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Supply and demand determinants of natural gas price volatility in the U.K.: A vector autoregression approach

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ABSTRACT

Since 2008, the U.K. natural gas market has witnessed a marked drop in volatility. This fall has coincided with specific events in oil and gas sector such as the onset of the U.S. "shale gas revolution" and the subsequent rerouting of liquefied natural gas (LNG) shipments from the U.S. to other markets such as Asia and Europe. LNG cargoes, along with other sources of flexibility such as underground storages and interconnector import, can potentially reduce volatility. On the other hand, demand shocks can increase volatility. To examine the dynamics relationship between daily shocks in U.K. gas demand and supply, and the gas spot price volatility, we use a vector autoregressive (VAR) model. While we find evidence that daily deviations in aggregated gas demand significantly impacts volatility, we are unable to find direct evidence for an impact from shocks in disaggregated demand or supply. In fact, one important contribution of the paper is to suggest that flexible sources of supply such as LNG, storage and interconnector flows react to shocks in retail demand, dampening their potential effects on volatility.

1. Introduction

Since 2008, the global natural gas markets have experienced a substantial change in market conditions. For instance, the financial crisis of 2008 had a large impact on U.S. natural gas prices, resulting in a large fall in gas prices from a high of around 14 USD/mmbtu[1] to below 2 USD/mmbtu. In the subsequent years, U.S. gas production experienced a game change with the onset of shale gas production from around 2009 [7,55]. Before the Shale gas revolution, the U.S. was a net importer of LNG. Due to increased domestic production from unconventional plays from 2009 onwards, LNG imports to the U.S. dropped dramatically, resulting in LNG cargoes having to find their port of call in other markets, such as Europe and Asia. The U.S. shale gas revolution in the U.S. thus impacted European gas markets through a shift in the LNG destination. LNG shipments introduce flexibility into global and regional gas markets through two ways. First, LNG cargoes can be rerouted between regional markets in order to take advantage of preferable price spreads. Second, LNG cargoes also possess timing flexibility, and can be rerouted to markets experiencing peaking prices. In fact, LNG regasification capacity is often marketed as a peak shaving service. Hence, this flexibility provides LNG with the possibility to influence volatility. In fact [4], attributes the fall in volatility to increased LNG imports. This inherent flexibility combined with increased LNG imports to the U.K. since 2008 might be one possible explanatory factor behind the decreased volatility in gas spot prices.

However, the U.K. gas system contains overcapacity, representing sources of flexibility. For instance, interconnecting pipelines link the U.K. market to Ireland, Belgium and the Netherlands, and the flows through these interconnectors can be adjusted or even reversed within a short period of time. In addition, underground gas storage facilities are able to switch between injection and withdrawal promptly, sometimes within hours. Therefore, several competing sources of flexible gas supply have the potential to react to shocks in prices (volatility), making the total picture quite complex. In fact, shocks in demand may be met by flexible sources, and may not result in increased volatility. We therefore find it appropriate to use a vector autoregression to capture the dynamics in the system. Since reactions to shocks in the system might take hours or even days, we find it appropriate to use lagged variables as explanatory factors.

To control for the impact of other external factors on gas volatility we also include the OVX crude oil volatility index. The literature suggests a hierarchy of volatility influence from oil to gas to

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[1] mmbtu = million british thermal units.

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electricity markets [29].

There have been several studies addressing the impact of LNG on energy markets, especially on market integration (e.g. Refs. [8,16,54,55]. Nevertheless, to the best of our knowledge, no study has addressed the impact of disaggregated supply or demand on volatility. Relevant studies tend to focus on the impact of aggregate demand and supply shocks on energy or stock market volatility [25,73].

We use a data sample for 2007–2014, which includes daily demand, supply and price data. We have collected disaggregated supply sources and demand uses. The supply sources include production from oil and gas field production, from LNG imports, imports through interconnectors, and withdrawals from underground gas storages. The uses of demand include demand from the industrial sector, the power sector and residential demand, in addition to demand from injection into underground gas storages and exports through interconnectors. To reduce the dimensions we use net storage withdrawals (daily storage withdrawals less daily storage injections) and net interconnector imports (daily interconnector imports minus daily interconnector exports).

Volatility is modelled using an autoregressive moving average generalized autoregressive conditional heteroskedasticity (ARMA-GARCH) model. We examine the effects of seasonal and trend adjusted demand and supply shocks on volatility in an eight-dimensional vector autoregressive (VAR) model.

Consistent with previous research we find that deviations in aggregate demand has a significant impact on the spot price volatility in the U.K. Contrary to expectations, we are unable to find robust evidence of the impact of deviations in disaggregated demand and supply on gas volatility. In fact, it seems that the deviations in some subcomponents are mitigated by opposite deviations in other supply/demand elements. This indicates that there is substantial flexibility in the U.K. gas system, which acts in a way to reduce the impact of individual shocks to the system on volatility. Only when there is a shock to the aggregated demand is volatility significantly affected. Moreover, we find that the long-term gas volatility is associated with trends in demand and crude oil volatility.

We make four contributions to the literature. First we examine the impact of deviations in disaggregated demand and supply on volatility. Similar studies apply aggregated demand or supply data (see e.g. Ref. [73]). However, sources of supply and demand vary in terms of flexibility and possible impact on volatility. Some sources are quite flexible and can respond to situations with increased volatility. Secondly, we look at daily data, which might uncover a different set of dynamic relationships compared to for instance monthly data. Third, we examine the claim that LNG is a major contributor to the reduction in volatility in the U.K. since 2010 and do not find direct evidence of a strong link between LNG and volatility. Fourth, our research suggests that flexibility in the gas system may explain why we are not able to find statistically significant relationships between disaggregated supply and demand shocks, and volatility.

The remainder of the paper is organized as follows: Chapter 2 reviews the literature, chapter 3 addresses the U.K. gas market and the reasons why the gas price volatility can be affected by shocks in different supply and demand elements. Chapter 4 develops the methodology and chapter 5 presents the data. In chapter 6 we present and discuss the results and chapter 7 concludes.

2. Background and literature

2.1. The U.K. Natural gas wholesale market

Unlike oil, which is sold globally, gas markets are regional markets. With the arrival of liquefied natural gas (LNG), gas markets have become more interconnected [8,16,54,55]. Nevertheless, complete global gas market integration will still be limited by LNG specific constraints such as liquefaction capacities (converting gas in gaseous form to liquid form), regasification capacities (converting gas in liquid form to gaseous form) and the availability of specialized LNG transport vessels and freight rates [56].

The U.K. natural gas wholesale market is the most liquid of all regional gas markets in Europe. Although it is a regional market for the United Kingdom, it is also connected to other markets in Europe through interconnectors and short-distance LNG vessels, making it part of a larger European market. The market place in the U.K., the National Balancing Point (NBP), is a pipeline grid, with several entry and exit points throughout the grid. Unlike many stock or commodity exchanges, the market place is not limited to a specific geographical point, but rather a notional market place comprising the entire grid.

The main supply sources of gas in the U.K. are 1) pipelines directly from fields or via processing plants on the U.K. Continental shelf or the Norwegian Continental shelf, 2) imports through interconnecting pipelines to Ireland (Moffat), the Netherlands (BBL) and Belgium (IUK), 3) LNG imports via LNG regasification facilities, and 4) withdrawals from underground storages (both seasonal and fast-response (so-called fast cycle) storages). The main uses of gas in the U.K. are 1) demand from the residential sector (LDZ[2] demand), 2) demand from industry (excluding power sector), 3) demand from the power sector,[3] 4) interconnector exports and 5) injection of gas into underground storage.

The different supply and demand elements are characterized by different elasticities.[4] Residential demand is very much affected by temperature since a substantial portion of gas is used for heating. Gas is a minor part of the cost for industrial sector. The opposite is the case for the power sector where gas is the major input factor. Pipeline imports from fields can be fairly inflexible since the flows are governed by geological characteristics and production permits.[5]

However, some of the supply and demand elements are more elastic. For instance, as a response to increased demand, underground storages can switch from injection of gas to withdrawal of gas, interconnectors can switch from export to imports and LNG shippers can reroute LNG cargoes to the U.K. Some of these assets are able to respond to changing demand quite quickly (such as fast cycle storages which are able to switch flow direction in a matter of hours) and interconnectors. Others flexible assets respond more slowly, such as LNG. Hence, these flexible assets contribute to peak shaving. In summary, shocks to different sources and uses of gas can have different impact on spot price volatility due to differing price elasticities of supply.

Ref. [4] attribute the drop in volatility to increased LNG imports and a fall in gas demand. Since 2009, supply from LNG to the U.K. has increased rapidly (Fig. 1). However, as Fig. 1 shows, the supply peaked around 2011. This increase between 2009 and subsequent decrease from 2011 can be related to two defining events for natural gas. The year 2009 is by many commentators considered as the start of the “Shale gas revolution” in U.S. [7,55]. Around the same time (~2009), due to technology advancements in the field, the U.S. experienced an increase in domestic tight gas (also called shale gas)

[2] LDZ = local distribution zones.

[3] Gas used to generate electricity in gas-fired power plants (e.g. CCGT), representing a substantial portion of total gas demand. During the 1990s “the dash for gas” resulted in replacement of coal fired power plants with gas fired power plants.

[4] [73] uncover several supply functions for the U.K gas market.

[5] However, some fields are flexible and can respond to changing demand. For instance, the Troll and Oseberg oil and gas fields on the Norwegian Continental shelf have flexible production rates.