Volatility Spillovers in North American Energy Markets

Neil A Wilmot, University of Minnesota Duluth, 1-218-726-7439, nwilmot@d.umn.edu

Overview

The interconnectedness of global oil markets [Adelman (1992), Gulen (1999), Ewing and Harter, 2000 and Wilmot (2013)] and natural gas markets [Siliverstovs *et al*, 2005; Neumann, 2009; Li *et al*, 2014;] has received much of the focus in the literature. As well, the interconnectedness relationship between crude oil and natural gas markets has seen much scrutiny [Bachmeier and Griffen, 2006; Hartley *et al*, 2008; Brown and Yucel, 2008, 2009; Erdos, 2012] Many of the econometric studies examine the dynamic and distributional properties of price and/or returns. The natural next step is an examination of the second moment (volatility) of the distribution. Volatility transmission among the bench market crude oil series is the focus of Jin *et al* (2012) who find that Brent and Dubai are highly responsive to market shocks, while the WTI response is relatively muted. Barunik *et al* (2015) find substantial volatility spillovers in petroleum markets (crude oil, gasoline, heating oil) over the 1987 - 2014 period. Across energy markets, Karali and Ramirez (2014) study WTI futures prices and Henry Hub natural gas contracts, finding bi-direction spillover effects. Alternatively, Efimova and Serletis (2014), using a trivariate model (oil, natural gas and electricity price volatilities) find spillovers to be unidirectional, suggestive of a hierarchy of influence, from oil to gas.

In the current analysis, the analysis of volatility spillovers is extended beyond the traditional benchmark series, into the regional market – an unexplored realm. Specifically, interest lies in examining the the relationship between Canadian and U.S. energy commodities (Crude oil and natural gas). The focus herein is on the flow of volatility between the benchmark (US) energy commodities (crude oil and natural gas) and the regional (Canadian) energy commodity series. The US is home to the benchmark series of WTI and Henry Hub, yet both commodities play an important role north of the border as well. Canada is the world's top five energy producers (EIA, 2014) and is the principle supplier of energy imports to the United States (EIA, 2014). Canada is the world's fifth-largest oil producer, with much of that production deriving from the oil sands located in Alberta. Canada also ranks fifth in dry natural gas production, with all of Canada's current natural gas exports shipped to the US market via pipelines. As such, Canada is heavily reliant on and inevitably tied to the US market.

It is expected the recent developments in U.S. oil and natural gas markets pertaining to the dramatic increase in shale extraction would impact energy commodity markets, both domestically and abroad. Barunik *et al* (2015) demonstrate the relationship among petroleum commodities (crude oil, gasoline, heating oil) changed substantially after 2008, with an increase in the magnitude of the spillovers. Herein, particular interest lies in examining the impact these recent and rapid changes experienced in the U.S. energy markets have had on volatility relationships, within commodities, across commodities, and across countries. The high degree of interconnectedness between the United States and Canada, suggests that understanding volatility flows would be important for assessing, hedging and undertaking capital investment in both countries.

Methods

Using daily data on crude oil and natural gas (spot) prices, from both the United States and Canada, (2000 – 2014), a VAR-BEKK model is employed. The multivariate conditional volatility model, by Engle and Kroner (1995) allows for an examination of volatility transmissions within and between commodity markets, as well as within and between countries.

Results

Prior to the multivariate GARCH analysis, conventional tests were utilized to determine the existence of a unit root. The ADF, Phillips – Perron and KPSS tests indicate that the price returns (calculated as 1^{st} – differences) of the four series are stationary over the period of study. Additionally, univariate GARCH methods support the existence of a time-varying volatility in each of the series. The application of multivariate GARCH models suggests that volatility does spillover in North American energy commodity markets. The findings suggest that, within a commodity group (ie crude oil), volatility spillovers are bi-directional, while a difference in magnitude exists. As expected, the

benchmark markets have a greater impact on the regional markets. Across commodities, within a country, contrary results appear. That is, volatility does not appear to spill over between commodities prices in the US (WTI – Henry Hub), but do appear to spillover in the regional Canadian market. Additionally, the cross commodity and country results appear mixed, with some evidence that volatility is transmitted through the cross product of innovations as well as squared innovations.

Conclusions

This paper presents an empirical study of multivariate GARCH models to daily crude oil and natural gas price data from the beginning of 2000 through the end of 2014, with an emphasis on the post 2008 period. The multivariate GARCH results reinforce the hypothesis of a North American 'pool' for energy commodities, given the volatility spill overs that are observed.

References

Adleman, M.A. 1984. International oil agreements. *The Energy Journal*, 5(3): 1 – 9

Bachmeier, LJ and Griffen, J.M.. 2006. Testing for market integration crude oil, coal and natural gas. *The Energy Journal*, 27: 55 – 71

Barunik,J., Kocenda, E., and Vacha, L.. 2015. Volatility spillovers across petroleum markets. *The Energy Journal*, 36(3): 309 - 329

Bollerslev, T. 1986. Generalized autoregressive conditional heteroscedasticity. *Journal of Econometrics*. 31: 307 – 327

Brown, S.P.A. and Yucel, M.K.. 2008. What drive natural gas prices? *The Energy Journal* 29: 45 – 60.

Brown, S.P.A. and Yucel, M.K.. 2009. Market Arbitrage: European and North American Natural Gas Prices. *The Energy Journal*, 30: 167 – 185

Efimova,O., Serletis, A., 2014. Energy markets volatility modelling using GARCH. *Energy Economics* 43: 264 – 273.

(EIA) Energy Information Administration. 2014. Countries: Canada Overview. Available at: http://www.eia.gov/countries/country-data.cfm?fips=ca

Engle, R.F. and Granger, C.W.J. 1987. Cointegration and error correction: representation, estimation and testing. *Econometrica* 55, 251 – 276

Engle, R.F. and Kroner, K.F. 1995. Multivariate simulation generalized ARCH. *Econometric Theory* 11: 122 – 150

Ewing, B.T., Harter, C.L. 2000. Co-movemets of Alaska North Slope and UK Nrent crude oil prices. *Applied Economic Letters*, 7(8), 553 – 558.

Erdos, P. 2012. Have oil and gas prices got separated? *Energy Policy*, 49:707 – 718

Gulen, S.G. 1999. Regionalization in the World crude oil market: further results. *The Energy Journal*, 20, 125 – 139.

Hansen, P.R. Lunde, A., 2005. A forecast comparison of volatility models: does anything beat a GARCH(1,1)? *Journal of Applied Econometrics*. 20: 873 – 889

Hartley, P.R., Medlock, K.B.III, and Rosthal, J.E.. 2008. The relationship of natural gas to oil prices. *The Energy Journal*, 28: 47 – 65

Jin, X., Lin, S.X. and Tamvakis, M. (2012) Volatility transmission and volatility impulse response functions in crude oil markets. *Energy Economics*. 34(6): 2125 – 2134

Karali, B., Ramirez, O.A. 2014. Macro determinants of volatility and volatility spillovers in energy markets. *Energy Economics* 46: 413-421

Li, R., Joyeux, R. and R.D. Ripple. 2014. International natural gas market integration. *The Energy Journal*. 35: 159 – 179

Neumann, A. 2009. Linking natural gas markets – is LNG doing its job? *The Energy Journal*, 30: 187 - 199

Phillips, P.C.B., Perron, P., 1988 Testing for a unit root in time series regression. *Biometrika* 75, 335 – 346

Serletis, A., Shahmoradi, A., 2006. Measuring and testing natural gas and electricity markets volatility: evidence from Alberta's deregulated markets. *Studies in Nonlinear Dynamics and Econometrics* 10(3): Article 10

Siliverstovs, B., G. L'Hegaret, A. Neumann, C. von Hirschhausen. 2005. International market integration for natural gas? A cointegration analysis of prices in Europe, North America and Japan. *Energy Economics* 27(4): 603 – 615.

Wang, Y., Wu, C., 2012 Forecasting energy market volatility using GARCH models: can multivariate models beat univariate models? *Energy Economics* 34, 2167 – 2181

Wilmot, N.A. 2013. Cointegration in the Oil Market Among Regional Blends. *International Journal of Energy Economics and Policy* 2(4), 424 - 433