

Seasonal causality in the energy commodities

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Abstract

The reason why we observe that the price evolution of some energy commodities follows a seasonal cycle is because their supply does not keep up the pace with their demand in certain weather seasons—when demand is exceptionally more elastic than supply. This paper is aimed on assessing the seasonal component of commodities present in their demand and prices. We highlight the fact that, most of the time, prices do not share the same seasonal cycle of demand arising a seasonal causality relationship between them. In the long-run, seasonal demand causes prices' seasonality as it is expected. But in the short-run, we find out that it is prices that anticipate (Granger-cause) the seasonal demand of commodities.

Keywords

Commodity prices, Seasonality, Causality, Energy.

JEL classification

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■ 1. Introduction

A very interesting difference between a typical financial asset and a commodity is that the latter can be experimenting weather seasonality. The reason why we observe that the price evolution of some commodities follows a seasonal cycle is because their supply does not keep up the pace with their demand in certain weather seasons—when demand is exceptionally more elastic than supply in the case of, for example, some energy commodities, or when the supply inelasticity relative to its demand is particularly accentuated in the case of, for example, some agricultural products (for example, see Lucia and Schwartz, 2002 or Sorensen, 2002).

There are many obstacles impeding supply to have enough flexibility to easily match the demand. Basically, the supply of commodities –with very few exceptions– is restricted by natural resources endowment. The case of fossil fuels is extreme because they are not renewable—though some of their derivative products can be recycled like motor oil. But even in the case of renewable raw materials, like agricultural products, it takes time to harvest the next crop and the fertile land is limited.

If the demand or supply of commodities is seasonal, so their price evolution is presumed to be related to seasonal cycles. It is common knowledge that heating oil demand rise in winter and gasoline's does during the summer. As a consequence, one may have the perception that the prices of these commodities would increase in the eve of those seasons. Obviously, those expectations are due to these products demand and supply being characterized by the seasons' weather conditions.

Borenstein and Shepard (1996) stated that “anticipated market conditions could also be the result of firms responding to expected changes by altering their inventory levels”. Though this statement was referred to the U.S. gasoline market it can also be applied to the heating oil's. The authors argue that suppliers (those with enough storage capacity) might increase their inventory holdings in the current period if they expect an increase in demand the next period. Then, as they rise their purchasing today expecting a higher demand tomorrow, the current prices might be driven up.

To confirm this conjecture we will test the spot prices anticipation using the Granger (1969) causality approach which does not determine whether or not a variable is the result of another one, but the precedence and information content of such a variable to explain and predict the other one.

Undoubtedly, demand causes prices and not vice versa. Any direct relation between prices and demand should not be interpreted as the future demand being determined by present prices. It would not make any sense that higher prices in a certain season

increase the demand for fuel in the next one as this rise in demand would be followed by a drop in the next season and there are costs and physical difficulties for consumers to store this commodity for subsequent increases in demand. In addition, though heating oil and gasoline demand might be kind of inelastic, it still has a negative slope, thus as prices rise, demand drops.

If we had observed that prices and demand share the same seasonal cycle we would search for instantaneous causality proof instead. However, this is not the case, and the purpose of using the Granger causality test is to establish the anticipation of prices seasonality with respect to seasonal demand. We are assuming that price seasonality incorporates the seasonal demand forecast. If this forecast is based on more information than past demand alone, then prices Granger-cause demand as the market agents try to anticipate the demand's seasonal movement.

■ 2. Data

In the present study we are going to assess seasonality for energy commodities traded in the United States of America (U.S.) given the availability of historical information on demand, supply and cash prices of those commodities in this country. A second reason to focus this study on the U.S. is the relevance of that country's share of the world's demand and supply of these products. Thirdly, there is a high trading volume of commodities' future contracts in the U.S. exchanges. The former and most liquid markets of commodities' futures are located in Chicago and New York.

Light/sweet crude oil at the New York Mercantile Exchange (NYMEX) is the most actively traded commodity all over the world, distantly followed by natural gas at that same exchange. However, we will exclude the crude oil from our seasonal analysis because the peaking demand season of a petroleum product might be the one representing the least volume demanded for another petroleum product, thus shading the presence of seasonality in crude oil. Borovkova and Geman (2006) stated that: "seasonal forward curves are not observed in the crude oil market, which is a world market."

The first petroleum product to be studied is gasoline as it is the most sold oil refined product in the U.S. It accounts for almost half of the domestic petroleum consumption. Briefly speaking, from a barrel of crude oil two thirds can be transformed into gasoline and one third into heating oil (also called No. 2 fuel oil), that is, three barrels of crude make two of gasoline and one of heating oil. Therefore, the second relevant petroleum product highly traded in the U.S. that we are going to study is heating oil.

Propane is a by-product of petroleum refining or natural gas processing. The U.S. demand of propane is approximately one-third that of heating oil. It is used for diverse purposes: residential cooking, production of petrochemicals, crop-drying in agriculture, but mainly as a substitute of natural gas during periods of peak heating demand.

Natural gas accounts for almost a quarter of energy consumption in the U.S. which represents about the third part of the world consumption of this commodity. It is mainly used for heating purposes of residential and commercial consumers, but since 2001 there is also an important use of natural gas to generate electrical power.

The main source of data on demand (product effectively supplied to consumers, that is, actual consumption) and spot prices of energy in the U.S. (OECD countries and the World aggregate) is the Energy Information Administration from the Department of Energy of the Government of the United States. The time period of the data is going to be the longest available for each commodity unless told the contrary. Most of the information available is monthly and we would privilege the use of that frequency as it is the most convenient to look for long-period components such as seasonality.

■ 3. Causality

Back in 1979, C. W. J. Granger said that “it would be interesting and perhaps worthwhile to perform a causal analysis of the seasonal component”. Thirty years later, we are going to enroll in such a task.

Granger (1969) theory is not relevant for nonstochastic variables as a purely deterministic series, that is, a series which can be predicted exactly from its past terms, cannot be said to have any causal influences other than its own past. The theory relies entirely on the assumption that future cannot cause the past. For example, future demand of heating oil in January cannot cause the past behavior of spot prices in October. As is stated in Hamilton (1994), “If an event Y is the cause of another event X , then event Y should precede the event X .”

In this paper we are going to test two null hypotheses:

1. Spot price (regressor) does not Granger-cause demand (dependent variable).
2. Demand (regressor) does not Granger-cause the spot price (dependent variable).

For that purpose we will run bivariate regressions of the form:

$$\text{demand}_t = a_0 + a_1 \text{demand}_{t-1} + \dots + a_{lag} \text{demand}_{t-lag} + b_1 \text{price}_{t-1} + \dots + b_{lag} \text{price}_{t-lag} + \varepsilon_t$$

$$\text{price}_t = c_0 + c_1 \text{price}_{t-1} + \dots + c_{lag} \text{price}_{t-lag} + d_1 \text{demand}_{t-1} + \dots + d_{lag} \text{demand}_{t-lag} + ut$$

F -testing the joint hypotheses of $a_1=b_1=\dots=a_{lag}=b_{lag}=0$ and of $c_1=d_1=\dots=c_{lag}=d_{lag}=0$.

There are several econometric tests for Granger Causality (see Hamilton 1994). One way to conduct an F -test of Granger null-hypotheses is to compare the sum of squared residuals of the bivariate autorregression of order p estimated by Ordinary Least Squares (OLS) against the resulting ones of the univariate autoregression estimated also by OLS.

As stated before, we are expecting to verify that the spot prices of gasoline and heating oil precede their demand with a short-term lag (a season or less), thus the first null hypothesis should be rejected (with 5% of statistical significance) for short-period lags, and not rejected (with the same statistical significance) for longer lags as prices do not cause the demand level in the long-run but vice versa.

On the other hand, Granger causality might not go the other way, that is, spot prices causing an anticipated reaction in demand. So, the second null hypothesis cannot be rejected for short-term lags, but should be rejected for long-period lags (about a year) because demand is one of the determinants of prices.

Therefore, in the bivariate regressions to be run, we disregard a priori all the lagged coefficient combinations that result into accepting or rejecting both null hypotheses at the same time.

■ 4. Results

The results for gasoline (Table 1) show that with one or two month-lag, the spot prices precede (Granger-cause) the level of demand, as for those lags the first null hypothesis is rejected, while the second one cannot be rejected. On the other hand, for a lag of eleven months, we cannot reject the first hypothesis but reject the second one. Hence, the information of demand in the preceding year, or so, helps to explain (Granger-cause) the present spot prices. This is natural given the fact that the demand along with the supply determines prices.

In the case of heating oil, three and twelve months are the only relevant lags; the rest can be disregarded according to our former criteria. However, the results in

Table 2 are exactly the opposite to our expectations and of the previous ones for gasoline (Table 1).

● **Table 1. Gasoline**

Period	H0: Prices does not Granger-cause demand			H0: Demand does not Granger-cause prices		
	F-Statistic	p-value	Rejected	F-Statistic	p-value	Rejected
Short (1)	14.1752	0.00023	Yes	0.81808	0.36707	No
Short (2)	3.38531	0.03630	Yes	0.35566	0.70126	No
Long (11)	0.87722	0.56426	No	1.94166	0.03930	Yes

● **Table 2. Heating Oil**

Period	H0: Prices does not Granger-cause demand			H0: Demand does not Granger-cause prices		
	F-Statistic	p-value	Rejected	F-Statistic	p-value	Rejected
Short (3)	0.64711	0.58543	No	2.89322	0.03589	Yes
Long (12)	1.86539	0.03967	Yes	1.10911	0.35355	No

When a three-month lag is considered, the first null hypothesis cannot be rejected meaning that the past three months information of prices does not provide any help in explaining present demand. On the contrary, the second null hypothesis is rejected, meaning that the information contained in the past quarter demand helps to predict to some extent the current spot prices.

In the other hand, when considering a twelve lagged months, the first null hypothesis can be rejected but the second one cannot. This result confirms that the heating oil monthly spot prices of the preceding year help to explain the current level of demand for fuel oil.

These results shows that heating oil seasonality has been changing due to the surge of fuel substitutes and its increased use as vessels' fuel as both factors affect its demand (Purvin & Gertz, Inc. 2008).

In the case of propane we can observe that the spot prices seasonal low is set in June and coincides with demand's low in that same month. However, price seasonality peaks in October while demand's does in January. Spot prices anticipate the increase in demand, but do not move in advance to the fall in consumption, but concurrently. The latter, is an indicative of instant causality between the propane's demand and its prices.

When we run the Granger-causality test for the prices and demand series of propane, the first null hypothesis cannot be rejected with a lag of four months (Table 3), thus we cannot confirm that price seasonality Granger-causes demand in the short-run. But the second null hypothesis is rejected for that same period lag implicating that demand Granger-causes prices in the short-run. The results of the other time lags tested—from one to twenty-four months—could not reject any of these hypotheses, meaning that neither demand nor prices anticipate the seasonal movement of each other.

● **Table 3. Propane**

Period	H0: Prices does not Granger-cause demand			H0: Demand does not Granger-cause prices		
	F-Statistic	p-value	Rejected	F-Statistic	p-value	Rejected
Short (4)	1.54523	0.19085	No	2.49669	0.04429	Yes
Long (12)	0.88034	0.56817	No	1.35811	0.19112	No

The natural gas spot prices have a seasonal high in December and a seasonal low in August while demand has its seasonal high and low a month later in January and September respectively. In the case of natural gas, the anticipation of prices seasonality to seasonal demand is not much, given the physical obstacles for distributors to store the gas longer in advance. Granger-causality tests show that in the short-term (one to six months earlier), prices Granger-cause demand as the first null hypothesis cannot be rejected for those lags while the second hypothesis is rejected. In the long-run, demand causation over prices can be as far as eighteen months in advance as the second null hypothesis cannot be rejected for nine to eighteen month-lags. The first null hypothesis is rejected for those same lags as prices do not Granger cause demand in the long-run. Table 4 presents the results only for four short-period lags and four long-period lags.

● **Table 4. Natural Gas**

Period	H0: Prices does not Granger-cause demand			H0: Demand does not Granger-cause prices		
	F-Statistic	p-value	Rejected	F-Statistic	p-value	Rejected
Short (1)	18.0687	2.7E-05	Yes	0.00775	0.92991	No
Short (2)	30.4336	5.2E-13	Yes	0.98133	0.37573	No
Short (3)	17.9701	6.1E-11	Yes	1.40815	0.23996	No
Short (4)	10.2636	6.6E-08	Yes	1.53597	0.19100	No
Long (9)	0.75223	0.66084	No	2.61265	0.00617	Yes
Long (10)	0.63130	0.78706	No	1.97713	0.03473	Yes
Long (11)	0.52637	0.88541	No	2.08703	0.02054	Yes
Long (12)	0.48852	0.92127	No	1.99535	0.02375	Yes

■ 5. Concluding Remarks

It is well known that the reason why we observe that the price evolution of some commodities follows a seasonal cycle is because their supply does not keep up the pace with their demand in certain weather seasons. Given the observed seasonal behavior of consumption, availability and prices of certain commodities, and due to the fact that seasonality arises when it is more difficult for supply to follow the demand in certain weather seasons we look for the causes of such phenomena in both the demand and supply of four energy commodities in the U.S. After performing a seasonal causality analysis of both patterns, we confirm that seasonal demand cause the seasonality in prices in the long-run as we presumed initially. But find out that in the short-run, it is prices' seasonality that Granger-cause seasonal demand. The study of heating oil, help us to learn about the causes that might change the seasonal behavior of commodities' demand and prices. In addition, through the seasonal causality analysis of this commodity we also realize that the seasonality of a certain commodity can affect the seasonal behavior of another one like it was the case of heating oil being influenced by natural gas.

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