IS THE U.S. NATURAL GAS MARKET INTEGRATED OR SEGMENTED? A DYNAMIC STUDY OF REGIONAL NATURAL GAS PRICES

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Overview

In this paper, we contribute to the existing literature on the convergence of regional natural gas prices while studying monthly Henry Hub spot price and 50 city gate prices covering most U.S. states. We investigate if regional natural gas prices follow the law of one price and scrutinize the degree of integration of the U.S. natural gas market.

Several factors drive U.S. natural gas prices across the country. For example, Ghoddusi (2016) finds that the production, import/export, transmission, storage and consumption factors drive natural gas market prices in the U.S. According to Ji et al. (2018), crude oil prices, macroeconomic determinants, seasonality, speculation, international trade flows and energy substitution effects drive U.S. natural gas prices. Moreover, the FERC reforms in the 80s and 90s have favored regional gas market prices (Walls, 1995), while decoupling gas transportation from natural gas production and trading (De Vany and Walls, 1993). However, recent FERC reforms also support spatial market integration (Arano and Velikova, 2009; Ghoddusi, 2016; Leitzinger and Collette, 2002; Mohammadi, 2011). Existing research investigates whether those regional market prices follow the law of one price, and gauges the extent to which regional natural gas markets are integrated. There exist reported connections between U.S. natural gas prices, that is, wellhead hub, city gate and futures prices among others (Huntington, 2016). For example, Mohammadi (2011) identifies an integrated U.S. natural gas market with regime-shifts and asymmetric adjustments (i.e. market imperfections). The author finds that electrical, industrial and city gate prices adjust fast to deviations from the equilibrium with wellhead prices. However, commercial and residential prices adjust slowly due to administered prices. Moreover, supply and demand shocks drive short-term prices while demand shocks drive long-term prices. Following the application of FERC reforms and related deregulation at the wellhead, natural gas prices adjust to market conditions. As a result, natural gas markets have switched from a highly regulated to a highly competitive marketplace. In particular, open access transportation allows for free natural gas transfers from producers to consumers across regions while natural gas trading is disconnected from natural gas transport transactions. Such decoupling feature favors the convergence of regional natural gas prices (De Vany and Walls, 1994, 1996).

However, the existence of tailbacks in the U.S. pipeline infrastructure (Brown and Yücel, 2008) generates a natural gas market segmentation with West region (Cuddington and Wang, 2006). Despite a competitive production and trading of natural gas, pipelines remain concentrated, which favors a monopolistic natural gas infrastructure (Brown and Yücel, 2008). In particular, the West natural gas market is a network with low connections. The low connectivity between West and the other U.S. regions (Cuddington and Wang, 2006) generates a split between the West and East gas markets (King & Cuc, 1996), while the U.S. natural gas market is globally integrated elsewhere. Consequently, there exist observed differences between regional natural gas market prices. In particular, the degree of integration decreases with the distance between regional markets, due to increased transaction costs (Olsen et al., 2015). Such transaction costs depend positively on the distance and the unused capacity. Moreover, transaction costs can also strengthen with bottlenecks, such rise being potentially coupled with increasing distance.

Methods

We apply efficiently the unobserved component modeling framework, using Kalman filter. The Kalman filter allows for extracting the common unobserved component in regional natural gas prices. Such component illustrates the fundamental natural gas price in U.S.A. Then, we check if regional natural gas prices follow such fundamental price component. Finally, we measure how far observed regional natural gas market prices are from their fundamental price component.

Under such setting, we assume that U.S. natural gas price series depend on two components, namely a fundamental price component (which is random and common to all price series but unobserved) and a transaction cost component. The transaction cost component is unobserved for Henry Hub price while it is approximated by a normalized absolute price differential between Henry Hub price and a given city gate price, for each city gate price series. Thus, all natural gas price series depend on the two price components as well as a dummy regime indicator when it is significant. We also handle data non-stationarity and structural breaks in the estimation process. Given the benchmark role of Henry Hub, we assume such natural gas price series to follow the law of one price.

Once we get the fundamental price component, we can measure how far U.S. natural gas prices lie from such benchmark price. For this purpose, we employ ten well-known distance metrics (5 classic and 5 time series-based distance measures). The proximity of regional gas prices with the fundamental gas price supports market integration while a gap between these prices advocates market segmentation. Thus, the smaller the distances, the more integrated the regional markets are. Conversely, the larger the distances, the more segmented the considered local markets are.

Results

Despite temporary deviations from the fundamental natural gas price, the law of one price globally prevails. However, results confirm discrepancies between West and East natural gas prices (Cuddington and Wang, 2006; King & Cuc, 1996), but also West and other regional natural gas prices. The western regions consist of Maine and New Mexico. Analogously, the extreme Northeast region, as represented by Maine, fails to follow the law of one price. Moreover, New Mexico city gate and Henry Hub prices have the lowest proportion of transaction cost while Maine and Wisconsin city gate prices unveil the highest proportion of transaction cost. Such cost depends strongly on the length of natural gas path through pipelines (Olsen et al., 2015).

As regards market integration, we highlight a homogeneous group of converging natural gas prices and a heterogeneous group of diverging natural gas prices. The homogeneous group exhibits prices which are close to the fundamental natural gas price while the prices of the heterogeneous group deviate from the fundamental price component. We aggregate such results in Figure 13. We compute the percentages of natural gas price series, whose Fréchet distance lies below (i.e. integrated regional gas markets) and above (i.e. segmented regional gas markets) a given threshold over each regime. Such calculation allows for getting a structural view of the two groups of natural gas prices across regimes. The percentage of integrated and segmented states exhibits a structural change from regime 3 to regime 4. Whatever the threshold, the U.S. gas market shifts towards a more integrated structure after august 2004, which highlights the delayed impact of FERC reforms and related natural gas market liberalization. The U.S. natural gas market segmentation prevails over the three first regimes (i.e. a market segmentation period from January 1989 to August 2004) while the three last regimes give rise to a period of market integration (i.e. a market integration period from September 2004 to August 2017). As a result, we clearly gauge the delayed effectiveness of FERC regulation/reforms, coupled with the shale gas revolution and the sustained development of interstate natural gas pipelines (i.e. investments in natural gas infrastructures).

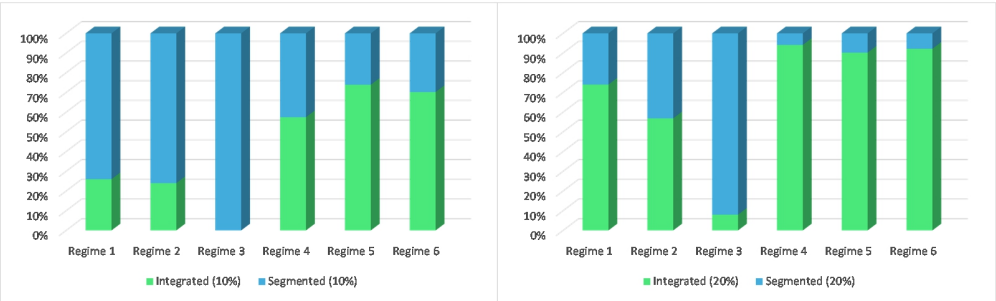

Figure 1: Converging and diverging natural gas price series as a function of the Fréchet threshold

Note: Numbers in between parentheses indicate the threshold's value for the Fréchet distance measure.

Conclusions

We propose a timely and genuine dynamic study with significant new results. First, most natural gas price series are close to but exhibit temporary deviations from the fundamental price component (i.e. law of one price). Second, results confirm the discrepancies between West and East natural gas prices, but we also show discrepancies between West and other regional natural gas prices. Third, computing distances between regional natural gas prices and the fundamental price component, we innovatively measure how far regional prices lie from the fundamental natural gas price, and show the existence of both a homogenous group of converging prices and a heterogeneous group of diverging prices. Finally, we genuinely run a dynamic distance analysis across time periods using the Fréchet distance, coupled with reasonable thresholds (i.e. degree of closeness). The percentage of integrated and segmented states (i.e. regional gas markets) exhibits a structural change from September 2004. Specifically, we show that the U.S. gas market shifts towards a more integrated structure, which translates the delayed impact of both FERC reforms and interstate pipelines' development policy. As a result, we are the first to time the efficiency of energy policies (e.g. deferred effectiveness of regulation or infrastructures' financing). Moreover, the implementation of relevant policies can help solve for the spatial isolation of some regions (i.e. distant locations, congestions in pipelines). Policy measures should also favor and support the implementation of pipelines efficiency (i.e. thermal, compressing and hydraulic efficiency) as well as the economic efficiency of natural gas production. The U.S. gas market efficiency will prevail only when all regional U.S. gas markets give rise to a global integrated marketplace.