarely compared with other financial markets, especially in the context of price discovery and causality across EM. Third, I reveal that the markets are more integrated (or efficient) during a common distressed period, which shows that price discovery process can be state dependent. Fourth, I also address the issue of synchronicity, and perform a multiple cointegration analysis linking all the four markets together simultaneously. This analysis sheds some light on the departures from pairwise cointegration studies performed in literature (Chan-Lau & Kim, 2004; Norden et al., 2009).

The remainder of this paper is as follows. The second section provides a brief literature review. Section 3 describes the data. Section 4 lays out the econometric methodology and elaborates on the empirical findings. The last section concludes the discussion.

2. Literature review

Majority of the literature on price discovery in CDS and bond markets have focused on the corporate sector. Blanco et al. (2005) and Zhu (2006) confirm that the two markets are cointegrated and CDS markets lead bond markets. They also argue that the discrepancies between the two markets can occur due to contract specifications such as the presence of a Cheapest-to-Deliver (CTD) option, measurement errors (Adler, 2010), repo costs, the changing credit and liquidity conditions, and moral hazards.[7]

[1] Adler and Song (2010) are not clear about whether their bond data is dollar denominated or not. I assume that JP Morgan provided the authors with USD denominated bond yields.

[2] Andritzky (2006) notes that sovereign local debt is about three times the external debt. As of December 2008, the size of LCB markets was around $6.2 Trillion, whereas the size of FCB was around $1.1 Trillion (Peiris, 2010).

[3] Ammer and Cai (2007).

[4] Due to lack of daily data and discontinuities, I did not include foreign currency bond (FCB) markets in my analysis.

[5] Blanco et al. (2005) and Longstaff, Mithal, and Neisl (2005) give very good introductions to CDS markets.

[6] G-20 Countries that are classified as emerging markets by MSCI Barra (June, 2009) except Russia, India, and South Africa. The quality and availability of data for these three countries was not sufficient to be included in the analysis.

[7] There is no point of buying a CDS if you believe that the (underlying) bond issuer will always be bailed out. In bailout scenarios, CDS buyers lose the value of their insurance (Cochrane, 2010).

Table 1
Holding period returns. This table reports the holding period returns over a common time frame of 4/2/2007 to 8/27/2009. The table compares the returns over a distressed period versus the entire period. Returns are calculated in USD terms, and using two data points, the first day and the last day of the time periods examined. Price of a 5-year local currency bond (LCB, zero-coupon) is calculated using the yields at two data points. Holding period returns for the LCBs are calculated using the initial and the final price, and they are adjusted for changes in FX rates.

Country	USD appreciation	Stock market	LCB yield (USD)
Holding period returns – distressed period (VIX > 40) (9/26/2008–4/7/2009, $T = 102$ days)			
Brazil	0.199	−0.283	−0.039
China	−0.001	0.065	0.072
Indonesia	0.207	−0.331	−0.069
Mexico	0.249	−0.354	−0.121
Turkey	0.302	−0.443	−0.038
US	n/a	−0.328	0.069
Holding period returns – entire period (4/2/2007–8/27/2009, $T = 472$ days)			
Brazil	−0.089	0.379	0.327
China	−0.117	0.023	0.191
Indonesia	0.115	0.143	0.046
Mexico	0.200	−0.188	−0.046
Turkey	0.080	0.005	0.496
US	n/a	−0.276	0.156

Based on a daily data of North American and European firms, Forte & Pena (2009) examine the interaction of stocks, bonds, and CDSs in their analysis. Different from earlier studies, the authors use a structural credit model to extract implied credit spreads from stock market information. They find that the stock market implied spreads lead both bond and CDS markets, and additionally CDS markets lead bond markets. They also show that the results of price discovery estimations are time-variant. A similar study in the sovereign context would be great if only daily data on sovereign balance sheets could be available.

Another corporate study by Giannikos et al. (2013) covers the 2005–2008 period for 10 US firms. They find that stock prices played a dominant role before the crisis whereas CDS markets gained more importance in price discovery mechanism during the crisis. They also add that CDS market led bond market in general.

Similarly, Norden et al. (2009) analyze the relationship between stock, bond, and CDS markets with varying frequencies such as monthly, weekly, and daily data. Their analysis covers 58 firms for the 2000–2002 period. The authors' major finding is that stock markets lead the other two, and CDS markets lead bond markets.

Different from earlier studies, Narayan et al. (2014) propose a panel cointegration framework where they analyze the interaction of stock and CDS prices while controlling for size, sector, and rating specific (investment grade vs. junk) characteristics for US stocks over the 2004–2012 period. They find that the stock market dominates the CDS market in price discovery, and that the crisis of 2008 strengthened this domination. The authors also noted that the information contained in price discovery coefficients would vary from sector to sector as well as across different sizes of companies and rating categories.

Table 2
Descriptive statistics. This table provides basic descriptive information and the number of observations for each country over the period 4/2/2007 to 8/27/2009. National holidays are removed across all countries and the data points have a one-to-one match. 5 Year CDS premiums (USD denominated) were acquired from Bloomberg as of January 15, 2010. 5 Year government (generic) bond yield (local currency) information were acquired from Bloomberg as of January 15, 2010. The benchmark rate used to calculate the bond spreads is the 5 year US Government generic bond yield (USGG5YR_Index), which is also acquired from Bloomberg. For Turkey, the common generic yield information was not available. Instead, generic Turkish $T + 0$ simple yield government bonds (Ticker: TGBY5YT0 Index, Quoted: Mid Yield, Currency: Lira) are used to compute LCB spreads. For China, 5 year bond yields are used instead of 5 year bond spreads. This was due to negative bond spreads observed in some subperiods. Information on stock market indices is acquired from Bloomberg (in USD). The indices used in the analysis are Brazil Bovespa Index (IBOV), China Shangai Stock Exchange Composite Index (SHCOMP), Mexico Bolsa Index (MEXBOL), Indonesia Jakarta Composite Index (JCI), and Turkey Istanbul Stock Exchange (ISE100). Concerning the exchange rates, the valuation is in terms of the number of U.S. dollars per local currency unit.

Country	N	CDS premiums (USD)				Bond spreads (local currency)				Stock market (USD)				Exchange rate (USD)			
		Mean	StDev	Min	Max	Mean	StDev	Min	Max	Mean	StDev	Min	Max	Mean	StDev	Min	Max
Brazil	472	0.018	0.011	0.006	0.059	0.098	0.023	0.052	0.160	28,245.729	7837.784	12,712.539	44,000.763	0.523	0.062	0.399	0.641
China	472	0.008	0.007	0.001	0.028	0.033	0.007	0.018	0.043	474.242	142.780	249.664	803.113	0.141	0.006	0.129	0.147
Indonesia	472	0.032	0.021	0.009	0.125	0.076	0.028	0.034	0.173	0.214	0.059	0.091	0.304	0.000	0.000	0.000	0.000
Mexico	472	0.017	0.013	0.003	0.060	0.047	0.012	0.025	0.074	2325.076	588.302	1103.134	3077.715	0.086	0.010	0.065	0.101
Turkey	472	0.028	0.012	0.014	0.082	0.137	0.027	0.088	0.220	30,034.183	9939.649	12,731.072	48,838.769	0.735	0.088	0.559	0.869

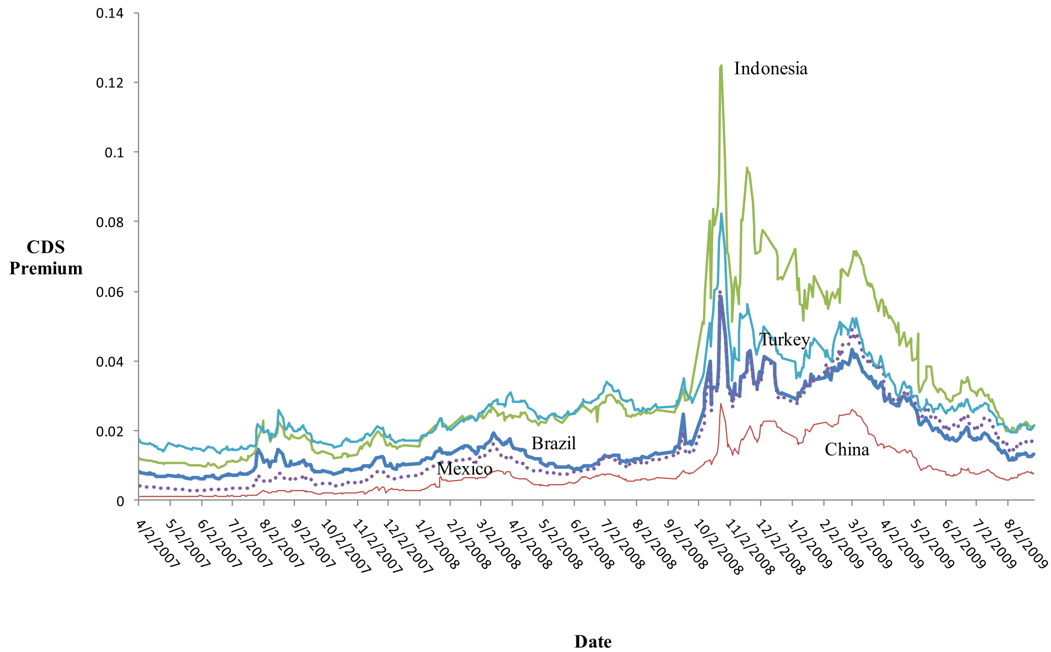

Fig. 1. CDS Markets. This figure illustrates 5 year sovereign CDS spreads (quarterly, USD denominated) for the major emerging markets over the period 4/2/2007 to 8/2/2009. These premiums are for senior claims and they assume a recovery rate of 25%. Source: Bloomberg.

Different from Narayan et al. (2014) who use 2/27/2007 to 12/30/2009 as the crisis period in their analysis (reported by St. Louis FED), I use a shorter period from 9/26/2008 to 4/7/2009 focusing on Volatility Index (VIX) values exceeding the value of 40 (Fig. 5). I believe that VIX is a better gage to measure the markets' pulse (Shaikh & Padhi, 2014).

Hull, Predescu, and White (2004) assess the impact of credit rating announcements on CDS and bond spreads, and vice versa. They find that reviews for downgrades contain significant information, but downgrades themselves do not. They also find that rating actions are predicted by CDS markets. Norden and Weber (2004) also perform a similar exercise by including stock markets in their analysis. They find that CDS and stock markets predict all types of rating actions. Similarly, Ismailescu and Kazemi (2010) argue that positive rating actions have spillover effects on other emerging markets, and negative rating actions are mostly anticipated by CDS markets.

In addition, Zhang, Yau, and Fung (2010) look at the lead-lag relation between CDS and currency markets. This study brings currency markets into the picture, but it ignores stock and bond markets. The authors find some evidence on the predictive power of the US corporate CDS markets on major exchange rate parities such as AUD/USD, EUR/USD, and JPY/USD. Francis, Hasan, and Hunter (2006) look at the linkages between currency and stock markets. They find that there are strong spillover effects from the currency market volatility to the stock market volatility. However, the price discovery analysis does not yield a dominant role for equity or currency markets.

The literature on price discovery among major EMs employs time-series methodologies similar to the corporate studies mentioned above, but the findings are mostly mixed or hardly consistent. Chan-Lau & Kim (2004) find some mixed results in their analysis on equity prices (MSCI), CDS premiums, and EMBI+ bond spreads for eight EMs over the 2001—2003 period.

Ammer and Cai (2007) show that bond and CDS spreads are cointegrated across a higher number of emerging markets (7 out of 9) over the 2001—2005 period. They show that the CDS markets lead in 4 out of 7 countries, and the bond spreads lead among the remaining 3 countries. Compared to Chan-Lau and Kim (2004), their results exhibit a higher level of market integration, and a more dominant role of the CDS markets. Similarly, Tse and Martinez (2007) examine the informational content of the international Exchange Traded Fund (ETF) indices and corresponding net asset values (NAV). They find a strong relationship between the ETF indices and NAVs.

Concerning the determinants of credit spreads, Longstaff, Pan, Pedersen, and Singleton (2011) convey that US equity and bond markets, and global risk premia explain more than 50% of the variation in sovereign credit spreads. The authors arrive at these conclusions by employing a principal component analysis methodology. Blanco et al. (2005) find that macroeconomic variables such as interest rates, term structure, and US equity market returns have a larger impact on bond spreads compared to CDS spreads.

Ngene et al. (2014) analyze the non-linear nature of the interaction of sovereign CDS and stock markets. This study also mentions the Merton (1974) model as a starting point to make a connection between equity and CDS prices, and non-linearities in the short-run and long-run relationships. They also argue that the speeds of adjustments will be different under different regimes. The authors find strong evidence toward non-linearities in CDS and equity returns. They also find that CDS markets lead equity markets in the "lower regime" when the basis is decreasing and risks are higher.

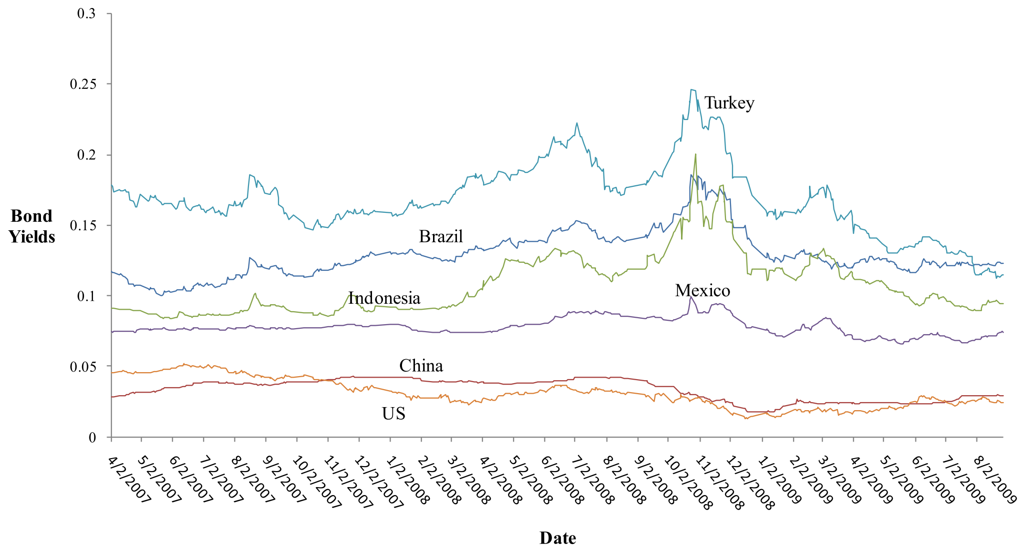

Fig. 2. Bond Markets. This figure illustrates generic 5 year government bond yields (local currency) for the major emerging markets and the US over the period 4/2/2007 to 8/2/2009. Source: Bloomberg.

The findings in this paper are usually in contrast with the previous studies which show that stock and the CDS markets generally lead bond markets (Blanco et al., 2005; Forte & Pena, 2009; Norden & Weber, 2009; Zhu, 2006). The analysis also covers a more recent period and have different results compared to the literature on EMs. I demonstrate that price discovery and causality results might change across different time periods, a similar finding to Forte & Pena (2009) and Ngene et al. (2014). Finally, I also address the synchronicity issue, and analyze 4 markets simultaneously via VECM and VAR methodologies.

3. Data description

A brief report on the performance of emerging financial markets during the period examined can be found in Table 1. During the highly volatile period (9/26/2008 to 4/7/2009), the flight to safe currencies (Kohler, 2010; McCauley and McGuire, 2009) is accompanied with a sharp drop in the local stock markets. However, over the entire period (4/2/2007 to 8/27/2009), the depreciations look less worrisome, and the stock and the bond markets achieve notable recoveries, except Mexico and the US market.

Descriptive statistics of the complete dataset (daily observations) can be found in Table 2, and Figs. 1–4 provide time-series graphs for each variable.

3.1. Bond markets

5 Year government (generic) bond yield information is acquired from Bloomberg as of January 15, 2010. The generic yield is calculated if there are at least 5 data contributors and by truncating the extreme values, and finally averaging the remaining quotes.[8] All of the yield information is in local currency denomination. However, there are exceptions for the bond data of Turkey and China (see Table 2). The benchmark rate used to calculate the bond spreads is the 5 year US Government generic bond yield (USD). Further information about the bond spreads is in Table 1.

3.2. CDS markets

5 Year CDS premiums (quarterly, USD denominated) are acquired from Bloomberg as of January 15, 2010.[9] These premiums are for senior claims and they assume a recovery rate of 25%.[10]

3.3. Stock markets

Stock Market information is acquired from Bloomberg (in USD). The indices used in the analysis are Brazil Bovespa Index (IBOV), China Shangai Stock Exchange Composite Index (SHCOMP), Indonesia Jakarta Composite Index (JCI), Mexico Bolsa Index (MEXBOL), and Turkey Istanbul Stock Exchange (ISE100).

3.4. FX markets

The valuation is in terms of the number of U.S. dollars per local currency unit and the data is acquired from Bloomberg.[11]

To measure the currency markets' reaction to highly uncertain and distressed periods, daily values of the VIX index (new methodology) are acquired from Chicago Board Options

[8] www.fimmda.org.

[9] Doc Clause: CR Cum (With) Restructuring, or Old Restructuring.

[10] Specific Bloomberg tickers are as follows: 1 - BRAZIL CDS USD SR 5Y Corp, 2 - CHINA GOVERNMENT CDS, 3 - INDON CDS USD SR 5Y Corp, 4 - MEX CDS USD SR 5Y Corp, 5 - TURKEY CDS USD SR 5Y Corp.

[11] Specific Bloomberg tickers are as follows. 1 - Real: BRLUSD Curncy, 2 - Yuan: CNYUSD Curncy, 3 - Rupiah: IDRUSD Curncy, 4 - Peso: MXNUSD Curncy, 5 - Lira: TRYUSD Curncy.

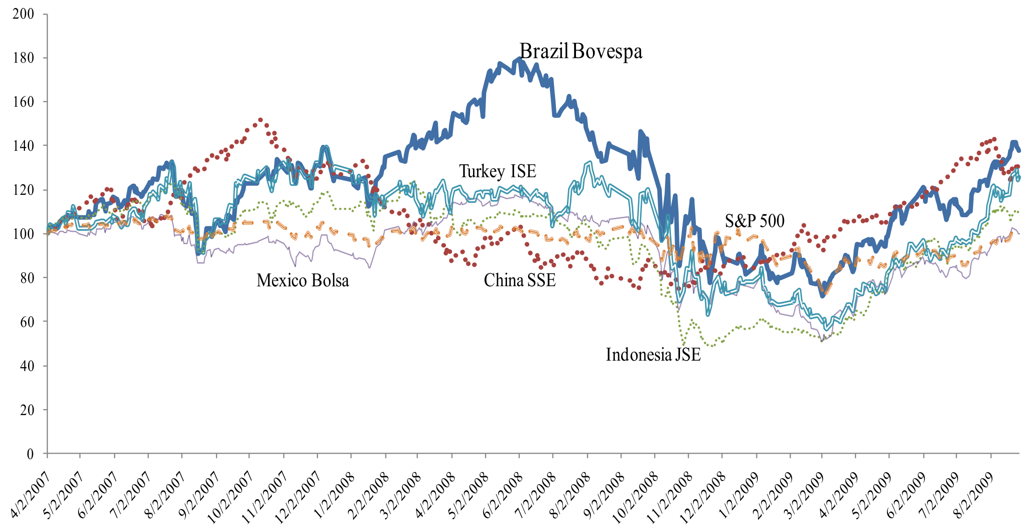

Fig. 3. Stock Markets. This figure illustrates returns on national stock market indices (in USD) for the major emerging markets over the period 4/2/2007 to 8/2/2009. The indices used in the analysis are Brazil Bovespa Index (IBOV), China Shangai Stock Exchange Composite Index (SHCOMP), Indonesia Jakarta Composite Index (JCI), Turkey Istanbul Stock Exchange (ISE100), Mexico Bolsa Index (MEXBOL), and United States S&P 500. Source: Bloomberg.

Exchange (CBOE).[12] A common time frame of 4/2/2007 to 8/27/2009 provides a comparably large number of observations across a number of countries, and it also includes the peaks of market fear (Fig. 5).

4. Time-series analysis

This section constitutes the majority of the findings. In Table 2, the average LCB spread (7.8%) exceed the average CDS spread (2%) substantially (also for each of the countries in the sample).[13] Although comparing a foreign currency denominated bond or JPMorgan's EMBIG (US Dollar denominated government bonds) spreads with CDS spreads would be a better “apples to apples” comparison, majority of the literature cannot find a parity relationship between these two markets either and there are data limitations concerning EMBIG. Due to potential scaling issues, I use the log transformation for all the variables used in the analysis (Forte & Pena, 2009).

The empirical analysis borrows from the literature on the relationship between CDS, bond, and stock markets. In general, a straightforward three-step procedure is used (Blanco et al., 2005; Enders, 2004; Forte & Pena, 2009). The first step checks the stationarity via Augmented Dickey-Fuller (ADF) tests. If the variables in question are non-stationary then the second step performs Johansen Cointegration tests to examine whether there is a long-run equilibrium relationship between the two markets. If the markets are cointegrated, then a Vector Error Correction Model (VECM) is appropriate to check for the price discovery mechanism as the third and final step. The equations below show a sample pair for the analysis between CDS and bond spreads. The same equations can be extended to the other pairs of markets.

Cointegrating Equation:

$$Z_t = CDS_t + \beta_i Bond_t + \gamma_i = I(0) \tag{1}$$

Vector Error Correction Model (VECM):

$$\begin{bmatrix} \Delta CDS_t \\ \Delta Bond_t \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \end{bmatrix} (z_{t-1}) + \begin{bmatrix} \sum_{j=1}^{p} r_{1,j} \Delta CDS_{t-j} \\ \sum_{j=1}^{p} r_{2,j} \Delta CDS_{t-j} \end{bmatrix} + \begin{bmatrix} \sum_{j=1}^{p} k_{1,j} \Delta Bond_{t-j} \\ \sum_{j=1}^{p} k_{2,j} \Delta Bond_{t-j} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \tag{2}$$

$$GG = \frac{\lambda_2}{\lambda_2 - \lambda_1} \tag{3}$$

$$Hasbrouck\ 1 = \frac{\lambda_2^2 \left(\sigma_1^2 - \frac{\sigma_{12}^2}{\sigma_2^2} \right)}{\lambda_2^2 \sigma_1^2 - 2\lambda_1 \lambda_2 \sigma_{12} + \lambda_1^2 \sigma_2^2} \tag{4}$$

$$Hasbrouck\ 2 = \frac{\left(\lambda_2 \sigma_1 - \lambda_1 \frac{\sigma_{12}}{\sigma_1} \right)^2}{\lambda_2^2 \sigma_1^2 - 2\lambda_1 \lambda_2 \sigma_{12} + \lambda_1^2 \sigma_2^2} \tag{5}$$

If the variables in question are not cointegrated, VECM is not a valid approach; instead one can perform Vector Autoregessive (VAR) model and Granger Causality tests using the first differences. This econometric analysis is very similar to the analysis done by Forte & Pena (2009), in which the authors look at the pairwise cointegration relations, and succeeding

[12] http://www.cboe.com/micro/vix/historical.aspx.

[13] The results do not change even if one uses 5 year US Swap Rates as the risk-free benchmark.

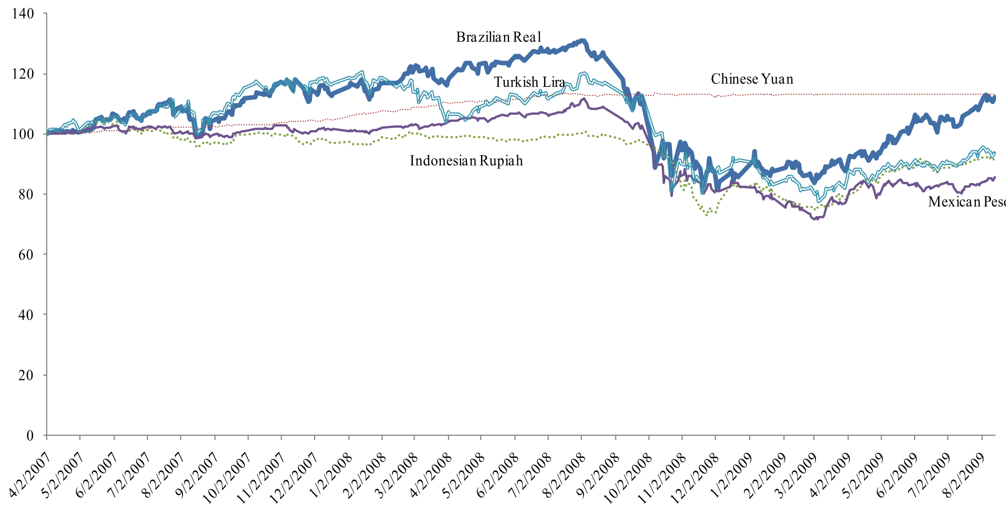

Fig. 4. Foreign Exchange Markets. This figure illustrates performance of local currencies (against USD) for the major emerging markets over the period 4/2/2007 to 8/2/2009. Source: Bloomberg.

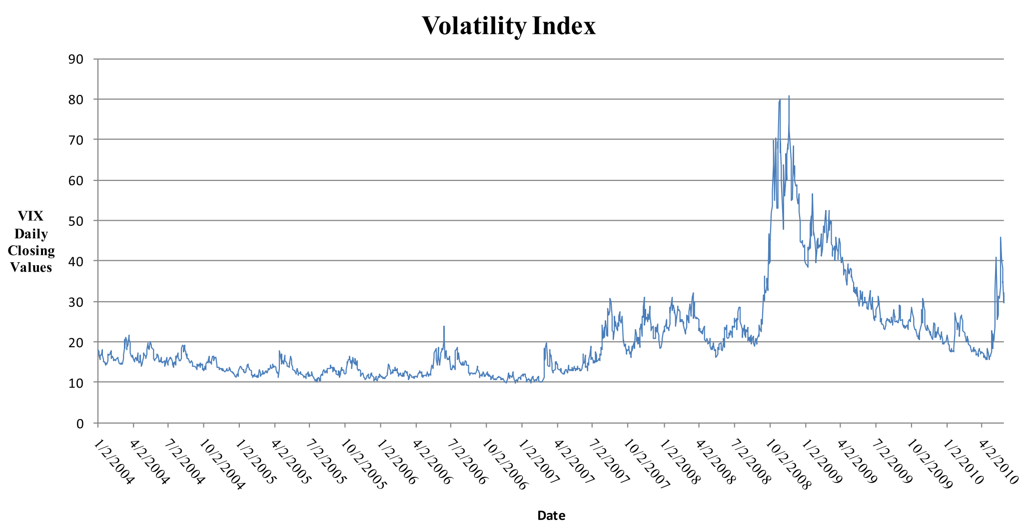

Fig. 5. Volatility Index (VIX). This figure illustrates daily values of VIX (new methodology) over the period 1/2/2004 to 5/28/2010. Source: CBOE.

VECM analysis with multiple markets and cointegrating vectors.[14]

VAR analysis performs simultaneous lead-lag regressions of the changes of log of the four series used in the study. The Chi-Squared statistics (Wald Test) are reported for each pair and VAR specification, and the null and the alternative hypotheses are as follows.

$$\Delta CDS_t = a_1 + \sum_{j=1}^{J} b_{1,j}\Delta CDS_{t-j} + \sum_{j=1}^{J} c_{1,j}\Delta Bond_{t-j} + \sum_{j=1}^{J} d_{1,j}\Delta Stock_{t-j} + \sum_{j=1}^{J} f_{1,j}\Delta FX_{t-j} + u_{1t} \quad (6)$$

H1o: Change in bond spread does not Granger-cause CDS spread

H1a: Change in bond spread Granger causes CDS Spread

H2o: Change in stock index does not Granger-cause CDS spread

H2a: Change in stock index Granger causes CDS Spread

H3o: Change in FX parity does not Granger-cause CDS spread

H3a: Change in FX parity Granger causes CDS Spread

Table 3 provides a quick snapshot of all the findings. These findings reveal that during a highly distressed time interval, LCB markets are the dominant markets across all emerging markets (except Indonesia) and FX markets also play an important role in the price discovery process. This evidence departs from the previous studies pointing towards the leading role of the stock and CDS markets. In addition, with a very few exceptions, CDS markets are found to follow the other markets.

[14] The authors also use a general approach considering the three series (stock implied spread, bond spread, CDS spread) simultaneously, and use different model specifications.

Table 3
Summary of findings. This table summarizes the findings associated with the price discovery analysis over a common time period. The distressed period is defined as the period when Volatility Index (VIX) exceeds the value of 40 (Fig. 5). Log of the variables are used in the analysis. The first step of a cointegration analysis is to check whether each variable is non-stationary. Augmented Dickey Fuller and Phillips–Perron tests are used to confirm that all of the variables are non-stationary. For the sake of brevity these results are not reported, but they are available upon request. The next step is the VECM if the variables are cointegrated. Otherwise Granger causality (Wald) tests are performed via VAR framework. The details of these tests are in Table 4. The final column reports the results concerning simultaneous multiple market cointegration analysis (MVECM). Details on these findings are reported in Table 5.

Country	Period	N	Cointegration (logs)					VECM	Granger causality	MVECM
				CDS	Bond	Stock	FX			
Brazil	4/2/2007–8/27/2009 (full period)	472	CDS	–					Bond causes FX	
			Bond	no	–				Feedback betw. Stock and Bond	
			Stock	no	no	–			Feedback betw. Stock and CDS	
			FX	no	no	yes	–		Feedback betw. CDS and FX	
	9/26/2008–4/7/2009 (distressed period)	102	CDS	–				Bond leads CDS and FX		Stock leads CDS
			Bond	yes	–			FX leads CDS and Stock		Bond leads Stock
			Stock	yes	yes	–		Stock leads CDS		
			FX	yes	yes	yes	–			
China	4/2/2007–8/27/2009 (full period)	472	CDS	–				Stock leads Bond		CDS, Stock, FX jointly lead Bond
			Bond	yes	–			Bond leads FX		CDS, Bond, FX jointly lead Stock
			Stock	no	yes	–		FX leads Stock		
			FX	no	yes	yes	–			
	9/26/2008–4/7/2009 (distressed period)	102	CDS	–				Bond leads CDS and FX		Bond, FX, Stock jointly lead CDS
			Bond	yes	–			Stock leads FX		Bond, CDS, Stock jointly lead FX
			Stock	no	no	–		FX leads CDS		
			FX	yes	yes	yes	–			
Indonesia	4/2/2007–8/27/2009 (full period)	472	CDS	–					Stock causes Bond and FX	CDS & Bond jointly lead FX
			Bond	no	–				CDS causes Bond	CDS, Bond, FX jointly lead Stock
			Stock	yes	no	–				
			FX	yes	no	no	–			
	9/26/2008–4/7/2009 (distressed period)	102	CDS	–				Bond leads CDS		Stock leads CDS
			Bond	yes	–			FX leads CDS and Stock		Stock leads FX
			Stock	yes	yes	–		Stock leads CDS		
			FX	yes	no	yes	–			
Mexico	4/2/2007–8/27/2009 (full period)	472	CDS	–					Stock causes CDS	
			Bond	no	–				Feedback betw. FX and CDS	
			Stock	no	no	–			Feedback betw. FX and Stock	
			FX	no	no	no	–			
	9/26/2008–4/7/2009 (distressed period)	102	CDS	–				Bond leads CDS, FX, and Stock		Stock, FX, Bond jointly lead CDS
			Bond	yes	–			FX leads CDS and Stock		
			Stock	yes	yes	–		Stock leads CDS		
			FX	yes	yes	yes	–			
Turkey	4/2/2007–8/27/2009 (full period)	472	CDS	–				FX leads CDS	FX causes Bond and Stock	FX leads CDS, Stock, and Bond
			Bond	no	–					(short-run causality)
			Stock	no	no	–				Stock leads FX
			FX	yes	no	no	–			(long-run causality)
	9/26/2008–4/7/2009 (distressed period)	102	CDS	–				Bond leads Stock and FX		Bond & Stock jointly lead FX
			Bond	no	–			FX leads CDS and Stock		(long-run causality)
			Stock	yes	yes	–		Stock leads CDS		
			FX	yes	yes	yes	–			

Table 4A
Time series analysis and detailed findings. Panel A – Brazil. This table shows Trace statistics for Johansen cointegration tests, adjustment parameters and their significance levels in VECM analysis, and Wald Statistics related to Granger causality tests. Bold numbers in the first section represent the rejection (at 95% confidence level) of the null hypothesis of zero (or one) cointegrating vectors in Johansen cointegration tests. In the second section, bold numbers represent the significance of adjustment parameters at 95% confidence level. Bold numbers in the third section represent the rejection of the null hypothesis that the second market does not Granger cause the first market. Therefore if the *p*-values are less than 5%, one can conclude that the second market Granger causes the first one.

Period	*N*		Number of cointegrating vectors: None	Number of cointegrating vectors: At most 1		Number of cointegrating vectors: None	Number of cointegrating vectors: At most 1
Cointegration analysis							
4/2/2007–8/27/2009 (full period)	472	CDS vs. Bond	5.080	1.552	Bond vs. Stock	10.902	3.697
		CDS vs. Stock	8.722	2.193	Bond vs. FX	10.170	3.071
		CDS vs. FX	7.805	2.334	Stock vs. FX	**22.354**	**5.268**
9/26/2008–4/7/2009 (distressed period)	102	CDS vs. Bond	**23.591**	0.543	Bond vs. Stock	**28.909**	0.798
		CDS vs. Stock	**39.270**	**12.957**	Bond vs. FX	**29.007**	0.723
		CDS vs. FX	**44.893**	**13.706**	Stock vs. FX	**37.550**	**7.216**

	Cointegrated markets	λ_1	*p*-value	λ_2	*p*-value	GG
4/2/2007–8/27/2009 (Full period)	Stock & FX	**0.049**	0.043	**0.038**	0.000	N/A
		(FX leads stock based on magnitude of adjustment parameters)				
VECM						
9/26/2008–4/7/2009 (distressed period)	CDS & Bond	**−0.245**	0.000	−0.023	0.167	N/A
		(Bond leads CDS based on significance of adjustment paramaters)				
	CDS & Stock	**−0.142**	0.000	**0.113**	0.000	0.443
		(Stock leads CDS based on GG measure)				
	CDS & FX	**−0.144**	0.000	**0.057**	0.000	0.282
		(FX leads CDS based on GG measure)				
	Bond & Stock	**0.022**	0.000	**−0.086**	0.002	N/A
	Bond & FX	**−0.014**	0.000	**0.020**	0.000	0.591
		(Bond leads FX based on GG measure)				
	Stock & FX	**−0.162**	0.000	**−0.081**	0.000	N/A
		(FX leads Stock based on magnitude of adjustment parameters)				

4/2/2007–8/27/2009 (full period)	CDS: chi2-statistic	CDS: *p*-value	Bond: chi2-statistic	Bond: *p*-value	Stock: chi2-statistic	Stock: *p*-value	FX: chi2-statistic	FX: *p*-value
VAR – Granger causality (Wald Tests)								
CDS caused by	–	–	4.481	0.106	**16.691**	0.000	**24.776**	0.000
Bond caused by	3.745	0.154	–	–	**7.970**	0.019	4.893	0.087
Stock caused by	**6.143**	0.046	**6.405**	0.041	–	–	N/A	
FX caused by	**6.285**	0.043	**7.448**	0.024	N/A		–	–

Table 4 provides a detailed explanation of the time series analysis performed on the natural log of daily sovereign CDS spreads, FX parities against USD, LCB spreads, and national stock market indices. Initially, the Augmented Dickey-Fuller (ADF) unit root – stationarity tests are performed under the null hypothesis that the time series data is non-stationary (i.e. I(1)). In the second step, Johansen Cointegration Tests (no restrictions on the coefficients) are performed under the null hypothesis that the two series are not cointegrated (Vecrank procedure, Stata). Ideally, in the first step the null of a zero cointegrating vectors ($r = 0$) should be rejected, and in the second step the null of one cointegration ($r = 1$) should not be rejected. The trace statistics are reported in the first sections of panels (Schwarz's Bayesian Information Criterion – SBIC lag length selection). Bold numbers show the "rejection" of the null hypothesis (at 95%) that there are at least 0 (or 1) cointegrating vectors in the system. In the third step, the Vector Error Correction Model (VECM) is used. In the VECM, λ_1 and λ_2 are the corresponding adjustment speeds (Enders, 2004) and they tell us which market adjusts fasters (i.e. follows the other market). In calculating the Gonzalo-Granger (GG) measure and the Hasbrouck lower and upper bounds the methodology from Blanco et al. (2005) is adopted; σ_1 and σ_2 stand for the standard deviations of e_{1t} and e_{2t}, and σ_{12} stands for the covariance between e_{1t} and e_{2t}. The results on GG are reported in Section 2. In the third and last section of the panels, I report the Granger causality (Wald Tests) results for the series that are not cointegrated. Bold numbers represent significance at the 5% level, i.e. rejecting the null hypothesis that the second market does not cause the first one.

Panels A through E of Table 4 elaborate on the details of the time-series analysis for each country and for two time periods (full vs. distressed). The first section of the panels performs pairwise cointegration tests and reports the trace statistics. For the cases in which the null hypothesis (zero cointegrating rank) is rejected, the markets are said to be cointegrated. The second section reports the VECM results for the cointegrated markets. The adjustment parameters λ_1 and λ_2, and their significance levels (*p*-values) are reported in this section.

Table 4B
Panel B – China. This table shows Trace statistics for Johansen cointegration tests, adjustment parameters and their significance levels in VECM analysis, and Wald Statistics related to Granger causality tests. Bold numbers in the first section represent the rejection (at 95% confidence level) of the null hypothesis of zero (or one) cointegrating vectors in Johansen cointegration tests. In the second section, bold numbers represent the significance of adjustment parameters at 95% confidence level. Bold numbers in the third section represent the rejection of the null hypothesis that the second market does not Granger cause the first market. Therefore if the *p*-values are less than 5%, one can conclude that the second market Granger causes the first one.

Period	*N*		Number of cointegrating vectors			Number of cointegrating vectors	
			None	At most 1		None	At most 1
Cointegration analysis							
4/2/2007–8/27/2009 (full period)	472	CDS vs. Bond	**22.353**	3.076	Bond vs. Stock	**27.277**	**3.990**
		CDS vs. Stock	11.017	1.504	Bond vs. FX	**21.118**	**9.540**
		CDS vs. FX	11.448	4.584	Stock vs. FX	**21.783**	**7.718**
9/26/2008–4/7/2009 (distressed period)	102	CDS vs. Bond	**17.584**	**3.923**	Bond vs. Stock	9.927	1.293
		CDS vs. Stock	13.238	0.603	Bond vs. FX	**34.675**	**6.096**
		CDS vs. FX	**40.740**	**11.458**	Stock vs. FX	**27.857**	0.941

	Cointegrated markets	λ_1	*p*-value	λ_2	*p*-value	GG
VECM						
4/2/2007–8/27/2009 (full period)	CDS & Bond	−0.004	0.440	**−0.004**	0.000	N/A
	Bond & Stock	**−0.017**	0.000	−0.008	0.218	N/A
		(Stock leads Bond based on significance of adjustment parameters)				
	Bond & FX	0.001	0.071	**0.000**	0.004	N/A
		(Bond leads FX based on significance of adjustment parameters)				
	Stock & FX	**−0.014**	0.014	**0.001**	0.005	0.054
		(FX leads Stock based on GG measure)				
9/26/2008–4/7/2009 (distressed period)	CDS & Bond	**−0.073**	0.001	0.013	0.107	0.151
		(Bond leads CDS based on significance of adjustment parameters)				
	CDS & FX	**−0.016**	0.196	**−0.001**	0.000	N/A
		(FX leads CDS based on significance of adjustment parameters)				
	Bond & FX	−0.006	0.151	**0.001**	0.000	N/A
		(Bond leads FX based on significance of adjustment parameters)				
	Stock & FX	−0.001	0.852	**0.001**	0.000	0.635
		(Stock leads FX based on significance of adjustment parameters)				

	CDS		Bond		Stock		FX	
	chi2-statistic	*p*-value	chi2-statistic	*p*-value	chi2-statistic	*p*-value	chi2-statistic	*p*-value
VAR – Granger causality (Wald Tests)								
4/2/2007–8/27/2009 (full period)								
CDS caused by	–	–	N/A		0.965	0.617	1.925	0.382
Bond caused by	N/A		–	–	N/A		N/A	
Stock caused by	1.879	0.391	N/A		–	–	N/A	
FX caused by	0.441	0.802	N/A		N/A		–	–
9/26/2008–4/7/2009 (distressed period)								
CDS caused by	–	–	N/A		**7.197**	0.027	N/A	
Bond caused by	N/A		–	–	1.489	0.475	N/A	
Stock caused by	0.040	0.941	4.473	0.107	–	–	N/A	
FX caused by	N/A		N/A		N/A		–	–

To interpret the VECM results, I also report the Gonzalo-Granger (GG) measures (Blanco et al., 2005) if the adjustment parameters have the right sign (λ_1 negative, λ_2 positive) and they are significant. A GG measure that is more than 0.5 implies a leading role for the first market in the VECM specification, and a value less than 0.5 implies a leading role for the second one. The Hasbrouck measure[15] provides lower and upper bounds for the contribution of the first market to the price discovery process. However, the lower and upper bounds found in our analysis fluctuate across a wide range, therefore it is not easy to interpret the results using this measure.

There are also a few other cases which can be used for price discovery analysis even though one of the adjustment parameters are not significant or they do not have the desired signs. For example, a significant λ_1 with a negative sign, and an insignificant λ_2 would still mean that the second market leads the first market. Similarly a significant λ_2 with a positive sign, and an insignificant λ_1 would show the lead of the first market. I call these outcomes “lead by significance” in Table 4. Moreover, as Enders (2004, pp. 366) and Aktug (2012) suggest, the error correction can also occur even though the adjustment parameters do not have the desired signs. For instance, a significant λ_1 with a negative sign, and a significant λ_2 with also a negative sign would also cause the error to be

[15] Hasbrouck measures are also calculated, and they are available upon request.

Table 4C
Panel C – Indonesia. This table shows Trace statistics for Johansen cointegration tests, adjustment parameters and their significance levels in VECM analysis, and Wald Statistics related to Granger causality tests. Bold numbers in the first section represent the rejection (at 95% confidence level) of the null hypothesis of zero (or one) cointegrating vectors in Johansen cointegration tests. In the second section, bold numbers represent the significance of adjustment parameters at 95% confidence level. Bold numbers in the third section represent the rejection of the null hypothesis that the second market does not Granger cause the first market. Therefore if the *p*-values are less than 5%, one can conclude that the second market Granger causes the first one.

Period	*N*		Number of cointegrating vectors			Number of cointegrating vectors	
			None	At most 1		None	At most 1
Cointegration analysis							
4/2/2007–8/27/2009	472	CDS vs. Bond	8.502	1.801	Bond vs. Stock	12.525	5.195
(Full Period)		CDS vs. Stock	**18.123**	2.642	Bond vs. FX	9.141	3.193
		CDS vs. FX	16.826	**2.879**	Stock vs. FX	12.114	1.609
9/26/2008–4/7/2009 (distressed period)	102	CDS vs. Bond	**20.869**	1.745	Bond vs. Stock	**20.090**	**4.712**
		CDS vs. Stock	**33.850**	**14.897**	Bond vs. FX	13.625	4.532
		CDS vs. FX	**25.908**	**7.018**	Stock vs. FX	**24.360**	**8.471**

	Cointegrated markets	λ_1	*p*-value	λ_2	*p*-value	GG
VECM						
4/2/2007–8/27/2009 (full period)	CDS & Stock	−0.003	0.781	**−0.013**	0.000	N/A
		(CDS leads Stock based on significance of adjustment parameters)				
	CDS & FX	0.003	0.760	**−0.005**	0.000	N/A
		(CDS leads FX based on significance of adjustment parameters)				
9/26/2008–4/7/2009 (distressed period)	CDS & Bond	**−0.282**	0.000	−0.004	0.908	N/A
		(Bond leads CDS based on significance of adjustment parameters)				
	CDS & Stock	**−0.091**	0.000	**0.025**	0.006	0.215
		(Stock leads CDS based on GG measure)				
	CDS & FX	**−0.187**	0.000	0.006	0.362	0.034
		(FX leads CDS based on significance)				
	Bond & Stock	**0.023**	0.036	**−0.034**	0.000	N/A
		(Bond leads Stock based on magnitude of adjustment parameters)				
	Stock & FX	**−0.151**	0.001	−0.019	0.281	−0.154
		(FX leads Stock based on significance of adjustment parameters)				

	CDS		Bond		Stock		FX	
	chi2-statistic	*p*-value	chi2-statistic	*p*-value	chi2-statistic	*p*-value	chi2-statistic	*p*-value
VAR – Granger causality (Wald Tests)								
4/2/2007–8/27/2009 (full period)								
CDS caused by	–	–	0.567	0.753	N/A		N/A	
Bond caused by	**30.779**	0.000	–	–	**6.334**	0.042	1.147	0.564
Stock caused by	N/A		1.730	0.421	–	–	0.657	0.720
FX caused by	N/A		0.195	0.907	**7.578**	0.023	–	–
9/26/2008–4/7/2009 (distressed period)								
CDS caused by	–	–	N/A		N/A		N/A	
Bond caused by	N/A		–	–	N/A		1.759	0.415
Stock caused by	N/A		N/A		–	–	N/A	
FX caused by	N/A		0.115	0.944	N/A		–	–

corrected if the magnitude of λ_1 is greater than λ_2. In this case, one can say that the second market leads the first market. Similar claims can be made when both adjustment parameters are significant and positive, and the second parameter is larger in magnitude. I call these outcomes "lead by magnitude" in Table 4.

The third sections in Panels A through E in Table 4 examines the Granger Causality relations among the markets that are not cointegrated via Vector Auto Regressive (VAR) model and Wald Tests. In this analysis, the first differences of the log of the variables are used. The null hypothesis is that the second market does not Granger cause the first market. Therefore rejection of the null hypothesis means that the second market Granger causes the first market.

The time-series analysis would not be complete if it did not consider the synchronous nature of markets when multiple markets are cointegrated with multiple cointegrating vectors (MVECM). A similar analysis is done by Forte & Pena (2009) with 3 series simultaneously: Implied Credit Spreads, Bond and CDS spreads. The interpretation of adjustment parameters is tricky and it gets even trickier when a fourth market comes into play. However, the adjustment parameters and the normalized cointegrating equations can give some clues. MVECM methodology and the details of this analysis are as follows.

Cointegrating Equations:

$$(\boldsymbol{CE}1): Z_{1t} = CDS_{1t} + \beta_{1i} Bond_{1t} + \beta_{1j} FX_{1t} + \beta_{1k} Stock_{1t} + \gamma_{1i} = I(0) \quad (7)$$

Table 4D
Panel D – Mexico. This table shows Trace statistics for Johansen cointegration tests, adjustment parameters and their significance levels in VECM analysis, and Wald Statistics related Granger causality tests. Bold numbers in the first section represent the rejection (at 95% confidence level) of the null hypothesis of zero (or one) cointegrating vectors in Johansen cointegration tests. In the second section, bold numbers represent the significance of adjustment parameters at 95% confidence level. Bold numbers in the third section represent the rejection of the null hypothesis that the second market does not Granger cause the first market. Therefore if the *p*-values are less than 5%, one can conclude that the second market Granger causes the first one.

Period	*N*		Number of cointegrating vectors			Number of cointegrating Vectors	
			None	At most 1		None	At most 1
Cointegration analysis							
4/2/2007–8/27/2009 (full period)	472	CDS vs. Bond	8.781	3.285	Bond vs. Stock	8.400	3.439
		CDS vs. Stock	6.635	1.581	Bond vs. FX	6.427	1.658
		CDS vs. FX	6.950	2.335	Stock vs. FX	8.581	2.655
9/26/2008–4/7/2009 (distressed period)	102	CDS vs. Bond	**25.149**	0.670	Bond vs. Stock	**25.149**	0.670
		CDS vs. Stock	**41.848**	**9.776**	Bond vs. FX	**20.173**	0.663
		CDS vs. FX	**39.845**	**6.067**	Stock vs. FX	**25.958**	**6.063**

	Cointegrated markets	λ_1	*p*-value	λ_2	*p*-value	GG
VECM						
9/26/2008–4/7/2009 (distressed period)	CDS & Bond	**−0.204**	0.000	**−0.039**	0.002	N/A
		(Bond leads CDS based on magnitude of adjustment parameters)				
	CDS & Stock	**−0.468**	0.000	**0.140**	0.000	0.230
		(Stock leads CDS based on GG measure)				
	CDS & FX	**−0.292**	0.000	0.049	5.870	0.144
		(FX leads CDS based on GG measure)				
	Bond & Stock	**−0.038**	0.010	**0.101**	0.000	0.725
		(Bond leads Stock based on GG measure)				
	Bond & FX	**−0.030**	0.045	**0.037**	0.000	0.551
		(Bond leads FX based on GG measure)				
	Stock & FX	**−0.168**	0.000	**−0.079**	0.000	N/A
		(FX leads Stock based on magnitude of adjustment parameters)				

	CDS		Bond		Stock		FX	
	chi2-statistic	*p*-value	chi2-statistic	*p*-value	chi2-statistic	*p*-value	chi2-statistic	*p*-value
VAR – Granger causality (Wald Tests)								
4/2/2007–8/27/2009 (full period)								
CDS caused by	–	–	1.023	0.6	**6.697**	0.035	**11.438**	0.003
Bond caused by	1.127	0.569	–	–	4.809	0.09	4.564	0.102
Stock caused by	5.804	0.055	4.703	0.095	–	–	**45.439**	0.000
FX caused by	**17.355**	0.000	3.678	0.159	**8.139**	0.017	–	–
9/26/2008–4/7/2009 (distressed period)								
CDS caused by	–	–	N/A		N/A		N/A	
Bond caused by	N/A		–	–	N/A		N/A	
Stock caused by	N/A		N/A		–	–	N/A	
FX caused by	N/A		N/A		N/A		–	–

$$(\boldsymbol{CE}2): Z_{2t} = Bond_{2t} + \beta_{2i}CDS_{2t} + \beta_{2j}FX_{2t} + \beta_{2k}Stock_{2t} + \gamma_{2i} = I(0) \quad (8)$$

$$(\boldsymbol{CE}3): Z_{3t} = FX_{3t} + \beta_{3i}CDS_{3t} + \beta_{3j}Bond_{3t} + \beta_{3k}Stock_{3t} + \gamma_{3i} = I(0) \quad (9)$$

Multiple Markets Vector Error Correction Model (MVECM):

$$\Delta CDS_t = a_1 + \lambda_{11}\boldsymbol{CE}1 + \lambda_{12}\boldsymbol{CE}2 + \lambda_{13}\boldsymbol{CE}3 + \sum\nolimits_{j=1}^{p} r_{1,j}\Delta CDS_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta Bond_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta FX_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta Stock_{t-j} + e_{1t} \quad (10)$$

$$\Delta Bond_t = a_2 + \lambda_{21}\boldsymbol{CE}1 + \lambda_{22}\boldsymbol{CE}2 + \lambda_{23}\boldsymbol{CE}3 + \sum\nolimits_{j=1}^{p} r_{1,j}\Delta CDS_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta Bond_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta FX_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta Stock_{t-j} + e_{2t} \quad (11)$$

$$\Delta FX_t = a_3 + \lambda_{31}\boldsymbol{CE}1 + \lambda_{32}\boldsymbol{CE}2 + \lambda_{33}\boldsymbol{CE}3 + \sum\nolimits_{j=1}^{p} r_{1,j}\Delta CDS_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta Bond_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta FX_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta Stock_{t-j} + e_{3t} \quad (12)$$

Table 4E
Panel E – Turkey. This table shows Trace statistics for Johansen cointegration tests, adjustment parameters and their significance levels in VECM analysis, and Wald Statistics related Granger causality tests. Bold numbers in the first section represent the rejection (at 95% confidence level) of the null hypothesis of zero (or one) cointegrating vectors in Johansen cointegration tests. In the second section, bold numbers represent the significance of adjustment parameters at 95% confidence level. Bold numbers in the third section represent the rejection of the null hypothesis that the second market does not Granger cause the first market. Therefore if the *p*-values are less than 5%, one can conclude that the second market Granger causes the first one.

Period	*N*		Number of cointegrating vectors			Number of cointegrating vectors	
			None	At most 1		None	At most 1
Cointegration analysis							
4/2/2007–8/27/2009 (full period)	472	CDS vs. Bond	4.227	0.193	Bond vs. Stock	15.189	5.565
		CDS vs. Stock	14.741	2.948	Bond vs. FX	11.175	1.351
		CDS vs. FX	**25.489**	3.300	Stock vs. FX	9.458	2.174
9/26/2008–4/7/2009 (distressed period)	102	CDS vs. Bond	12.117	0.242	Bond vs. Stock	**20.506**	0.575
		CDS vs. Stock	**22.270**	3.064	Bond vs. FX	**19.792**	0.290
		CDS vs. FX	**35.808**	**13.461**	Stock vs. FX	**44.711**	**13.915**

	Cointegrated markets	λ_1	*p*-value	λ_2	*p*-value	GG
VECM						
4/2/2007–8/27/2009 (full period)	CDS & FX	**−0.020**	0.002	−0.001	0.541	N/A
		(FX leads CDS based on significance of adjustment parameters)				
9/26/2008–4/7/2009 (distressed period)	CDS & Stock	**−0.028**	0.000	**0.023**	0.000	0.448
		(Stock leads CDS based on GG measure)				
	CDS & FX	**−0.155**	0.000	**0.042**	0.000	0.211
		(FX leads CDS based on GG measure)				
	Bond & Stock	**−0.012**	0.000	**0.028**	0.000	0.694
		(Bond leads Stock based on GG measure)				
	Bond & FX	**−0.018**	0.012	**0.024**	0.000	0.565
		(Bond leads FX based on GG measure)				
	Stock & FX	**−0.576**	0.000	**−0.158**	0.003	N/A
		(FX leads Stock based on magnitude of adjustment parameters)				

	CDS		Bond		Stock		FX	
	F-statistic	*p*-value	*F*-statistic	*p*-value	*F*-statistic	*p*-value	*F*-statistic	*p*-value
VAR – Granger causality (Wald Tests)								
4/2/2007–8/27/2009 (full period)								
CDS caused by	–	–	3.024	0.220	0.974	0.615	N/A	
Bond caused by	0.003	0.998	–	–	1.211	0.546	**9.102**	0.011
Stock caused by	2.120	0.346	1.518	0.468	–	–	**24.349**	0.000
FX caused by	N/A		2.466	0.291	0.635	0.728	–	–
9/26/2008–4/7/2009 (distressed period)								
CDS caused by	–	–	1.689	0.43	N/A		N/A	
Bond caused by	1.084	0.582	–	–	N/A		N/A	
Stock caused by	N/A		N/A		–	–	N/A	
FX caused by	N/A		N/A		N/A		–	–

$$\Delta Stock_t = a_4 + \lambda_{41}\boldsymbol{CE}1 + \lambda_{42}\boldsymbol{CE}2 + \lambda_{43}\boldsymbol{CE}3 + \sum\nolimits_{j=1}^{p} r_{1,j}\Delta CDS_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta Bond_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta FX_{t-j} + \sum\nolimits_{j=1}^{p} k_{1,j}\Delta Stock_{t-j} + e_{4t} \quad (13)$$

Table 5 Panels A to E report the results on VECM analysis of multiple markets simultaneously for each country. A representative sample of cointegrating equations is given above for the case of a maximum of 3 cointegrating vectors (linear case). Johansen normalizations would show the actual form of these equations and significance of the variables. These equations are reported at the bottom of each panel. For further discussion on how to interpret adjustment parameters, see Forte and Pena (2009, pp. 2016–2018) and Enders (2004).

To wrap up the econometric discussion, the summary of all the findings (VECM, Granger Causality, MVECM) are in Table 3, and the detailed interpretations of the results for each country are in Tables 4 and 5.[16]

We can start (Table 4 – Panel A) to explore the specifics of each country with Brazil. There is only one pair where a cointegration relation is observed for the full period (Stock and FX), and the adjustment parameters do not have the appropriate signs in VECM. However, when we restrict the analysis to the distressed period, the picture changes dramatically, and all the pairs are found to be cointegrated

[16] To diagnose and cope with problems related to autocorrelation and non-normality in VECM, I ran Jarque-Bera (normality) and Lagrangian Multiplier (autocorrelation) tests after each estimation. It appeared that both diagnostics showed some concern. Accordingly, I also ran the models with standardized variables (demeaning and dividing by the standard deviation, Narayan et al. 2014) and more lags for robustness purposes. It appeared that the results did not change and the autocorrelation problems became less significant.

Table 5A
Vector error correction model with multiple markets (MVECM). Panel A – Brazil.

Period	N		Number of cointegrating vectors: trace statistics			
			None	At most 1	At most 2	At most 3
Cointegration analysis – Multiple markets						
4/2/2007–8/27/2009 (full period)	472	CDS, Bond, Stock, FX	55.703	**27.213**		
		Critical Values	47.210	29.680	15.410	3.760
9/26/2008–4/7/2009 (distressed period)	102	CDS, Bond, Stock, FX	90.071	54.307	25.892	**0.791**
		Critical Values	47.210	29.680	15.410	3.760

VECM – Multiple markets (cointegrating rank = 1, lags = 1)

Period				
4/2/2007–8/27/2009 (full period)	CDS vs. Bond-FX-stock	λ_{11}	λ_{12}	λ_{13}
	Coefficients	−0.017	N/A	N/A
	p-Values	0.296		
	Bond vs. CDS-FX-Stock	λ_{21}	λ_{22}	λ_{23}
	Coefficients	**0.020**	N/A	N/A
	p-Values	0.000		
	FX vs. CDS-Bond-Stock	λ_{31}	λ_{32}	λ_{33}
	Coefficients	−0.004	N/A	N/A
	p-Values	0.407		
	Stock vs. CDS-Bond-FX	λ_{11}	λ_{12}	λ_{13}
	Coefficients	0.000	N/A	N/A
	p-Values	0.981		

VECM - Multiple markets (cointegrating rank = 3, lags = 1)

Period				
9/26/2008–4/7/2009 (distressed period)	CDS vs. Bond-FX-Stock	λ_{11}	λ_{12}	λ_{13}
	Coefficients	**−0.271**	0.066	−0.351
	p-Values	0.001	0.475	0.426
	(Stock leads CDS based on CE1*)			
	Bond vs. CDS-FX-Stock	λ_{21}	λ_{22}	λ_{23}
	Coefficients	0.038	0.000	0.183
	p-Values	0.155	0.997	0.205
	FX vs. CDS-Bond-Stock	λ_{31}	λ_{32}	λ_{33}
	Coefficients	0.016	−0.028	−0.041
	p-Values	0.515	0.311	0.754
	Stock vs. CDS-Bond-FX	λ_{11}	λ_{12}	λ_{13}
	Coefficients	−0.002	**−0.221**	0.720
	p-Values	0.965	0.000	0.017
	(Bond leads Stock based on CE2**)			

Johansen Normalization & Restricted Cointegration Equations (bold variables are significant at 5%)

Full period
Cointegrating Eq. (1) = 6.743 + **CDS** − 1.603**Bond** + 4.058**FX** − .360Stock

Distressed period
* Cointegrating Eq. (1) = 0.907 + **CDS** + .250Stock
** Cointegrating Eq. (2) = −152.571 − 5.55e − 17CDS + **Bond** − 2.00E − 15FX + 3.674**Stock**
Cointegrating Eq. (3) = −1.708 − 5.55e − 17CDS + −2.78e − 17Bond + **FX** + 3.604**Stock**

which strikes as a strong sign of a regime change (Ngene, 2014). We have very similar observations for Indonesia, Mexico, and Turkey. These findings support the hypothesis of increased market integration during distressed periods and a regime change.

The second section of Panel A in Table 4 reports the VECM results for Brazil. Even though there is only one pair to analyze for the full period, there are six pairs to be examined for the distressed period. Accordingly, there is significant lead of LCB and FX markets over the CDS and stock markets during the distressed period (VECM), and the lead of the bond market over FX market over the full period (Granger causality). Looking at Panel A of Table 5 for the MVECM analysis, one can see the lead of LCB over stock market as well. To summarize, all the findings point to a dominant role of LCB market for the case of Brazil. CDS markets are almost always dominated by other markets in the analysis.

Concerning China (Tables 4 and 5 Panel B), results are mixed. First, the integration across markets do not change much in two different periods. Second, Granger causality tests and MVECM analysis do not tell much as well. However, the lead of the LCB market in the distressed period is noticeable.

About Indonesia (Tables 4 and 5 Panel C), pairwise VECM analysis and MVECM results have some discrepancies. Even though stock market is confirmed to lead CDS markets in both methodologies, the lead of the stock market over FX market in MVECM is in contrast with the findings of pairwise analysis. Overall, one can argue that the stock market leads other markets, and CDS market lags the others in general for the case of Indonesia.

Table 5B
Panel B – China.

Period	N		Number of cointegrating vectors: trace statistics			
			None	At most 1	At most 2	At most 3
Cointegration analysis – Multiple markets						
4/2/2007–8/27/2009 (full period)	472	CDS, Bond, Stock, FX	67.928	33.212	**12.660**	
		Critical Values	47.210	29.680	15.410	3.760
9/26/2008–4/7/2009 (distressed period)	102	CDS, Bond, Stock, FX	54.991	**20.715**		
		Critical Values	47.210	29.680	15.410	3.760

VECM – Multiple markets (cointegrating rank = 2, lags = 1)				
4/2/2007–8/27/2009 (full period)	CDS vs. Bond-FX-stock	λ_{11}	λ_{12}	λ_{13}
	Coefficients	−0.001	0.004	N/A
	p-Values	0.860	0.833	
	Bond vs. CDS-FX-Stock	λ_{21}	λ_{22}	λ_{23}
	Coefficients	**−0.006**	**−0.019**	N/A
	p-Values	0.000	0.000	
	(CDS, Stock, and FX lead Bond based on CE1*, Stock and FX leads Bond based on CE2**)			
	FX vs. CDS-Bond-Stock	λ_{31}	λ_{32}	λ_{33}
	Coefficients	0.000	0.001	N/A
	p-Values	0.075	0.102	
	Stock vs. CDS-Bond-FX	λ_{11}	λ_{12}	λ_{13}
	Coefficients	**−0.006**	**−0.019**	N/A
	p-Values	0.004	0.005	
	(CDS and FX lead Stock based on CE1*, Bond and FX lead Stock based on CE2**)			
VECM – Multiple markets (cointegrating rank = 3, lags = 1)				
9/26/2008–4/7/2009 (distressed period)	CDS vs. Bond-FX-stock	λ_{11}	λ_{12}	λ_{13}
	Coefficients	**−0.028**	N/A	N/A
	p-Values	0.049		
	(Bond, FX and Stock lead CDS based on CE1***)			
	Bond vs. CDS-FX-Stock	λ_{21}	λ_{22}	λ_{23}
	Coefficients	0.008	N/A	N/A
	p-Values	0.085		
	FX vs. CDS-Bond-Stock	λ_{31}	λ_{32}	λ_{33}
	Coefficients	**−0.001**	N/A	N/A
	p-Values	0.000		
	(Bond, CDS and Stock lead FX based on CE1***)			
	Stock vs. CDS-Bond-FX	λ_{11}	λ_{12}	λ_{13}
	Coefficients	0.005	N/A	N/A
	p-Values	0.215		

Johansen Normalization & Restricted Cointegration Equations (bold variables are significant at 5%)

Full period
*Cointegrating Eq. (1) = −168.014 + **CDS** + 80.442FX + 55.774**Stock**
Cointegrating Eq. (2) = 51.344 + **Bond − 26.620FX − 16.868**Stock**

Distressed period
***Cointegrating Eq. (1) = 670.22 + **CDS** − 0.754Bond + 344.623**FX** − 1.184Stock

Mexico is where one can also emphasize the leading role of LCB and FX markets (Tables 4 and 5 Panel D). Lastly, the findings concerning Turkey (Tables 4 and 5 Panel E) adds to the general findings of the analysis in Tables 4 and 5, that the LCB and FX markets have a strong presence in price discovery, and CDS markets generally lag others.

Overall, the empirical analysis demonstrates the significant role played by the rapidly growing LCB markets in the price discovery process along with the FX markets (except Indonesia) especially during the distressed period. Although the underlying economic or behavioral reasons are not easily quantifiable, the analysis shows that the new information is first reflected in the LCB and FX markets, and it generally flows into the stock and CDS markets with a delay. The reasons behind these findings might be related to size, liquidity, and trading volume of the LCB and FX markets. In addition, there might also be other microeconomic or behavioral factors related to large institutional investors.[17]

The significance of the LCB markets might also be the result of asymmetric information, and more importantly better and more timely information possessed by major banks and institutional investors who have a large stake in bond markets. Andersen, Bollerslev, Diebold, and Vega (2007) note that the real-time reaction of bond markets to major U.S. economic news are stronger compared to stock and FX markets across

[17] European Regulators to Charge Banks Over Derivatives, The Wall Street Journal, March 26, 2013. Mock, Dalton, Burne.

Table 5C
Panel C – Indonesia.

Period	N		Number of cointegrating vectors: trace statistics: None	At most 1	At most 2	At most 3
Cointegration analysis – Multiple markets						
4/2/2007–8/27/2009 (full period)	472	CDS, Bond, Stock, FX	66.294	**23.661**	9.578	3.951
		Critical Values	47.210	29.680	15.410	3.760
9/26/2008–4/7/2009 (distressed period)	102	CDS, Bond, Stock, FX	76.620	38.672	16.220	**5.977**
		Critical Values	47.210	29.680	15.410	3.760

VECM – Multiple markets (cointegrating rank = 1, lags = 1)				
4/2/2007–8/27/2009 (full period)	CDS vs. Bond-FX-stock	λ_{11}	λ_{12}	λ_{13}
	Coefficients	−0.013	N/A	N/A
	p-Values	0.482		
	Bond vs. CDS-FX-Stock	λ_{21}	λ_{22}	λ_{23}
	Coefficients	**0.042**	N/A	N/A
	p-Values	0.000		
	FX vs. CDS-Bond-Stock	λ_{31}	λ_{32}	λ_{33}
	Coefficients	**−0.009**	N/A	N/A
	p-Values	0.000		
	(CDS and Bond lead FX based on CE1*)			
	Stock vs. CDS-Bond-FX	λ_{41}	λ_{42}	λ_{43}
	Coefficients	**−0.037**	N/A	N/A
	p-Values	0.000		
	(CDS, Bond, FX lead Stock based on CE1*)			
VECM – Multiple markets (cointegrating rank = 3, lags = 1)				
9/26/2008–4/7/2009 (distressed period)	CDS vs. Bond-FX-stock	λ_{11}	λ_{12}	λ_{13}
	Coefficients	**−0.207**	**0.209**	−0.225
	p-Values	0.011	0.004	0.687
	(Stock leads CDS based on CE1**)			
	Bond vs. CDS-FX-Stock	λ_{21}	λ_{22}	λ_{23}
	Coefficients	0.081	−0.009	−0.214
	p-Values	0.056	0.805	0.464
	FX vs. CDS-Bond-Stock	λ_{31}	λ_{32}	λ_{33}
	Coefficients	0.007	**0.024**	**−0.213**
	p-Values	0.627	0.046	0.022
	(Stock leads FX based on CE3***)			
	Stock vs. CDS-Bond-FX	λ_{41}	λ_{42}	λ_{43}
	Coefficients	−0.059	−0.027	0.333
	p-Values	0.073	0.359	0.142

Johansen Normalization & Restricted Cointegration Equations (bold variables are significant at 5%)

Full Period
* Cointegrating Eq. (1) = 28.945 + **CDS** − .784**Bond** + 2.937**FX** + 0.241Stock

Distressed Period
** Cointegrating Eq. (1) = 13.330 + **CDS** + 4.929**Stock**
Cointegrating Eq. (2) = 16.638 − 6.66E − 16CDS + **Bond** + 6.715**Stock**
Cointegrating Eq. (3) = 10.475 + 1.39E − 16CDS + **FX** + 0.524Stock

the three major economies, the US, the UK, and Germany. Their results are very much in line with the findings of this study.

Peiris (2010) notes that the LCB markets are on average approximately 6 times larger than the foreign currency bond (FCB) markets (end of 2008) across EMs. Considering the fact that the average size of FCB is on average 9.2 times the CDS markets for the five emerging markets in our analysis, a quick and dirty computation would tell us that the LCB markets are around 55.2 times as large as the CDS markets for the countries in our analysis.[18] In addition, stock markets and the FX markets are found to be as large as (often exceed) LCB markets.[19] So the size of the markets might have an effect on the results, especially for the CDS markets' weak role in price discovery.

The volume of trading activity or liquidity (bid-ask spreads) of these markets might also provide further explanations. Burger and Warnock (2007) and Peiris (2010) emphasize a rapid growth in LCB markets and reduced levels of foreign currency debt in emerging markets due to a more creditor friendly legal environment and policies. These positive developments might have led to higher LCB trading activity.

[18] Bloomberg Markets, May 2010.

[19] Bloomberg, Burger and Warnock (2007), and Author's Calculations.

Table 5D
Panel D – Mexico.

Period	N		Number of cointegrating vectors: trace statistics			
			None	At most 1	At most 2	At most 3
Cointegration analysis – Multiple markets						
4/2/2007–8/27/2009 (full period)	472	CDS, Bond, Stock, FX	**23.060**			
		Critical Values	47.210	29.680	15.410	3.760
9/26/2008–4/7/2009 (distressed period)	102	CDS, Bond, Stock, FX	64.506	**25.042**		
		Critical Values	47.210	29.680	15.410	3.760
VECM – Multiple markets (cointegrating rank = 0, lags = 2)						
4/2/2007–8/27/2009 (full period)		CDS vs. Bond-FX-Stock		λ_{11}	λ_{12}	λ_{13}
		Coefficients		N/A	N/A	N/A
		p-Values				
		Bond vs. CDS-FX-Stock		λ_{21}	λ_{22}	λ_{23}
		Coefficients		N/A	N/A	N/A
		p-Values				
		FX vs. CDS-Bond-Stock		λ_{31}	λ_{32}	λ_{33}
		Coefficients		N/A	N/A	N/A
		p-Values				
		Stock vs. CDS-Bond-FX		λ_{11}	λ_{12}	λ_{13}
		Coefficients		N/A	N/A	N/A
		p-Values				
VECM – Multiple markets (cointegrating rank = 1, lags = 1)						
9/26/2008–4/7/2009 (distressed period)		CDS vs. Bond-FX-stock		λ_{11}	λ_{12}	λ_{13}
		Coefficients		**−0.449**	N/A	N/A
		p-Values		0.000		
		(Stock, FX, and Bond lead CDS based on CE1**)				
		Bond vs. CDS-FX-Stock		λ_{21}	λ_{22}	λ_{23}
		Coefficients		**−0.072**	N/A	N/A
		p-Values		0.003		
		(Stock, FX, and Bond lead CDS based on CE1**)				
		FX vs. CDS-Bond-Stock		λ_{31}	λ_{32}	λ_{33}
		Coefficients		**0.067**	N/A	N/A
		p-Values		0.000		
		Stock vs. CDS-Bond-FX		λ_{11}	λ_{12}	λ_{13}
		Coefficients		**0.141**	N/A	N/A
		p-Values		0.000		

Johansen Normalization & Restricted Cointegration Equations (bold variables are significant at 5%)

Distressed period
Cointegrating Eq. (1) = −4.079 + **CDS** − 0.165Bond − 0.018FX − .947**Stock**

There are a few studies concentrating on the role of FX markets the price discovery process (Francis et al., 2006; Zhang, 2010). However, these studies do not provide any economic explanations as to why the currency markets would be more active compared to other markets. Campbell et al. (2010) on the other hand, suggests hard currencies (US Dollar, Euro, Swiss Franc) as an important tool of hedging for the global equity investors. Therefore, the volume of currency trading might be high due to its role in investments and risk management, especially during volatile periods.

Finally, as noted earlier, changes in LCB spreads and FX rates have an immediate impact on the default probability calculations for a sovereign using the Merton (1974) model. The sum of local currency liabilities (domestic debt and monetary base) is treated as the "equity-like" portion of the sovereign balance sheet (Gray et al., 2007), and the appreciation/depreciation of the local currency is automatically embedded into the value of this equity. So if the analogy in the corporate markets is that the stock markets are leading other markets in price discovery (Forte & Pena, 2009; Narayan et al., 2014), then it should be natural to observe LCBs as the leading markets for the sovereign case since LCB is a sovereign's "equity". Of course, one might argue that there are many problems related to market efficiency and liquidity in the case of EMs. The analysis provided in this article demonstrates that the developing world is getting there.

5. Conclusion

In this study, the role of the LCB and FX markets in price discovery mechanism is questioned in sovereign context. The analysis links four major markets (LCB, FX, CDS, and stock markets) that are exposed to sovereign risk, and it examines five major developing economies. The results highlight the dominant role of LCB and FX markets in the empirical dynamics during a highly turbulent period; beginning approximately ten days after the bankruptcy of Lehman Brothers (9/

Table 5E
Panel E – Turkey.

Period	N		Number of cointegrating vectors: trace statistics			
			None	At most 1	At most 2	At most 3
Cointegration analysis – Multiple markets						
4/2/2007–8/27/2009 (full period)	472	CDS, Bond, Stock, FX	56.802	32.270	17.901	**6.514**
		Critical Values	47.210	29.680	15.410	3.760
9/26/2008–4/7/2009 (distressed period)	102	CDS, Bond, Stock, FX	67.463	30.433	**11.104**	1.060
		Critical Values	47.210	29.680	15.410	3.760

VECM – Multiple markets (cointegrating rank = 3, lags = 2)

4/2/2007–8/27/2009 (full period)	CDS vs. Bond-FX-Stock	λ_{11}	λ_{12}	λ_{13}	B_{DBond}	B_{DFX}	B_{DStock}
	Coefficients	−0.016	−0.022	0.070	0.105	**−1.092**	0.097
	p-Values	0.362	0.387	0.339	0.426	0.000	0.422
	(Short-run causality from FX to CDS)						
	Bond vs. CDS-FX-Stock	λ_{21}	λ_{22}	λ_{23}	B_{DCDS}	B_{DFX}	B_{DStock}
	Coefficients	**0.018**	−0.019	0.003	0.011	**−0.323**	−0.059
	p-Values	0.022	0.098	0.923	0.724	0.002	0.276
	(Short-run causality from FX to Bond)						
	FX vs. CDS-Bond-Stock	λ_{31}	λ_{32}	λ_{33}	B_{DCDS}	B_{DBond}	B_{DStock}
	Coefficients	−0.004	**0.016**	**−0.043**	0.027	0.031	−0.020
	p-Values	0.413	0.034	0.046	0.209	0.422	0.585
	(Long-run causality from Stock to FX based on CE3*)						
	Stock vs. CDS-Bond-FX	λ_{11}	λ_{12}	λ_{13}	B_{DCDS}	B_{DBond}	B_{DFX}
	Coefficients	−0.014	−0.003	0.039	0.069	−0.087	**0.765**
	p-Values	0.255	0.884	0.449	0.183	0.351	0.000
	(Short-run causality from FX to Stock)						

VECM – Multiple markets (cointegrating rank = 2, lags = 1)

9/26/2008–4/7/2009 (distressed period)	CDS vs. Bond-FX-stock	λ_{11}	λ_{12}	λ_{13}
	Coefficients	0.019	−0.008	N/A
	p-Values	0.237	0.858	
	Bond vs. CDS-FX-Stock	λ_{21}	λ_{22}	λ_{23}
	Coefficients	0.007	−0.001	N/A
	p-Values	0.255	0.954	
	FX vs. CDS-Bond-Stock	λ_{31}	λ_{32}	λ_{33}
	Coefficients	**−0.016**	**0.032**	N/A
	p-Values	0.001	0.015	
	(Long-run causality jointly from Bond and Stock to FX based on CE2**)			
	Stock vs. CDS-Bond-FX	λ_{41}	λ_{42}	λ_{43}
	Coefficients	−0.01	−0.016	N/A
	p-Values	0.326	0.574	

Johansen Normalization & Restricted Cointegration Equations (bold variables are significant at 5%)

Full period
Cointegrating Eq. (1) = 0.794 + **CDS** − 2.22E16Bond + 0.279Stock
Cointegrating Eq. (2) = 10.439 − 2.22E − 16CDS + **Bond** − 0.820**Stock**
*Cointegrating Eq. (3) = 6.851 − 1.11E − 16Bond + **FX** − 0.637Stock

Distressed period
Cointegrating Eq. (1) = −346.670 + **CDS** − 53.327**FX** + 33.557**Stock**
Cointegrating Eq. (2) = −152.571 + **Bond − 5.55E − 17CDS − 27.461**FX** + 14.619**Stock**

15/2008) and lasting for the next 102 business days where the market fear (VIX) exceeds a certain level (40). The findings are more clear and consistent for Brazil, Mexico, and Turkey. Although coming to clear-cut conclusions is not possible at this time, LCB markets have an important presence in empirical dynamics during the distressed period regardless of the country (except Indonesia).

Although size, liquidity, and the behavior of large financial institutions might provide some explanations, I argue that using the Merton (1974) model in the sovereign context (Aktug, 2014; Gray et al., 2007) make things clear as to why LCB and FX markets are crucial in sovereign risk analysis (Eichengreen et al., 2002).

This study leaves several directions open for further research. First, an analysis covering a daily frequency might not be enough to capture the signals in financial markets. Intraday data, minute-by-minute, or even second-by-second observations might reveal different market interactions (Andersen et al., 2007; Chen & Gau, 2010; Gyntelberg, Hördahl, Ters, & Urban, 2013). Second, similar to Bekaert, Harvey, and Lumsdaine (2002) and Ngene (2014), structural breaks and nonlinearities can be identified in a more systematic manner for the individual cases and noticeable events, and time-series analysis can be performed accordingly (Erenburg, Kurov, & Lasser, 2006). Merton (1974) modeling for the sovereign case (Gray et al., 2007) also supports the claim that the relationships between macroeconomic variables can be highly nonlinear (Akdogan & Chadwick, 2013). Third, currency derivative markets can also bring some additional insights (Carr & Wu, 2007). Lastly, new techniques and approaches can be explored to gain additional insights in price discovery such as panel cointegration methodology (Narayan et al., 2014).

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