RESIDUAL SUPPLY CURVES OF CANADIAN NATURAL GAS FOR SELECTED U.S. CITYGATE MARKETS

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Overview

Vast is the literature containing market integration tests for the North American natural gas network. All those studies use price and, sometimes, transaction cost data. Commodity flow patterns, however, have rarely been studied in order to determine the extent to which allocation decisions are efficient. This paper assesses whether natural gas flows reallocate among their possible destinations when price transmission is lagged and/or incomplete. Such hypothesis is investigated using daily data on prices and flows at U.S. markets connected directly via pipeline to the Western Canadian Sedimentary Basin area in Alberta for the period going from March 2002 through March 2007.

The relevant price signal to investigate allocation decisions on a network is not the price level at the destination market. Producers decide who to sell to and customers whom to buy from comparing price differentials between alternative producing and consuming areas. Residual supply curves relate the quantity of gas that each of the selected citygates, namely PG&E Citygate (California), Chicago Citygate and New York Citygate receive from the producing region with the price differential relative to that area. Moreover, they account for factors that shift demand at the competing markets centers. Daily changes in temperature are chosen as demand shifters for this analysis.

The relative size of demand requirements drives flow allocation. Those relative sizes depend on demand composition and climate normals in different geographical locations. For instance, California is relatively warmer and produces a larger fraction of the electricity it needs for covering air conditioning loads than the competing Midwest and Northeast locations. Thus, California will purchase relatively more Canadian gas in the summer than in the winter. The reverse pattern holds at the other two citygates. Daily data allows going beyond relative seasonal patterns – those are known beforehand and taken into account for planned-ahead gas purchases - and ask whether the physical flows delivered to each of these markets respond to short-term arbitrage opportunities.

Methods

A preliminary analysis of the price and flow series reveals several data features that are important for the subsequent analysis. First, the magnitude of price differentials between citygates located to the East of the producing area are larger than the one relative to California. The difference in magnitude might either reflect higher transportation costs on those routes or a higher willingness to pay for gas in eastern than in western markets. Second, New York Citygate displayed several extreme price peaks during the period of investigation – the price was over 20 $/MMBtu 13 times over this five-year period. Those peaks result in correlation coefficients below 0.72 between that price and the rest while for the other price pairs the correlation coefficients are above 0.9. Third, the coefficient of variation of daily production is much smaller than the coefficient of variation of the daily flows to each of the destination markets. Production levels remain steady throughout the year. Fluctuations in demand levels at the consuming centers are the major source of variability in flows at the various routes considered in this analysis.

According to the seasonal factors observed separately in the flow and price series, the seasonal allocation of gas towards California and New York Citygate markets appears sensible. The price differential with respect to the producing area widens in the summer for California and shrinks for New York Citygate and so do the volumes of gas flowing to each of those markets. On the other hand, flows toward the Midwest decrease during the injection season even though the price differential broadens. Seasonal flow patterns could be explained just as a function of the degree day seasonal profiles as well.

The next step consists in combining the flow and price information with exogenous shifters for costs at the producing area and demand at competing market centers to estimate residual supply curves. Daily series are highly autocorrelated, which complicates the econometric analysis. For that reason, a regression of changes in flow on changes in price differentials seemed more appropriate than one of flow levels on price levels. Focusing on the first difference of the series makes sense not only because of technical reasons but also because of the marketing arrangements that actually take place. Only a portion of the natural gas flowing any given day on a pipeline toward one of the destination markets has been purchased on the spot market. The rest was negotiated through long-term contracts or hedged so that it is not being purchased at the spot price.

The price of crude oil will be included in the model as a supply shifter. The current and first two lagged changes in heating and cooling degree days at the competing markets are used as demand shifters. In order for these variables to identify demand peaks which are of interest on regressions that use daily data, they were constructed using minimum and maximum daily temperatures rather than average temperatures. Degree data at the local market and the producing area are used as instruments for the endogenous variable – the price differential. Additionally, indicator variables were included to control for abnormal price peaks. The three residual supply curves are estimated as a system using three stage least squares to account for the fact that the residuals from each curve are likely to be correlated.

Results

Increases in degree days at competing markets trigger reallocation of flows away from the local market and towards the consuming areas with relatively heavier loads on the same day and the following two days. In particular, today's flow allocation is very sensitive to changes in heating degree days in the last 24 hours. New York Citygate is the only destination market for which the effect of changes in cooling degree days at competing markets is statistically significant. The estimated coefficient on the change in price spread is positive in all the flow series but statistically significant only for California flows. The magnitude of the effect is very small. A change of one dollar in the price differential between the PG&E Citygate and NOVA AECO prices from one day to the next would bring about an increase of 137 MMcf in Canadian flows coming to California the next day. The elasticity implied by that coefficient is 0.06.[1]

Conclusions

This study addresses questions which have already been explored in the agricultural economics and energy economics literature but does so from a different perspective. The large majority of studies on commodity market integration have only looked at prices while here the focus is on understanding flow patterns and gauging their degree of price responsiveness. The relationship between natural gas demand and energy has been extensively acknowledged by energy economists. However, changes in degree days at competing markets had never been used to identify a residual supply curve for daily gas deliveries. The set of market centers chosen for this study is particularly well suited for this type of analysis. With one producing region and several alternative destination markets all of which are directly connected via pipeline and display different demand profiles, flow displacement effects can be identified.

According to the analysis presented in this paper, flows are inelastic to daily changes in the spot price differentials beyond seasonal changes reflecting the relative strength of demand at the various citygates. The possibility of injecting or withdrawing gas in underground storage as well as short-term pipeline storage weakens the link between prices and flows. When storage cannot be used as a buffer, as it happened when cold spells hit the Northeast markets at the end of the winter and underground stocks were already low, observed behavior shows that it is feasible to reallocate large volumes on short notice.

[1] Only 19 out of 1826 days in the data set did this price differential experience a daily change of one dollar or more in absolute value