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Volatility transmission from commodity markets to sovereign CDS spreads in emerging and frontier countries

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ABSTRACT

We investigate the volatility transmission from commodities to sovereign credit defaults swaps (CDS) spreads of emerging and frontier markets. Using daily data for seventeen emerging and six frontier countries, we document a significant volatility spillover from commodity markets to sovereign CDS spreads of emerging and frontier markets. We find that this effect is strong for most of the countries in our sample, but the results differ by country and over time. We also examine whether particular commodity sectors are the main driver of the transmission of volatility and our results show a stronger effect of energy and precious metals volatility.

1. Introduction

A large number of developing countries are dependent on commodities as a source of export revenues. According to a United Nations Development Program report, highly volatile commodity prices lead to macroeconomic instabilities, volatility in export earnings, foreign exchange reserves and economic growth in developing countries (UNDP, 2011). The higher the degree of commodity dependence, the more susceptible the country is to commodity price shocks (UNDP, 2011). Furthermore, the more volatile the macroeconomic fundamentals of a country are, the higher the likelihood of extreme deterioration of fundamentals that can lead to sovereign debt default, particularly for countries generating export revenues in dollars and having payments on external dollar-denominated debt (Hilscher & Nosbusch, 2010). This increased credit risk is reflected in the spreads of government bonds and the annual cost of protection for possible losses incurred on government debt.

Sliding oil prices and commodity prices in general since 2014 have resulted in multiple articles in the financial media relating changes in commodity prices to fluctuations in sovereign credit default swap premia. Liau and Karunungan (2016) report in a Bloomberg article that "the recent tightening of Malaysia's CDS spread is mainly due to the rebound in oil prices from the trough in January." Similar stories could be found about Russia, Saudi Arabia, Brazil, South Africa and other major commodity exporters. Sovereign credit default swaps (CDS) have received additional attention in the media also due to the ongoing European sovereign debt crisis, where the CDS speculative nature and potential to exacerbate credit market turmoil, as well as possibly affect borrowing costs, have been the focal point. Sovereign risk is an important consideration for investors looking for direct or portfolio investment in emerging markets, and the sovereign CDS market has been used as a market-based reference for sovereign credit risk.

Sovereign CDS are bilateral contracts between a buyer and a seller where the seller is offering protection against credit event by a sovereign borrower. The buyer pays a premium to the protection seller in exchange for compensation in case of a credit event. The CDS premium is quoted as a fraction of the notional value of the reference obligation (in basis points). The failure of a sovereign borrower to meet debt obligations is known as a credit event. Qualifying credit events include failure of the sovereign borrower to pay principal or interest payments, restructuring or moratorium. While the overall CDS market has peaked from $58 trillion in 2008 to $27 trillion in 2012, Augustin (2014) reports that sovereign CDS have a notional value of $2.99 trillion USD in 2012, which accounts for about 11% of the over-the-counter credit derivatives market. As credit derivatives have been in the spotlight during the 2008 global financial crisis and the European debt crisis, the academic literature on sovereign CDS is growing. A number of papers investigating the dynamics and determinants of sovereign CDS spreads show that

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sovereign spreads are driven not only by country-specific fundamentals, but also by global financial market variables.

However, what has received little attention so far are questions in relation to the volatility transmission from commodities to sovereign CDS. In this paper, we therefore investigate the transmission of volatility between asset markets, and specifically, between commodity and credit markets. In particular, we are interested in the following questions. Is there a significant volatility spillover from commodity markets to emerging and frontier credit risk markets, where we measure sovereign credit risk using sovereign credit default swap spreads? Do the spillover effects differ among countries and over time? More importantly, does the transmission of volatility differ by commodity sector, i.e. energy, industrial metal, precious metals, etc.? Addressing those questions is important to indicate which countries, in terms of credit risk, are most (least) vulnerable to commodity price volatility. It also helps understand better whether this vulnerability depends on the country's heterogeneity in terms of the contribution of its commodity-related exports. Methodologically, we model the conditional mean and variance using an AR-GARCH specification and employ the Lagrange Multiplier (LM) methodology presented by Hafner and Herwartz (2006) to test for causality in variance.

Our findings can be summarized as follows. We find that the volatility of sovereign CDS spreads of emerging and frontier markets is affected by commodity prices and this effect is strong for most of the countries in our sample. The results differ by country, i.e. 10 out of 17 emerging market CDS are affected by commodity price volatility and four out of six frontier markets experience a significant volatility spillover. The volatility spillover effect is similar when an equally-weighted commodity index is used. When commodity sector indices are used, energy and precious metals appear as large contributors to sovereign spreads volatility across most countries in our sample. Our results add to the literature on sovereign credit risk and economic fundamentals and have implications for policy makers concerned with the stability of financial markets and costs of insuring emerging market debt. They are also useful in assessing the contribution of the commodity-specific risk in the overall country risk and the resulting implications for asset pricing and risk management.

The rest of our paper is organized as follows. Section 2 provides a brief survey of the relevant literature. Section 3 discusses the econometric framework, while Section 4 describes the data. The main results are reported in Section 5. Section 6 offers concluding remarks.

2. Literature review

While the literature on the determinants of emerging markets sovereign bond yield spreads is growing, studies focusing specifically on the effects of commodity prices on sovereign debt are scarce. Hilscher and Nosbusch (2010) create a country-specific commodity price index and study the effect of global and country-specific factors on sovereign bond yield spreads of 31 emerging markets. The authors find that countries exporting commodities with more volatile prices could also experience larger swings in the terms of trade and as a result are more vulnerable to outside shocks (Hilscher & Nosbusch, 2010). Sun, Tenengauzer, Bastani, and Rezania (2011) investigate the factors driving emerging markets spreads and also include a commodity index along with macroeconomic factors in their models. They show that commodity price increases are associated with lower sovereign spreads. A recent paper by Arezki and Bruckner (2010) studies how changes in international commodity prices affect foreign currency revenues of emerging market countries and how this ultimately affects the sovereign bond spreads of these countries. While they show that, on average, sovereign bond spreads decrease when export-related commodity prices increase, the result depends on the stage of democratic development. For instance, higher commodity prices result in lower spreads in democracies, while in autocratic regimes spreads increase. Their analysis adds to the resource curse literature, which argues that natural resource abundant economies tend to underperform economies without substantial resources and the strength of this effect depends on the quality of political institutions (Mehlum, Moene, & Torvik, 2006).

Few other studies include the impact of oil prices while modeling sovereign spreads (Duffie, Pedersen, & Singleton, 2003; Alexandre & de Benoist, 2010; Hooper, 2015). More notably, Alexandre and de Benoist (2010) investigate the effect of oil prices on emerging country bond risk premiums and show that the effect of oil price fluctuation depends on the status of a country as an oil exporter or importer. The largest effect of oil prices on sovereign spreads were found for Russian, Argentinian, and Venezuelan spreads. Another study on the impact of oil price uncertainty on CDS returns is by Sharma and Thuraisamy (2013) and they include eight Asian countries in their sample. The authors show that oil price uncertainty predicts out-of-sample CDS returns for six countries under study, namely Indonesia, Japan, Malaysia, the Philippines, South Korea and Vietnam. Hooper (2015) focuses on the link between oil and gas reserves and sovereign spreads. Using annual panel data from 1994 to 2014 for 10 emerging oil-exporting countries, Hooper measures the impact of oil and gas reserves on the mean spread obtained from the JP Morgan Emerging Markets Bond Index. Her findings reveal that oil reserves contribute to widening sovereign spreads when the country has a higher level of corruption and political turmoil, but decrease spreads in politically stable countries.

A number of papers examine the impact of crude oil prices on equity returns for developed markets, but fewer studies investigate this relation for emerging and frontier markets. Gomes and Chaibi (2014) study the volatility spillover from crude oil to 21 frontier stock indices and find significant volatility transmission for some of the markets. Basher, Haug, and Sadorsky (2012) focus on emerging markets and use a structural vector autoregression model to examine the relation between oil prices, exchange rates and stock returns (MSCI emerging stock market index is used a proxy). Basher et al. (2012) find that emerging markets stocks have a negative short-term (2–3 months) relation with oil prices. An earlier study by Basher and Sadorsky (2006) uses daily, weekly and monthly data for 21 emerging markets and reports that the impact of oil price increases on stock returns differs when different data frequencies are used. Few other studies on the impact of oil on emerging or frontier markets include Maghyereh (2006), Maghyereh and Al-Kandari (2007), Aloui, Nguyen, and Njeh (2012), Ajmi, El-montasser, Hammoudeh, and Nguyen (2014), Ghosh and Kanjilal (2014), Bouri (2015), among others. Along this line of research, Arouri, Lahiani, and Nguyen (2011) measure the volatility transmission between oil and stocks in Gulf Cooperation Council (GCC) markets. They document substantial spillover effects in three out of the six markets under study. Significant volatility spillover from oil to Gulf equity markets (Saudi Arabia, Kuwait, and Bahrain) is also reported by Malik and Hammoudeh (2007).

The above short survey of the relevant literature shows that no direct association between the volatilities of commodities and credit markets has been studied. Accordingly, this paper addresses this relevant literature gap.

3. Econometric framework

To test for causality in variance from energy and non-energy commodity indices to the CDS spreads in emerging and frontier economies we employ the Lagrange Multiplier (LM) methodology presented by Hafner and Herwartz (2006). In this framework, the commodity index (Y) is said to cause CDS spread (X) in variance if the former variable has predictive power for forecasting the variance for the latter variable.

Unlike the cross-correlation function (CCF) tests proposed by Cheung and Ng (1996) and Hong (2001), which are not only sensitive to the order of leads and lags but also suffer from oversizing in small and medium samples when the volatility process is leptokurtic, Hafner and Herwartz (2006) propose a causality test based on the LM and show, using Monte Carlo simulations, that this causality test is preferable for applied work. The LM test is applied in two steps. First, a univariate GARCH-based model is estimated for each return series. In this regard, two univariate models are considered for the conditional variance process: a standard GARCH model (Bollerslev, 1986) and an asymmetric GARCH model (Glosten, Jagannathan, & Runkle, 1993) known as a GJR-GARCH. Along the lines of Beine and Laurent (2003), the order of the Autoregressive (AR) specification in the mean equation, as well as the type of GARCH formulation and its related density are selected by relying on Schwarz information criterion (SIC). The latter leads to a parsimonious specification. This step is important in selecting the best fitted models; according to Javed and Mantalos (2011), misspecification in fitting a GARCH-based model can undermine the efficiency of the related estimators, leading to spurious or missed causalities. Second, standardized squared residuals, conditional variance, and GARCH derivatives are extracted from the first step estimation and used to construct an LM test statistic in line with Hafner and Herwartz (2006). This is done in order to test the null hypothesis that the variance of commodity returns has no predictive power in forecasting the variance of sovereign CDS spreads.

By letting R_t $(R_{c,t}, R_{\text{cds}})'$ be a vector of daily returns of the commodity price index (c) and daily changes of the CDS spread (cds) in day t, respectively, the asymmetric AR(k)-GJR-GARCH(p,q) model is specified as:

$$\begin{cases} R_t = \varphi_0 + \sum_{i=1}^{k} \varphi_i R_{t-i} + \varepsilon_t \\ h_t = \omega + \sum_{i=1}^{p} \alpha \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta\, h_{t-j} + \sum_{j=1}^{q} d \varepsilon_{t-j}^2 I_{\varepsilon<0}\ (\varepsilon_{t-j}) \end{cases} \tag{1}$$

In the conditional mean equation, R_t is the daily return/change on each price series on day t, R_{t-i} is the lagged daily return/change on each price series, and ε_t is the disturbance term. Note that in order to control for potential autocorrelation in the data series, the lagged return/change term is included in the mean equation for each data series.

Also, in the conditional variance equation, h_t represents a 2×1 vector of daily conditional variances of $R_{c,t}$ and R_{cds} at time t, respectively, α the ARCH term which measures the impact of past innovations on current variance, and β the GARCH term that measures the impact of past variance on current variance. The degree of persistence of the variance shock is measured by the sum of the ARCH and GARCH parameters $(\alpha + \beta)$. To ensure stationarity and stability, the standard GARCH process $(\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta \sigma_{t-j}^2)$ must respect the following constraints: $\omega > 0$; $\alpha \geq 0$; $\beta \geq 0$; $\alpha + \beta < 1$.

In the asymmetric GJR-GARCH process, I is a dummy variable that measures the asymmetric response of the conditional variance to an unexpected price decrease. I takes a value of 1 in response to negative shocks and 0 in response to positive shocks. A positive and significant value of d indicates that a negative shock increases future conditional variance more than a positive shock of the same magnitude. For stationarity and stability of the asymmetric process, the following constraints must be respected: $\omega > 0$; $\alpha \geq 0$; $\beta \geq 0$; $\beta + d \geq 0$; $\alpha + \beta + 0.5\, d < 1$.

Using the maximum likelihood approach, the conditional volatility is estimated using three probability distributions: normal, t-distribution, and the generalized error distribution (GED). To ensure that the conditional variance process fits well with the data series, Box–Pierce diagnostic tests for the squared residuals for each selected model are employed.

For the second step of the LM test, the null hypothesis of non-causality in variance is given by:

$$\mathrm{H}_0 : \mathrm{Var}(\varepsilon_{\text{cds},t} | E_{t-1}) = Var(\varepsilon_{\text{cds},t} | F_{t-1})$$

where $E_t = \{R_{\text{cds},t-f}; f \geq 0\}$ and $F_t = \{R_{\text{cds},t-f}, R_{c,t-f}; f \geq 0\}$, representing the information set at time t_{-1} based on past CDS changes (E_t) and on both the changes in CDS spread and commodity returns (F_t), respectively. $Var(\varepsilon_{\text{cds},t} | F_{t-1})$ in this specification denotes the GARCH variance given the CDS-based information at time $t-1$.

Hafner and Herwartz (2006) show that the null hypothesis of non-causality in variance can be tested by H_0: $\pi = 0$ in $\varepsilon_{\text{cds},t} = \xi_{\text{cds},t} \sqrt{h_{\text{cds},t} g_t}$, where $g_t = 1 + z_{c,t}' \pi$ and $z_{c,t} = (\varepsilon_{c,t-1}^2, h_{c,t-1})'$. In this specification $\xi_{\text{cds},t}$ and $h_{\text{cds},t}$ denote the standardized residuals and the conditional variance for CDS series, respectively. Similarly, $\varepsilon_{c,t-1}^2$ and $h_{c,t-1}$ denote the squared disturbance term and the conditional variance for commodity return series. The null hypothesis of non-causality in variance (H_0: $\pi = 0$) against the alternative hypothesis (H_1: $\pi \neq 0$) implies the lack of volatility spillover effects from commodity returns to CDS spreads, suggesting non-causality in variance. In other words, the null hypothesis of $\pi = 0$ suggests that the information contained in commodity returns has no predictive power for forecasting the variance for CDS changes. The null hypothesis is then tested using the LM statistic (λ_{LM}) given by:

$$\lambda_{\text{LM}} = \frac{1}{4T} \left(\sum_{t=1}^{T} \left(\xi_{\text{cds}t}^2 - 1 \right) z_{ct}' \right) V(\theta_i)^{-1} \left(\sum_{t=1}^{T} \left(\xi_{\text{cds}t}^2 - 1 \right) z_{ct} \right) \xrightarrow{d} \text{Chi-square} \tag{2}$$

where $V(\theta_i) = \frac{n}{4T} (\sum_{t=1}^{T} z_{ct} z_{ct}' - \sum_{t=1}^{T} z_{ct} x_{\text{cds}t}' (\sum_{t=1}^{T} x_{\text{cds}t} x_{\text{cds}t}')^{-1} \sum_{t=1}^{T} x_{\text{cds}t} z_{ct}')$, $n = \frac{1}{T} \sum_{t=1}^{T} (\xi_{\text{cds}t}^2 - 1)^2$ Hafner and Herwartz (2006) show that λ_{LM} follows an asymptotic Chi-square distribution with two degrees of freedom. The LM statistic (λ_{LM}) is obtained by:

a. Estimating the univariate GARCH model for series c and cds for $\varepsilon_{c,t}$ and $\varepsilon_{cds,t}$ and obtaining the standardized residuals ($\xi_{\text{cds},t}$), the volatility process ($h_{c,t}$) while entering $z_{c,t}$, and the derivatives ($x_{\text{cds},t}$) where $x_{\text{cds},t} = h_{\text{cds},t}^{-1} (\frac{\partial h_{\text{cds},t}}{\partial \theta \text{cds}})$, $\theta_{\text{cds}} = (\omega_{\text{cds}}, \alpha_{\text{cds}}, \beta_{\text{cds}})'$.
b. Regressing $\xi_{\text{cds},t}^2 - 1$ on $(x_{\text{cds},t})'$ and the misspecification indicators in $(z_{c,t})'$.
c. Estimating λ_{LM} as the (number of observations) $\times R^2$ where R^2 is the goodness of fit measure for the regression in (ii).

4. Data

The sovereign CDS spreads data are gathered from Datastream. The CDS data consist of daily changes in sovereign CDS mid-spreads of contracts with five years to maturity, which is typically the most liquid contract. The daily changes in CDS spreads are expressed in basis points (bps). Due to liquidity issues, and to examine the latest changes in oil and commodity prices, the sample period is selected to be from June 2, 2010 to July 27, 2016.[1] We also ensure that it doesn't overlap with the global financial crisis of 2008–2009. The entire sample is divided into two sub-samples relating to before and after the recent slide in crude oil and commodities prices in 2014 (subsample 1 spans from June 2, 2010 to May 30, 2014, whereas subsample 2 spans from June 1, 2014 to July 27, 2016). Since some of the contracts can be illiquid, only countries with >85% of available data are included in the sample. As such, our sovereign CDS spreads sample consists of 23 emerging and frontier economies. For a comparative analysis, the sample is divided between emerging and frontier economies as first done by Morgan Stanley Capital International (MSCI). Accordingly, the final sample consists of 17 emerging (Brazil, Chile, China, Colombia, Costa Rica, Hungary, Indonesia, South Korea, Malaysia, Mexico, Panama, Peru, Philippines, Russia, South Africa, Thailand, Turkey), and six frontier economies

[1] We ensure that each of the two subsample periods includes at least 500 observations. This is in lines with Hwang and Pereira (2006) who highlight the difficulty in obtaining reliable GARCH estimates in a sample that contains <500 observations.

Table 1
Commodity exports per country.

	Commodity exports as % of merchandise exports	Commodity exports as % of GDP	Exports by commodity group			
			All food items	Agricultural raw materials	Fuels	Ores, metals, precious stones, non-monetary gold
Emerging countries						
Brazil	65	6.8	52	6	14	28
Chile	87	24.7	23	7	1	69
China	8	2.5	29	6	23	42
Colombia	83	13.2	11	3	79	7
Costa Rica	24	5.8	91	5	0	4
Hungary	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Indonesia	64	13.6	28	9	51	12
South Korea	64	n.a.	7	2	66	25
Malaysia	39	28.5	31	6	55	8
Mexico	25	7.7	24	1	54	21
Panama	50	19.2	35	3	49	13
Peru	88	18.6	18	1	14	67
Philippines	21	4.2	48	5	16	32
Russia	60.5	n.a.	1	2.5	50.3	6.6
South Africa	60	13.4	15	3	16	65
Thailand	29	16.7	45	17	22	16
Turkey	25	4.7	42	2	18	38
Frontier countries						
Croatia	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Cyprus	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
El Salvador	29	6.4	81	3	8	8
Kazakhstan	70.5	n.a.	4.3	1.3	53.3	11.7
Venezuela	85	20.2	2	0	95	3
Vietnam	32	24	53	11	33	3

Source: UNCTAD (2014) http://unctad.org/en/PublicationsLibrary/suc2014d7_en.pdf. Russia and Kazakhstan data is obtained from http://www.imf.org/external/pubs/ft/weo/2015/02/.

(Croatia, Cyprus, El Salvador, Kazakhstan, Venezuela, Vietnam). The main commodity-related exports of each of these countries as a percent of GDP and as a percent of exports can be found in Table 1.[2]

Commodity exports account for over 80% of merchandise exports in Chile, Colombia, Peru and Venezuela. Other countries with substantial portion of commodities in exports are Kazakhstan, South Africa, Russia, South Korea, Indonesia and Brazil. For most of these countries, commodity exports also are responsible for >10% of GDP. When looking at the exports by commodity group, food items are the majority of exports in Costa Rica, El Salvador and Guatemala, with 91, 81 and 77% of commodity exports, respectively. Fuels are over 95% of Venezuela's commodity exports, followed by 79% for Colombia. Other countries with larger percentage of commodity exports concentrated in fuels are Kazakhstan, Russia, Mexico, Malaysia, South Korea and Indonesia. The last commodity group listed in Table 1 is ores, metals, stones and non-monetary gold. The countries with highest percentage exports of commodities from that group are Chile, Peru and South Africa.

The Commodity Research Bureau (CRB) indices (i.e., Thomson Reuters/CoreCommodity CRB Index (TR CC CRB Index), Thomson Reuters Equal Weight Commodity Index (TR EW index) and seven Thomson Reuters CRB sub-indices (energy, grain, industrials, live, precious metals, and soft)) are collected from DataStream. The decomposition of each of the main commodity indexes (the TR CC CRB Index and the TR EW Index) can be found in Table 2. The weight assigned to each of the commodities differs from one index to another. The weight of energy commodities (crude oil, natural gas, heating oil, and RBOB gasoline) in the TR CC CRB Index is 39% and the weight of agriculture is 41%, while precious metals and industrial metals comprise 7 and 13% of the index, respectively. The TR EW Commodity Index includes 17 commodities and they all have a 5.88% weight in the index. The energy commodity group accounts for only 18% of the TR EW Commodity index, while metal, agriculture and soft commodities have a weight of 24, 29 and 29%, respectively. The TR CC CRB Index is rebalanced at the end of the sixth business day each month. To compute the index, a performance series is calculated for each commodity using the price of the front and back month futures contract and the weight of the front and back month futures contract. The front month is the futures contract closest to expiration. The contracts roll over from the front to the back contract

Table 2
Commodities index composition.

TR CC CRB Index			TR EW commodity index		
Group	Component	Weight (%)	Group	Component	Weight (%)
Energy			Energy		
	Crude oil	23		Crude oil	5.88
	Natural gas	6		Natural gas	5.88
	Heating oil	5		Heating oil	5.88
	RBOB Gasoline	5	**Total**		**18**
Total		**39**			
Agriculture			Agriculture		
	Corn	6		Corn	5.88
	Soybeans	6		Soybeans	5.88
	Live cattle	6		Wheat	5.88
	Sugar	5		Live cattle	5.88
	Cotton	5		Lean hogs	5.88
	Coffee	5	**Total**		**29**
	Cocoa	5	Softs		
	Wheat	1		Cocoa	5.88
	Orange juice	1		Coffee	5.88
	Lean hogs	1		Cotton	5.88
Total		**41**		Sugar	5.88
Precious metals				Soybean oil	5.88
	Gold	6	**Total**		**29**
	Silver	1	Metals		
				Gold	5.88
Total		**7**		Silver	5.88
Base/industrial metals				Copper	5.88
	Aluminum	6		Platinum	5.88
	Copper	6	**Total**		**24**
	Nickel	1			
Total		**13**			

[2] Source http://unctad.org/en/PublicationsLibrary/suc2014d7_en.pdf.

during the first four business days of each month. The weight of the commodities in the TR EW Commodity Index is maintained daily to the target equal weight and the averaging includes two to five futures contracts for each commodity. The rollover takes place six times a year during the week preceding the second Friday of the months of January, February, April, June, August and November. All commodities indexes and sub-indices enter the equation in the form of daily logarithmic returns.

Table 3 presents the summary statistics for the five-year CDS spread changes in basis points and the logarithmic returns in percent for the commodity indices and sub-indices. Compared to the CDS spreads, the commodity indices and sub-indices have lower standard deviation in the full sample (Panel A). As for the third and fourth moments of the return distribution, most of the CDS spreads are more skewed and leptokurtic than the commodity indices and sub-indices return and the normal return distributions. Notably, in sub-sample 2 (Panel C) the mean of the CDS spreads is positive in most cases, whereas in sub-sample 1 (Panel B) they are negative in several cases. Venezuela has the highest mean credit spread change in sub-sample 2, with a daily average of 5.81 basis points. The mean return of almost all commodities over the 2010–2014 period is positive (with the exception of the precious metals index), while the mean over the second subsample is negative over the 2014–2016 period. While the standard deviation of commodity indices and sub-indices doesn't differ a lot across the full sample and the two sub-samples, the situation is completely different for the CDS spreads changes; in fact, the standard deviation is relatively higher in sub-sample 2 during which energy and commodity prices dropped. We also noticed higher values for the kurtosis in sub-sample 2 as compared to sub-sample 1. To assess whether the data is stationary or not, the null hypothesis of the existence of a unit root is tested. Results of the augmented Dickey–Fuller unit root tests with intercept, which are not reported here but are available from the authors, show that all series are stationary. The application of this test is a necessary prerequisite to ensure reliable estimates of the GARCH models.

5. Empirical results

5.1. Univariate volatility processes

In order to fit the appropriate univariate model to each data series the best AR(k)-(GJR)GARCH(p,q) models is selected based on AIC. According to the results presented in Table 4, the AR(1)-GARCH(1,1) model is selected for the TR CC CRB Index and the CRB industrial metal index, the GJR-GARCH(1,1) model for the equal weight CRB index, the CRB grains and oilseed index and the CRB livestock index, the AR(1)-GJR-GARCH(1,1) model for the energy index and the precious metal index and the GARCH(1,1) model for the soft commodities index. As for CDS data series, the asymmetric GARCH model is selected in 11 out of 23 instances, the asymmetric AR-GARCH-based model is chosen in six instances, the standard AR-GARCH-based model is the appropriate choice for one of the cases and the GARCH model in the remaining five cases.[3] The variance equations show a good fit for most series. Six of the coefficients for the lagged terms of the mean equation estimates are found to be significant while the ARCH term is significant for 26 of the series (all countries and the CRB index, the EW Commodity index and the CRB soft commodities index) and the GARCH term under all instances, suggesting the presence of ARCH and GARCH effects for most data series. Whereas high ARCH values indicate high short-term persistence of the conditional variance, a slow change of the conditional variances, large GARCH values imply more persistence in the long-term.

The stationarity condition for the univariate processes is respected, i.e., for the case of symmetric GARCH model: $\alpha + \beta < 1$ and for the asymmetric GARCH model: $\alpha + \beta + 0.5\, d < 1$, indicating that the conditional variance is stationary. This is also true for the stability conditions given that the constant, ARCH, and GARCH terms are positive in the variance equation.

Finally, diagnostics results clearly indicate that autocorrelation and heteroscedasticity are present in several of the estimated models. Results of the Ljung–Box Q-statistic at a lag length of 9 show that the autocorrelation of the original series is not removed after applying the AR(1) filters in the case of the CRB energy index, CRB precious metals index, CRB soft commodity index, Brazil, Colombia, Costa Rica, Croatia, Hungary, Kazakhstan, Malaysia, Panama, Peru and Vietnam. The presence of autocorrelation is a clear sign that the countries possess inefficient CDS markets in which investors can exploit predictable changes in sovereign CDS.[4]

5.2. Causality in variance test

Having estimated the best fitted univariate AR(k)-(GJR)GARCH (p,q) models, we apply the Hafner and Herwartz (2006) causality in variance test. The results are presented in Table 5 and discussed below.

5.2.1. CRB-to-country CDS effects

As evidenced by the significance of LM statistic estimates, the results from Table 5 Panel A show a volatility transmission from the CRB index to 10 out of 17 CDS series of emerging economies. Over the full sample, the volatility of the TR CC CRB Index causes the volatility of emerging economies' CDS spreads in all cases except for Brazil, Chile, Colombia, Indonesia, South Korea, Panama and the Philippines. The causality results for the full sample for the frontier economies suggest a lack of evidence of significant volatility transmission in the case of four out of six countries. Panel B and Panel C report the causality in variance results for subsamples 1 and 2, respectively. While the results in subsample 1 are generally in line with the full sample results, in the second subsample we see weaker volatility spillover from the commodity index to the country credit spread changes. A notable exception is Venezuela, where we find no evidence in spillover prior to mid-2014 and highly significant results during the recent slump in crude oil prices. This finding is probably due to the fact that the oil/commodity sector accounts for a significant portion of the GDP in this country. Accordingly, oil/commodity price fluctuations probably have direct effects, on not only macroeconomic variables, but also on corporate profits. In Table 5, we also report the LM statistics from a model including the TR EW Commodity Index, which has lower weight of energy commodities. The full sample results utilizing the equally weighted-index are very similar to the full sample results using the TR CC CRB Index as evidenced in Panel D of Table 5.

Even though we document significant volatility spillover effects from commodity index returns to 5-year sovereign CDS spreads, as is the case of most of the countries examined, based on our study and the particular period covered, in some instances this connection cannot be made. In the case of Chile, Indonesia, South Korea, Panama, Philippines, Cyprus, El Salvador and Kazakhstan, no significant spillover effect between these credit spreads and the CoreCommodity CRB index is identified. Although Sharma and Thuraisamy (2013) find that oil price uncertainty predicts out-of-sample CDS returns for six Asian countries, possible reasons for changes in sovereign CDS in our sample could be

[3] The asymmetric GARCH based models is utilized in the case of Chile, Colombia, EL Salvador, Hungary, Kazakhstan, Malaysia, Mexico, Panama, South Africa, Thailand and Vietnam. The asymmetric AR-GARCH based models is utilized in the case of Brazil, Croatia, Indonesia, South Korea, Philippines and Venezuela. The GARCH model is used in the case of China, Costa Rica, Peru, Russia and Turkey. Finally, the standard AR-GARCH-based model is the appropriate only in the case of Cyprus.

[4] Bystrom (2005) and Pereira da Silva, Rebelo, and Afonso (2014) found the presence of autocorrelation in the European CDS market while Sharma and Thuraisamy (2013) reported the existence of autocorrelation in the second order of eight Asian countries.

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Table 3
Summary statistics.

	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis
Panel A: Full sample (June 2, 2010–July 27, 2016)						
Commodity indices returns						
CC CRB Index	−0.005	0.034	−0.043	0.008	−0.307	5.495
Equal weight commodity index	−0.021	0.045	−0.050	0.010	−0.234	5.200
CRB energy index	−0.028	0.088	−0.089	0.017	−0.072	6.033
CRB grains and oilseed index	−0.002	0.069	−0.062	0.014	0.078	5.376
CRB industrial metals index	−0.012	0.046	−0.093	0.012	−0.677	7.766
CRB livestock index	0.001	0.048	−0.045	0.009	−0.215	5.095
CRB precious metals index	−0.004	0.052	−0.105	0.014	−0.829	8.218
CRB softs index	0.009	0.048	−0.048	0.011	0.020	4.162
Emerging countries changes in CDS spreads						
Brazil	0.087	38.460	−83.957	7.090	−0.738	19.206
Chile	−0.007	32.989	−20.715	3.389	0.727	13.607
China	0.017	24.930	−19.553	3.286	0.583	11.436
Colombia	0.017	34.971	−34.800	5.123	0.093	9.328
Costa Rica	0.155	198.460	−215.290	15.272	−0.446	82.946
Hungary	−0.075	99.000	−62.050	8.182	1.691	29.115
Indonesia	−0.014	45.000	−28.462	6.058	0.495	11.546
Korea	−0.058	29.001	−25.514	3.368	0.258	16.731
Malaysia	0.017	31.220	−25.620	4.131	0.473	11.331
Mexico	0.008	28.000	−22.299	4.053	0.261	7.807
Panama	0.011	30.973	−21.207	4.164	0.372	8.897
Peru	−0.005	29.964	−25.570	4.577	0.224	8.321
Philippines	−0.046	32.000	−26.439	4.011	0.157	12.568
Russia	0.019	110.150	−85.620	13.334	0.167	15.345
South Africa	0.039	42.720	−29.402	5.482	0.208	9.249
Thailand	−0.035	23.701	−27.028	3.618	0.339	11.470
Turkey	0.041	36.840	−39.521	5.917	0.033	8.156
Frontier countries changes in CDS spreads						
Croatia	−0.006	77.010	−40.250	6.376	1.126	22.760
Cyprus	0.069	374.465	−305.070	24.447	2.783	79.102
El Salvador	0.080	170.580	−98.060	12.787	0.893	39.154
Kazakhstan	−0.004	63.560	−42.330	6.488	0.859	16.957
Venezuela	1.749	1193.821	−2230.832	176.753	−1.268	32.633
Vietnam	−0.040	43.966	−33.275	5.368	0.362	13.069
Panel B: subsample 1 (June 2, 2010–May 30, 2014)						
Commodity indices returns						
CC CRB index	0.017	0.034	−0.043	0.008	−0.473	6.139
Equal weight commodity index	0.019	0.045	−0.05	0.009	−0.468	6.322
CRB energy index	0.034	0.069	−0.083	0.014	−0.345	6.139
CRB grains and oilseed index	0.031	0.069	−0.062	0.015	0.046	5.483
CRB industrial metals index	0.003	0.046	−0.093	0.014	−0.803	7.522
CRB livestock index	0.039	0.037	−0.032	0.008	−0.193	4.907
CRB precious metals index	−0.002	0.052	−0.105	0.014	−1.109	8.762
CRB softs index	0.015	0.048	−0.048	0.011	−0.017	4.316
Emerging countries changes in CDS spreads						
Brazil	0.005	32.020	−20.712	4.510	0.498	9.005
Chile	−0.025	32.989	−20.715	3.359	1.169	18.299
China	−0.008	24.930	−19.553	3.517	0.631	11.574
Colombia	−0.080	34.971	−28.031	4.452	0.489	12.849
Costa Rica	0.080	62.620	−67.740	9.290	−0.078	15.356
Hungary	−0.084	99.000	−62.050	9.948	1.424	20.395
Indonesia	−0.039	45.000	−28.462	6.458	0.618	12.056
Korea	−0.085	29.001	−25.514	3.930	0.230	13.590
Malaysia	−0.020	30.000	−20.899	3.629	0.734	13.213
Mexico	−0.061	28.000	−22.299	3.725	0.567	10.384
Panama	−0.045	30.973	−21.207	4.049	0.616	11.671
Peru	−0.051	29.964	−23.802	4.443	0.515	9.744
Philippines	−0.083	32.000	−26.439	4.531	0.151	11.179
Russia	−0.016	60.210	−58.890	7.815	0.211	19.416
South Africa	−0.010	33.440	−29.402	4.937	0.047	9.446
Thailand	−0.025	23.701	−27.028	3.842	0.216	11.366
Turkey	−0.025	36.840	−39.521	6.047	0.054	9.359
Frontier countries changes in CDS spreads						
Croatia	0.013	77.010	−40.250	7.552	1.019	17.486
Cyprus	0.209	374.465	−305.070	29.463	2.312	57.053
El Salvador	0.121	170.580	−85.310	14.405	1.279	33.844
Kazakhstan	−0.070	37.840	−42.330	6.073	0.118	9.924
Venezuela	−0.439	116.730	−107.780	25.944	0.111	5.602
Vietnam	−0.046	43.966	−33.275	6.077	0.336	11.561
Panel C: subsample 2 (June 1, 2014–July 27, 2016)						
Commodity indices returns						
CC CRB Index	−0.048	0.022	−0.026	0.007	0.110	3.250
Equal weight commodity index	−0.094	0.039	−0.047	0.011	0.086	3.997

Table 3 (*continued*)

	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis
CRB energy index	−0.143	0.088	−0.089	0.022	0.148	4.515
CRB grains and oilseed index	−0.063	0.063	−0.049	0.013	0.119	4.572
CRB industrial metals index	−0.039	0.037	−0.036	0.010	0.078	4.151
CRB livestock index	−0.071	0.048	−0.045	0.010	−0.131	4.573
CRB precious metals index	−0.010	0.044	−0.044	0.012	0.204	4.360
CRB softs index	−0.001	0.031	−0.038	0.010	0.107	3.572
Emerging countries changes in CDS spreads						
Brazil	0.239	38.460	−83.957	10.290	−0.804	11.818
Chile	0.026	14.730	−16.647	3.446	−0.036	5.759
China	0.063	17.360	−14.411	2.809	0.398	8.475
Colombia	0.196	25.570	−34.800	6.179	−0.230	6.223
Costa Rica	0.294	198.460	−215.290	22.506	−0.403	49.523
Hungary	−0.060	31.610	−17.950	2.759	2.395	40.418
Indonesia	0.032	30.050	−25.233	5.242	0.054	7.383
Korea	−0.009	12.100	−10.136	1.931	0.557	9.580
Malaysia	0.087	31.220	−25.620	4.931	0.233	8.767
Mexico	0.134	19.330	−21.718	4.602	−0.078	5.200
Panama	0.114	16.570	−17.655	4.371	0.002	5.039
Peru	0.080	18.900	−25.570	4.818	−0.209	6.336
Philippines	0.022	18.520	−15.111	2.804	0.251	8.996
Russia	0.084	110.150	−85.620	19.870	0.112	8.040
South Africa	0.129	42.720	−27.320	6.375	0.321	8.142
Thailand	−0.055	20.370	−15.482	3.164	0.722	10.209
Turkey	0.162	23.630	−25.210	5.671	−0.003	5.176
Frontier countries changes in CDS spreads						
Croatia	−0.042	23.605	−19.800	3.210	0.433	17.716
Cyprus	−0.190	146.590	−48.790	9.822	6.197	98.123
El Salvador	0.005	63.430	−98.060	9.061	−2.405	42.456
Kazakhstan	0.117	63.560	−40.840	7.197	1.654	22.578
Venezuela	5.810	1193.821	−2230.832	296.721	−0.807	11.804
Vietnam	−0.030	23.010	−17.633	3.714	0.406	9.219

political crises, economic slowdown, changes in monetary policy, economic growth prospects, and stock price volatility.[5]

Between 2014 and 2016, investors had to deal with diverging forces that influenced volatility spillovers, such as the slowdown of the Chinese economy and the US Federal Reserve's expected rise in interest rates. Furthermore, China's stock market crash, its downbeat economic data and weakening of its real estate market caused the government to devalue its currency, which ultimately affected Indonesia's, South Africa's and Vietnam's CDS markets. A weak GDP growth in Indonesia was also observed during this same period. Similarly, an increase in US interest rates lead investors to worry about the possible diversion of funds from emerging markets to the US. Conversely, lower commodity and energy prices had probably positive effects on the trade balance, public finance, and thus sovereign CDS, suggesting weaker volatility spillovers from commodities to the CDS changes of China (one of the largest consumers of oil and gold).[6]

Geopolitical events between Turkey and Syria have caused bondholders to exit the Turkish sovereign bond market in 2015, a situation that was not helped by Turkey's president confrontational stance against the country's central bank. In the case of Brazil, changes in CDS spreads could be due to a shortage of confidence attributable to their ongoing currency, economic and political crisis. These crises can further be ascribed to the stagnant growth outlook, the sell-off in the markets, failure to enact fiscal reforms, decline of the real and scandals in the state-run oil company, among others, that Brazil experienced during the period under study. However, the credit market in Brazil has reacted positively to the impeachment process against President Dilma Rousseff that started in late 2015 and ended in the summer of 2016[7]; in addition, the lack of significant volatility spillover from commodities to Brazil can be explained by the fact that Brazil is well positioned in term of a large stock of foreign reserves and a low public external debt burden that may provide a buffer against a credit event (BMI Research, 2016). Also, the Argentina's comeback to the international bond market has probably led to a lower credit risk in Brazil, Colombia, Peru and Chile (Mehta, 2016).

5.2.2. Sector indices to CDS spreads effects

The volatility transmission from different commodity sector indices to sovereign CDS spreads is investigated next. Table 6 reports the causality-in-variance results over the full sample using energy, grains and oilseed, industrial metals, livestock, precious metals and softs commodity sub-indices. The sub-indices that appear most significant in influencing the variance of sovereign spreads are energy and precious metals. The significant LM statistic for the energy index for almost all emerging and frontier markets can be partly attributed to the role of fuel exports in some countries, a finding similar to that shown by Pavlova and de Boyrie (2016). We also find that in the case of countries such as Peru and South Africa, whose percentage of exports of ores, metals, precious stones and non-monetary gold is over 60% of exports, the LM statistic is significant as expected. However, the volatility spillover appears to affect other emerging and frontier markets, even if they are not predominantly exporting a particular commodity. For instance, even though commodity exports are only 2.5% of GDP and 8%

[5] Using sovereign bond spreads to find the determinants a country's risk premium, Baldacci, Gupta, and Mati (2011) find that low levels of political risk and efforts at financial consolidation reduce the sovereign bond spread. Especially during times of financial turmoil. Csontó (2014) finds that the global financial conditions affects emerging market sovereign bond spreads during periods of high volatility. Bystrom (2005) show evidence of the existence of a strong positive correlation between stock price volatility and the iTraxx CDS index market spread. For the period between 2001 and 2007, Chan, Fung, and Zhang (2009), report a negative correlation between the stock index and CDS spreads for several of the Asian countries under study.

[6] We also assessed whether the volatility of sovereign CDS markets has increased or decreased in subsample 2 (June 2014 to July 2016) by estimating an extended GARCH-based model that includes a dummy variable that takes the value of one during the period June 2014–July 2016, and zero otherwise. The results, which are not reported here but are available from the authors upon request, show that in this subsample the volatility of CDS changes increased in the case of Brazil, Chile, Russia, Cyprus, and Venezuela and decreased in the case of Hungary, South Korea, Philippines, Thailand, Croatia and El Salvador.

[7] "Markets see the ousting of Rousseff as a path that will ultimately lead to reforms needed to get the country out of recession" from: http://www.markit.com/Commentary/Get/19042016-Credit-Brazil-leads-as-credit-risk-in-Latam-region-recedes

Table 4
Estimated parameters from GARCH processes.

	CRB index	Equal weight CRB index	CRB energy index	CRB grains and oilseed index	CRB industrial metals index
Mean equation					
Constant	0.000	0.000	0.000	0.000	0.000
AR(1)	0.026	–	−0.049**	0.008	0.038
Variance equation					
Constant	0.000	0.000	0.000	0.000	0.000
ARCH	0.036***	0.022***	0.007	0.049	0.038
GARCH	0.958***	0.955***	0.972***	0.944***	0.955***
Asymmetric term	–	0.037***	0.039***	−0.009	–
Diagnostic test					
Ljung-Box (9)	4.317	4.417	9.627*	5.939	6.077
	CRB livestock index	CRB precious metals index	CRB softs index	Brazil	Chile
Mean equation					
Constant	0.000	0.000	0.000	0.040	0.000
AR(1)	–	−0.052**	–	0.102***	–
Variance equation					
Constant	0.000***	0.000	0.000	0.172***	0.122**
ARCH	0.001	0.047	0.037***	0.167***	0.221***
GARCH	0.930***	0.956***	0.941***	0.897***	0.852***
Asymmetric term	0.067***	-0.019	–	−0.130***	−0.146***
Diagnostic test					
Ljung-Box (9)	2.404	24.300***	8.528*	9.046*	1.911
	China	Colombia	Costa Rica	Croatia	Cyprus
Mean equation					
Constant	0.000	−0.006	0.000	0.000	0.000
AR(1)	–	–	–	0.000***	−0.62***
Variance equation					
Constant	0.333	0.217***	0.176***	0.565*	0.597***
ARCH	0.146***	0.191***	0.040***	0.061***	0.051***
GARCH	0.852***	0.885***	0.951***	0.997***	0.898***
Asymmetric term	–	−0.162***	–	−0.120***	–
Diagnostic test					
Ljung-Box (9)	4.011	8.886*	22.460***	66.49***	0.260
	El Salvador	Hungary	Indonesia	Kazakhstan	South Korea
Mean equation					
Constant	0.080***	0.000	0.000	0.000	0.000
AR(1)	–	–	0.005	–	0.000
Variance equation					
Constant	0.163***	0.769	0.089	5.373*	0.117**
ARCH	0.050***	0.143***	0.123***	0.474***	0.195***
GARCH	0.902***	0.999***	0.935***	0.999***	0.843***
Asymmetric term	0.050***	−0.287***	−0.118***	−0.953***	−0.079*
Diagnostic test					
Ljung-Box (9)	0.066	356.100***	6.378	11.240**	4.866
	Malaysia	Mexico	Panama	Peru	Philippines
Mean equation					
Constant	0.000	−0.010	0.000	−0.005	0.000
AR(1)	–	–	–	–	0.000
Variance equation					
Constant	0.103***	0.378***	0.203***	0.356***	0.835*
ARCH	0.112***	0.229***	0.232***	0.172***	0.195***
GARCH	0.942***	0.847***	0.846***	0.827***	0.863***
Asymmetric term	−0.112***	−0.177***	−0.158***	–	−0.117**
Diagnostic test					
Ljung-Box (9)	11.100**	7.540	15.870***	11.447**	5.925
	Russia	South Africa	Thailand	Turkey	Venezuela
Mean equation					
Constant	0.000	0.000	−0.97	0.000	−0.225
AR(1)	–	–	–	–	0.195***
Variance equation					
Constant	1.135***	0.392**	0.218***	0.661**	14.047***

Table 4 (*continued*)

	CRB index	Equal weight CRB index	CRB energy index	CRB grains and oilseed index	CRB industrial metals index
ARCH	0.165***	0.182***	0.208***	0.135***	0.219***
GARCH	0.833***	0.880***	0.859***	0.861***	0.859***
Asymmetric term	–	−0.126***	−0.138***	–	−0.158***
Diagnostic test					
Ljung-Box (9)	6.513	3.467	1.479	2.156	0.638

	Vietnam
Mean equation	
Constant	0.000
AR(1)	–
Variance equation	
Constant	1.571***
ARCH	0.073*
GARCH	0.999***
Asymmetric term	−0.147**
Diagnostic test	
Ljung-Box (9)	176.730***

This table presents the estimates for the AR-(GJR)GARCH model described in Eq. (1). Ljung-Box Q-statistics on standardized squared residuals test the null hypothesis of no autocorrelation up to order 9. ***, **, * indicate statistical significance at 1%, 5% and 10% levels, respectively.

of merchandise exports of China, the volatility of different commodity sectors appears to affect Chinese sovereign spreads volatility. Further investigation of this relation may be warranted, since studies have shown Chinese demand and macroeconomic factors in China to affect commodity markets (Yin & Han, 2016, among others).

Based on the empirical results, it can be argued that the information flows from commodities markets to sovereign CDS market have taken on a somewhat broader role, reflecting the market's expectations regarding deteriorating credit quality in emerging and frontier economies due to higher volatility in commodity prices. Some of these effects may also be attributed to the so-called financialization of commodities and the increased correlation between commodities, i.e. the recent decline of oil prices led to the decline of other commodity prices. The above-mentioned results are important to better understand the effects of declining commodity prices and the volatility that accompanied this decline on the volatility of sovereign CDS spreads of emerging and frontier economies.

6. Conclusion

Financial services companies such as Markit, Ltd., a global financial information and services company that provide daily credit default swap pricing, often cite a high correlation between changes in sovereign CDS spreads and changes in commodity prices. This sentiment is supported by Hilscher and Nosbusch (2010) who ascertain that an increase in the volatility of macroeconomic fundamentals can increase the

Table 5
Causality in variance test (aggregate Commodity index-to-country CDS Effects).

CC CRB Index-to-country CDS effects				Equal weight commodity index-to-country CDS Effects
Null hypothesis	Panel A: full sample LM statistic	Panel B: subsample 1 LM statistic	Panel C: subsample 2 LM statistic	Panel D: full sample LM statistic
Emerging countries				
CRB ⇏ Brazil	6.279	7.790*	2.321	7.045
CRB ⇏ Chile	3.412	6.168	6.783	4.227
CRB ⇏ China	15.042***	12.559**	6.176	17.762***
CRB ⇏ Colombia	4.327	10.053**	4.231	9.360**
CRB ⇏ Costa Rica	33.554***	782.569***	12.624**	44.749***
CRB ⇏ Hungary	22.808***	458.680***	6.090	9.013
CRB ⇏ Indonesia	3.492	2.948	1.457	4.779
CRB ⇏ South Korea	3.963	6.071	2.577	3.831
CRB ⇏ Malaysia	1530.761***	69.496***	6.759	1530.317***
CRB ⇏ Mexico	18.683***	2.878	14.375***	23.544***
CRB ⇏ Panama	3.089	3.992	2.013	5.911
CRB ⇏ Peru	13.340***	1012.006***	6.047	15.104***
CRB ⇏ Philippines	2.872	2.389	3.137	3.898
CRB ⇏ Russia	1287.281***	39.722***	125.590***	1284.811***
CRB ⇏ South Africa	10.715**	12.893**	10.018**	9.614**
CRB ⇏ Thailand	29.179***	18.650***	20.130***	25.505***
CRB ⇏ Turkey	1443.429***	707.109***	555.373***	1443.396***
Frontier countries				
CRB ⇏ Croatia	846.329***	876.105***	397.839***	829.525***
CRB ⇏ Cyprus	2.517	2.861	4.551	5.993
CRB ⇏ El Salvador	6.654	5.898	4.679	6.355
CRB ⇏ Kazakhstan	2.191	4.588	3.091	3.466
CRB ⇏ Venezuela	5.000	4.123	18.417***	9.122*
CRB ⇏ Vietnam	1260.891***	885.500***	3.303	1260.189***

The full sample spans from June 2, 2010 to July 27, 2016; subsample 1 spans from June 2, 2010 to May 30, 2014; subsample 2 spans from June 1, 2014 to July 27, 2016. The null hypothesis of no causality in variance is represented by the symbol "⇏". ***, **, * indicate a rejection of the null hypothesis at the 1%, 5% and 10% significance levels, respectively.

Table 6
Causality in variance test – CRB subindices-to-country CDS effects in the full sample.

Null hypothesis	Panel A: energy LM statistic	Panel B: grains and oilseed LM statistic	Panel C: industrial metals LM statistic	Panel D: livestock LM statistic	Panel E: precious metals LM statistic	Panel F: softs LM statistic
Emerging countries						
CRB $\nRightarrow$ Brazil	6.153	6.332	5.381	6.120	3.993	4.631
CRB $\nRightarrow$ Chile	66.594***	6.088	2.686	3.325	56.653***	3.911
CRB $\nRightarrow$ China	44.677***	17.997***	14.188***	16.902***	39.335***	16.364***
CRB $\nRightarrow$ Colombia	37.518***	7.600	3.546	8.306*	32.325***	6.490
CRB $\nRightarrow$ Costa Rica	35.504***	33.557***	32.827***	44.021***	33.518***	32.189***
CRB $\nRightarrow$ Hungary	12.540**	11.742**	21.928***	7.904*	10.579**	9.854**
CRB $\nRightarrow$ Indonesia	10.325**	4.075	2.625	3.780	8.053*	2.079
CRB $\nRightarrow$ South Korea	29.488***	5.008	3.238	2.982	25.355***	3.607
CRB $\nRightarrow$ Malaysia	1564.630***	1535.657***	1530.299***	1529.491***	1558.510***	1532.694***
CRB $\nRightarrow$ Mexico	21.111***	18.148***	17.930	22.609***	18.502***	16.681***
CRB $\nRightarrow$ Panama	18.169***	3.735	2.273	5.045	14.559***	2.248
CRB $\nRightarrow$ Peru	26.017***	18.237***	12.530**	14.274**	23.303***	16.300***
CRB $\nRightarrow$ Philippines	8.381*	5.441	2.080	3.015	5.263	3.384
CRB $\nRightarrow$ Russia	1287.432***	1287.625***	1286.971***	1283.916***	1285.271***	1282.931***
CRB $\nRightarrow$ South Africa	12.873**	5.047	10.036**	8.816**	11.412**	3.769
CRB $\nRightarrow$ Thailand	66.926***	26.529***	28.175***	24.610***	77.341***	25.486***
CRB $\nRightarrow$ Turkey	1446.609***	1446.332***	1442.998***	1442.687***	1443.758***	1442.690***
Frontier countries						
CRB $\nRightarrow$ Croatia	827.960***	845.065***	846.979***	828.765***	824.003***	840.425***
CRB $\nRightarrow$ Cyprus	33.725***	8.790*	1.687	5.153	28.290***	7.313
CRB $\nRightarrow$ El Salvador	31.705***	9.488**	5.948	5.454	26.469***	7.950*
CRB $\nRightarrow$ Kazakhstan	40.652***	4.607	1.389	2.624	34.458***	3.086
CRB $\nRightarrow$ Venezuela	7.834*	5.528	4.289	8.150*	5.105	4.106
CRB $\nRightarrow$ Vietnam	1261.777***	1263.643***	1260.368***	1259.318***	1259.282***	1261.699***

See notes to Table 5.

probability of sovereign debt default. Testing for causality in variance between the two variables using the Lagrange Multiplier (LM) methodology presented by Hafner and Herwartz (2006), this study finds that this relationship does not always hold. While studying the relationship between the CRB indices (i.e., the CC CRB Index, the EW Commodity Index, and six CRB sub-indices) and sovereign CDS spreads for 17 emerging and six frontier economies, it is determined that there is a significant volatility spillover between commodity prices and sovereign CDS spreads for most of the countries under study. The results, however, differ over time and by commodity sector, and are not directly proportional to the amount of commodity exports per country as a percent of exports or GDP. Even though the lack of contribution of commodities to the variance of sovereign spreads for some countries may seem surprising, given that some of these countries are major commodity importers or exporters, it is here put forth the idea that other factors such as political crisis, economic slowdown, changes in monetary policy which ultimately affected the currency value of a country, economic growth prospects, equity market volatility, as well as global economic factors could be the true drivers of volatility in the sovereign CDS spreads of these economies.

Studying intermarket linkages and information transmission is important from portfolio and risk management perspectives. Our results can help gauge which countries are more sensitive to commodity price volatility and how this sensitivity translates into increased credit risk. Our study also helps understand better some of the sources of this vulnerability in terms of the contribution of commodity-related exports.

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