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The long-run oil–natural gas price relationship and the shale gas revolution

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ABSTRACT

The gas extraction technological developments of the 2000s have allowed shale gas production, which in the US has become a significant part of the total gas production. Such a significant change might have affected the long-run relationship between oil and natural gas prices postulated by several authors. By using monthly data of oil and gas prices, as well as gas quantities from 1997 to 2013, we test for the presence of a long-run relationship, allowing also for possible breaks. We first show the stationarity of gas quantity data before the production of shale gas and the existence of a break in the trend (and in the intercept) on the integrated gas price time series, by the time shale gas enters the market. Then, applying a Vector Error Correction Model, we show that shale gas production has affected the relationship across variables. Gas quantities become relevant in the formation of gas prices after the beginning of shale gas production, while impact of oil prices on the gas ones doubles. However, on the basis of the available data, it is not unequivocally possible to assess whether or not a new long-run relationship between oil and gas has been established.

1. Introduction

From as early as 2005, technological developments, such as the extraction of shale gas[1] from shales using hydraulic fracturing and horizontal drilling, began making the supply of natural gas (from now on "gas" for brevity) to the market economically convenient in the United States (US).[2] Shale gas has been traded in the market, in particular at the US Henry Hub, from the beginning of 2007. Fig. 1 reports the evolution of US gas price and quantity and the share of shale gas quantity on the total gas production from 1997 to 2013 (natural gas spot prices at Heny Hub; US natural gas gross withdrawals). Notice that gas quantity increases from 2007 onward with an upward sloping trend, due to the increase in shale gas production that reaches about 40% of the total quantity of gas produced in 2013.

Notice also that from the end of 2008 US gas prices started to decrease, yielding a tremendous competitive advantage for the country's manufacturing and chemical industries and eliminating the need to import gas. This development is often referred to as the "shale gas revolution", highlighting its importance and hinting at a fundamental (and perhaps irreversible) change in the long-run gas price, and possibly in the dynamic evolution of the gas price over time. Indeed, the so-called shale gas revolution should imply a permanent impact on the trend of gas prices that would be determined by the increase in the gas supply due to the introduction of shale gas. Deviations in the price from the trend should, therefore, be seen as temporary and could be determined by several contingent factors impinging on the gas market to be identified case-by-case (Brown and Yücel, 2008). This article aims at evaluating the alleged revolutionary impact of shale gas on the long-run gas price levels. It is well known that oil and gas prices are linked (Hartley et al., 2008). There are technical and economic reasons that justify the correlation, such as price formation rules, contractual arrangements, market structures and liquidity (Villar and Joutz, 2006), the need to hedge huge investment risks in the cultivation of joint oil and gas fields

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[1] We follow here the EIA definition for shale gas: "Shale gas is defined as natural gas produced from wells that are open to shale formations. Shale is a fine-grained, sedimentary rock composed of mud from flakes of clay minerals and tiny fragments (silt-sized particles) of other materials". Shale gas figures do not include coal bed methane and tight gas.

[2] A similar technological development has occurred in the oil industry. Note that when referring to oil production, the industry uses the term tight oil production rather than shale oil production because it is a more encompassing term with respect to the different geologic formations producing oil at any particular well.

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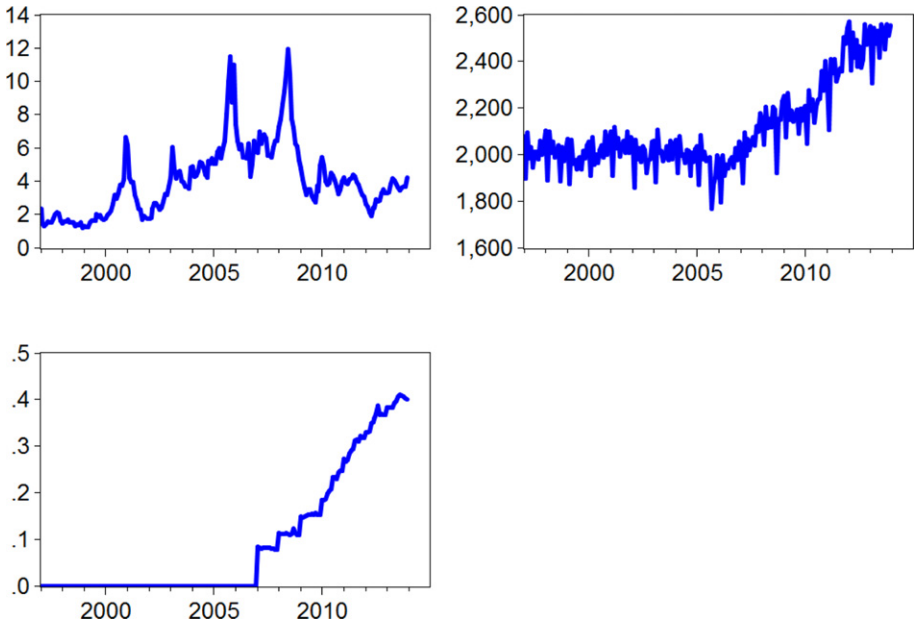

Fig. 1. Natural gas real spot price (USD/MMBTU — upper left plot) and natural gas gross withdrawals (MCF — upper right plot) and relative share of shale gas withdrawals on total gas withdrawals (percent — lower plot) from 1997 to 2013.
Source: our elaboration from EIA data.

and demand substitutability between oil and gas products, as well as the competition for the same scarce inputs. The latter in particular can give rise to a covariation of oil and gas prices, even in the absence of a contractual indexation of gas contracts to oil since, a) in the final products, oil and gas are often substitutes and b) when developing non-joint fields, companies compete in the same markets for technical and financial resources, so that, for instance, when the oil price spikes, the cost of inputs for gas field development rises, which in turn increases gas prices. This latter aspect can be particularly relevant for shale gas (and tight oil) development, due to its (their) short time to market and the high financial leverage of the relatively small companies that cultivate it (them), particularly in the case of the US. Several scholars have addressed the question of the oil–gas price relationship. Ghouri (2006), for instance, finds that oil and gas prices do have a long-run relationship. Rosthal (2010) specifies that periods of temporary gas over-supply, e.g., the warm winter of 2006–2007, can determine the short-run departures from the long-run equilibrium between oil and gas. It also assesses that causality works from oil to gas, but the opposite is not true. This contrast to what suggested by Villar and Joutz (2006), who argued for bidirectional causality between oil and gas prices. Pindyck (2004), conducting Granger causality tests, finds a result similar to Rosthal.[3] On the contrary, Wolfe and Rosenman (2014) (using high-frequency intraday oil and gas futures prices) show a bidirectional casual relationship. Foss (2015) conjectures that an oil–gas relationship exists that weakens over time, since gas prices seem to be determined by market fundamentals while oil prices are more volatile. Erdos (2012) finds that the oil and gas market relationship starts to weaken from 2002. Romagus (2012) sets the end of the long-term price relationship between oil and gas prices at 2008. Brigida (2014) shows that the long-term oil and gas price relationship (modeled through an error correction model using data of oil and gas futures) has experimented a regime switching and that oil and gas price temporarily decoupled in the early 2000s. All of these studies leave open the question if and when the entrance of shale gas into the market has started to determine a structural change in the market behavior, and in particular, whether it has affected gas price formation, so that the long-run relationship between oil and gas prices, if present, has been permanently affected. Indeed, Wakamatzu and Aruga (2013) ask a similar question for the case of the US and Japan. Applying a structural break test, they set the structural change for US gas at 2005. However, they do not investigate further the nature of the long-run relationship and the impact of shale gas on a new long-run relationship, if present. This is the aim of our study: we investigate a) if there exists a long run relationship between oil and gas prices and b) if and by how much such a relationship has been affected by the shale gas production. Both these points are quite relevant for the geopolitics of energy, since they help relating regional markets (such as the gas ones) to a more global market such as the oil one and help quantifying to what extent events that can impact the oil market reflect on the price of a regional market like the US gas one. In order to perform our task, we need to identify the long-run characteristics and properties of the gas prices, oil prices and gas quantities time series. Indeed, it is well known (Pindyck, 1999; Villar and Joutz, 2006) that energy data might be non-stationary. Modeling energy data without taking into account possible non-stationarity can lead to spurious results. A non-stationary variable is integrated of order 1 (call it $I(1)$) if its first difference is stationary, in which case we can

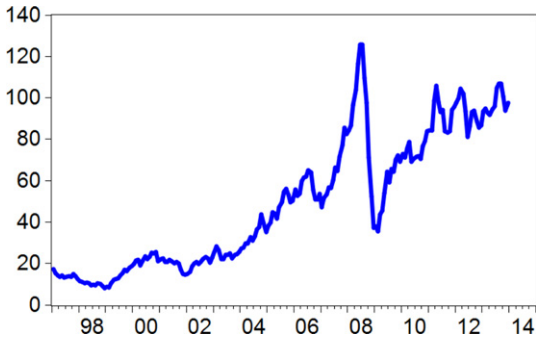

Fig. 2. Oil monthly real prices from 1997 to 2012.
Source: our elaboration from EIA data.

[3] See also Asche et al. (2006) for an analysis of Granger-causality in the UK energy market.