Temporal dynamics of volatility spillover: the case of energy markets

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Overview

Volatility and the transmission of volatility, frequently referred to as volatility spillover, have been a debated topic within both the financial and commodity literature throughout the last decades. Understanding the dynamics of time-varying volatility transmission is crucial for investment allocation, asset valuation, risk management, and monetary policymaking (see e.g. Karyotis and Alijani, 2016; Andreasson et al., 2016). This paper examines the volatility spillover between the futures markets of five energy related commodities using daily data over the period from July 2001 to June 2016. Following Diebold and Yilmaz (2012) methodology (hereafter: DY), we show that spillover between energy commodities are relatively stable over time. However, during the financial and economic turmoil, the spillover increases significantly. Our findings indicate bidirectional volatility spillover between the energy commodities, which is consistent with the findings of Asche et al. (2012), indicating a long-run relationship between the energy markets. Additionally, as pointed out by Asche et al. (2012), it is important to understand the development of relationship between natural gas and coal, because natural gas is often considered a substitute to coal. Therefore, investigation of this relationship is of special interest. Finally, in harmony with the mainstream literature, our findings indicate that spillover from crude oil significantly affects the volatility in other energy commodities. In addition, our findings indicate that heating oil plays a significant role in volatility spillover in energy markets.

Methods

Existing literature on volatility spillover is mainly constrained to implementation of multivariate generalized autoregressive conditional heteroscedastic models (MGARCH). However, a key limitation of MGARCH is its inability to provide the direction of spillover. To overcome this limitation, we apply a methodology proposed by Diebold and Yilmaz (2012). DY is a variance decomposition of forecasted errors (FEVD) obtained from a generalized vector autoregressive model (VAR), which provides directional spillover.[1] Based on the log-returns of the five evaluated commodity prices, we fit a VAR(1) model in order to obtain the residuals for later decomposition. Our dataset consists of nearby futures prices of each commodity. Specifically, our sample encompasses of energy commodities trading on NYMEX/COMEX, namely, crude oil WTI (CL), natural gas (NG), coal (QL), gasoline (RB), and heating oil (HO). We extract daily data from the Commodity Research Bureau (CRB) database for the period of July 2001 to June 2016. We choose this span to include the period of financial crisis and the European debt crisis in our sample, which can further elucidate the spillover dynamics among the five selected commodities.

Results

Table 1 presents the total volatility spillover and the bidirectional spillover between the five energy commodities, which are based on the decomposition of 100-days-ahead error variances from the VAR(1). The total volatility spillover index indicates that on average 40.17% of the volatility in the energy commodities is cause by spillover. As can be seen from the table, crude oil is a significant transmitter of volatility, transmitting 67.22% to other energy commodities and receiving 60.88% in return. The net spillover is the difference between the volatility transmitted and the volatility received by a given commodity. For instance, crude oil is overall a net transmitter with a net spillover of 6.34% (= 67.22% − 60.88%), and thereby it gives away more volatility than it receives. The second largest net contributor is heating oil, contributing 5.23%. Regarding net receivers, coal is the largest receiver of volatility, receiving 6.34% more than it transmits to other commodities, followed by natural gas that receives 5.49%. The findings indicate that market participants need to pay close attention to the fluctuations in crude oil and heating oil prices as it can change the dynamics in other energy commodities. Regarding the relationship between coal and natural gas, we can see that none of these commodities is significant volatility transmitter or receiver from each other. This is interesting because coal often competes with natural gas as a fuel for power stations (Asche et al. 2012), and therefore we should expect some spillover between these commodities. However, there is considerable variation in the connectedness between the energy commodities across time. This temporal dynamic of volatility spillover cannot be discern from Table 1. For instance, while there is little connection between coal and natural gas on average, further analysis using time-varying DY reveals transitory spikes of increased connectedness between these two commodities – see Figure 1 (b). Figure 1 illustrates the temporal development of total volatility spillover index for the five commodities using a rolling window of 250-days in a VAR(1) model. The total volatility index provides information about the average spillover between commodities and it can be approximated through the ratio between the row sum (excl.) and row sum (incl.). On average, a negative trend in the total volatility spillover is apparent from the figure. An additional key finding is regarding

[1] We fit a VAR(1) model in order to obtain the residuals for decomposition. We select one lag by utilising the SBIC.

the spillover during the periods of financial and economic turmoil, which is apparent from the spikes during these periods indicating a higher total volatility spillover between these commodities during the economic downturn.

Table 1. Directional volatility spillover between energy commodities

Table shows all the possible bivariate relations of directional volatility spillover between the energy commodities. Each diagonal entry of the table shows the self-caused volatility within the given commodity. The sum (excluding diagonal entries) column displays the volatility received by the given commodity. The sum (excluding diagonal entries) row shows the spillover transmitted by a given commodity to the rest of the commodities. The net spillover is the difference between the column and row sum (Excl.), which is informative of whether the given commodity tends to receive more volatility than it does transmits. The total volatility index displays the average spillover between commodities and it can be approximated through the ratio between the row sum (excl.) and row sum (incl.).

To/From	Heating oil	Crude oil	Gasoline	Coal	Natural gas	Sum (Excl.)
Heating oil	39.53	31.50	26.49	1.94	0.54	60.47
Crude oil	31.14	39.12	27.22	2.31	0.21	60.88
Gasoline	27.68	28.79	41.29	1.98	0.26	58.71
Coal	4.27	5.06	4.14	86.10	0.42	13.90
Natural gas	2.62	1.87	1.66	0.76	93.09	6.91
Sum (Incl.)	105.23	106.34	100.81	93.11	94.51	
Sum (Excl.)	65.71	67.22	59.52	7.01	1.42	
Net spillover	5.23	6.34	0.81	-6.89	-5.49	
Total Spillover Index						40.17%

(a) total volatility index (b) pairwise spillover (Coal & Natural gas)

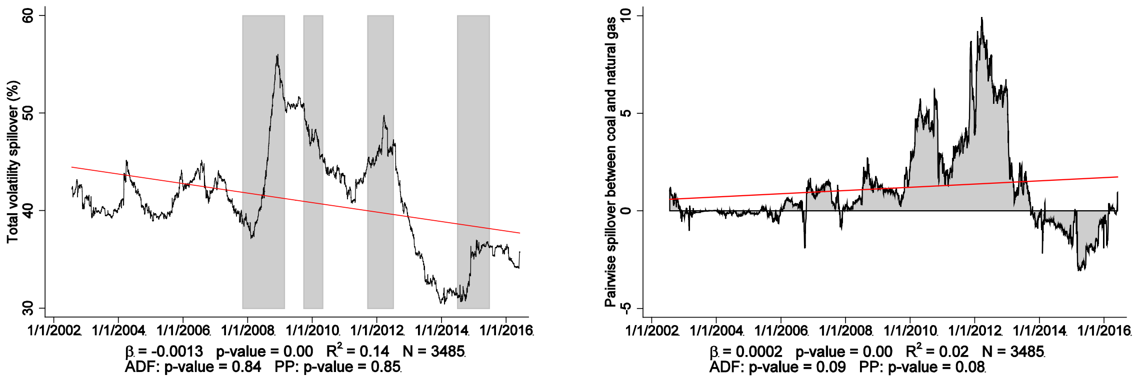

Figure 1. Development of total volatility spillover index (a) and pairwise spillover between coal and natural gas (b). The total volatility index provides information about the average spillover between commodities and it can be approximated through the ratio between the row sum (excl.) and row sum (incl.). The highlighted region in figure (a) displays the period of financial crisis (2008), two European debt crisis (2010 and 2012, respectively), and the decline in crude oil prices (2014-2015). Figure (b) is the net spillover between coal and natural gas. A gradual upward trend is apparent, which is augmented by the transitory spikes of increased connection between these two commodities.

Conclusion

Through our analysis, we find that most of the energy commodities are connected through volatility spillover. There are several noteworthy findings. First, the amount of spillover is time variant and appears to be decreasing throughout the sample period. Second, not all commodities are equally important. For instance, crude oil is a large net transmitter while coal is a net receiver. Third, during the period of financial and economic turmoil, the total volatility spillover between the energy commodities significantly increases. Finally, contrary to ex-ante expectations, there is no or little connection between coal and natural gas on average. However, taking the time-varying property of this relation into account, there are periods of increased spillover between coal and natural gas.

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