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Forecasting the oil–gasoline price relationship: Do asymmetries help?

Andrea Bastianin [a,b,*], Marzio Galeotti [a,c], Matteo Manera [b,d]

[a] University of Milan, Italy
[b] FEEM - Fondazione Eni Enrico Mattei, Italy
[c] IEFE-Bocconi, Italy
[d] University of Milano-Bicocca, Italy

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ABSTRACT

According to the Rockets and Feathers Hypothesis (RFH), the transmission mechanism of positive and negative changes in the price of crude oil to the price of gasoline is asymmetric. Although there have been many contributions documenting that downstream prices are more reactive to increases than to decreases in upstream prices, little is known about the forecasting performance of econometric models incorporating asymmetric price transmission from crude oil to gasoline. In this paper we fill this gap by comparing point, sign and probability forecasts from a variety of Asymmetric-ECM (A-ECM) and Threshold Autoregressive ECM (TAR-ECM) specifications against a standard ECM. Forecasts from A-ECM and TAR-ECM subsume the RFH, while the ECM implies symmetric price transmission from crude oil to gasoline. We quantify the forecast accuracy gains due to incorporating the RFH in predictive models for the prices of gasoline and diesel. We show that, as far as point forecasts are involved, the RFH does not lead to significant improvements, while it can be exploited to produce more accurate sign and probability forecasts. Finally, we highlight that the forecasting performance of the estimated models is time-varying.

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1. Introduction

Empirical evidence suggests that in many markets the adjustment process of an output price differs depending on the sign of the corresponding input price variations. For instance, Peltzman (2000) reports that output prices tend to respond faster to input price increases than to decreases in 160 out of 242 markets.

This tendency, known as Asymmetric Price Transmission (APT), has been widely studied also by energy economists. According to the so-called "Rockets and Feathers Hypothesis" (RFH), the transmission mechanism of positive and negative changes in the price of oil to the price of gasoline is asymmetric. Surveys of the APT literature are provided by Frey and Manera (2007) and Meyer and von Cramon-Taubadel (2004), while Geweke (2004) focuses on the RFH.

Although, starting from Bacon (1991), there have been many contributions addressing how downstream prices respond to increases in upstream prices (see, among others, Al-Gudhea et al., 2007; Balke et al., 1998; Borenstein et al., 1997; Brown and Yücel, 2000; Douglas, 2010; Galeotti et al., 2003; Godby et al., 2000; Grasso and Manera, 2007), little is known about the forecasting performance of reduced-form econometric models incorporating RFH from crude oil to gasoline. As pointed out by Bachmeier and Griffin (2003), if gasoline prices respond asymmetrically to crude oil price variations, asymmetric cointegration models should produce more accurate forecasts than the symmetric Error Correction Model (ECM).

Our work fills this gap. We systematically investigate the merits of forecasting models incorporating the RFH relative to models that do not incorporate asymmetry. In this sense, we contribute to the literature by providing fresh empirical evidence which can guide forecast users and producers in their search for more accurate models to forecast the prices of gasoline and diesel.

We focus on U.S. fuel markets and model the oil–gasoline price relation consistently with the RFH. Specifically, we compare point, sign and probability forecasts from a variety of Asymmetric-ECM (A-ECM) and Threshold Autoregressive ECM (TAR-ECM) against a standard ECM. Forecasts from A-ECM and TAR-ECM subsume the RFH, while the ECM implies symmetric price transmission from crude oil to gasoline prices.

* Corresponding author at: DEMM — Dipartimento di Economia Management e Metodi Quantitativi, University of Milan, Via Conservatorio 7, I-20122 Milano, Italy.
E-mail address: andrea.bastianin@unimi.it (A. Bastianin).

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The aim of our paper is to quantify the forecast accuracy gains due to introducing the RFH in predictive models for the prices of gasoline and diesel. In particular, we provide answers to the following research questions:

1. Is the RFH useful when forecasting gasoline price changes (point forecasts)?
2. Is the RFH helpful when forecasting the sign of gasoline price movements (direction-of-change or sign forecasts)?
3. Is the RFH useful when forecasting the probability of gasoline price movements (probability forecasts)?
4. Are asymmetries constant through time or time-varying (time-varying forecast accuracy)?
5. At which sampling frequency (daily, weekly or monthly) are forecasts based on the RFH helpful?
6. At which stage of the transmission mechanism (i.e. either spot or retail, or both) are the forecasts based on the RFH more accurate than the forecasts obtained from symmetric models?

Our answer to the first question is negative, while questions 2 and 3 have a positive answer. Asymmetries are helpful for sign and probability forecasting, but they do not lead to more accurate point forecasts than the symmetric ECM specification. We also show that the forecasting performance of models changes through time: in some periods A-ECM produces more accurate forecasts than the ECM, while in other time periods the ECM dominates the asymmetric specifications. Empirical evidence also highlights that accuracy gains can be achieved mostly at daily or monthly sampling frequency for both spot and retail prices.[1]

The relative merits of models with and without the RFH are robust to the choice of the oil price benchmark. It is well documented that that insufficient pipeline capacity in U.S. has recently lead to a bottleneck of crude oil at Cushing, Oklahoma, where the West Texas Intermediate (WTI) crude oil is priced on the New York Mercantile Exchange. This bottleneck has resulted in the failure of WTI prices to track those of alternative markers, Brent in particular, since early 2011. As pointed out by Borenstein and Kellogg (2014), among others, the decoupling between WTI and Brent has important implications for the prices of refined products in the U.S., namely motor gasoline and diesel. For this reason, many analysts have started using Brent to model and forecast petroleum product prices. In our paper we consider both the WTI spot price, given its relevance for the U.S. gasoline and diesel markets, and the Brent spot price, which we use to test the robustness of our results.[2]

Our findings are relevant for a number of economic agents, whose activities involve decisions that are inherently forward-looking. For instance, gasoline producers need accurate point forecasts for hedging activities and portfolio allocation. On the other hand, policy makers exploit point and probability forecasts for stockpiling decisions (e.g. management of inventories and strategic reserves). Moreover, investors rely on direction-of-change forecasts to design technical trading rules and on probability forecasts for risk management (e.g. Value-at-Risk).

The plan of the paper is as follows. Section 2 describes the data. The empirical methods are introduced in Section 3. Results are discussed in Section 4, while robustness tests are presented in Section 5. Section 6 concludes.

2. Data

Our analysis focuses on the U.S. fuel markets. We consider the relations between the spot price of West Texas Intermediate (WTI) light crude oil and the following petroleum products[3]:

1. spot price of New York Harbour Conventional Gasoline (NY);
2. spot price of U.S. Gulf Coast Conventional Gasoline (GC);
3. spot price of Los Angeles Reformulated RBOB Regular Gasoline (LA);
4. retail price (excluding taxes) of U.S. Regular All Formulations Gasoline (G);
5. retail price (excluding taxes) of U.S. No 2 Diesel (D).

We have obtained all price series from the U.S. Energy Information Administration website. Crude oil and gasoline spot prices have been collected at daily sampling frequency, while retail gasoline and diesel prices are available only at weekly frequency.

The spot and retail prices of petroleum products do not include taxes and are denominated in dollars per gallon, while the spot price of oil is expressed in dollars per barrel.

Weekly and monthly spot prices have been calculated by averaging daily prices. Monthly retail prices have been computed by averaging data at weekly frequency. In all cases, in order to have synchronous prices, we preliminary dropped those observations for which it was not to possible to match gasoline or diesel prices with crude oil prices. A description of the dataset is presented in Table 1.[4]

3. Models and methods

Let O_t be the spot price of WTI crude oil and let P_{kt} denote the price of the k-th petroleum product at time t, k = NY, GC, LA, G, and D, and $t = 1,\ldots,T$. We use the following notation: $p_{kt} \equiv 100 \times \ln(P_{kt})$, $o_t \equiv 100 \times \ln(O_t)$, $\Delta p_{kt} \equiv p_{kt} - p_{kt-1}$, and $\Delta o_t \equiv o_t - o_{t-1}$, with $\ln(.)$ indicating the natural logarithmic transformation. From now on we drop the subscript k for ease of notation. Moreover, in this section we will use the generic expression "petroleum product" (PP) to indicate any of the petroleum products considered in the study.

Following previous research on the RFH, we assume that the price of crude oil (o), being oil the main production input, is the only driver of the PP price (p):

$$p_t = \omega_0 + \omega_1 o_t + z_t \quad (1)$$

where z_t denotes the error term at time t. As highlighted by Bachmeier and Griffin (2003), Eq. (1) should not be given a structural interpretation. Actually, there are many other factors affecting the price of gasoline (e.g. inventory levels, refinery outages, changes in regulations, refining capacity utilization). If both the price of oil and the PP price are integrated of order one, while their liner combination is stationary, they are said to be co-integrated[5] (Engle and Granger, 1987), and the forecasts for the PP price should be produced with the following Error Correction Model (ECM):

$$\Delta p_t = \alpha + \sum\nolimits_{i=0}^{p} \beta_i \Delta o_{t-i} + \sum\nolimits_{j=1}^{q} \gamma_j \Delta p_{t-j} + \theta z_{t-1} + \varepsilon_t \quad (2)$$

where $z_{t-1} \equiv p_{t-1} - \omega_0 - \omega_1 o_{t-1}$ represents the stationary linear combination (or long-run equilibrium relationship) between the PP price and the price of crude oil. Coefficients β_i and γ_j measure the short-run impact of (lagged) crude oil and PP prices on the current PP price, while θ describes the speed of adjustment to long-run equilibrium. Clearly, the ECM entails a symmetric adjustment process, in that

[1] We are aware that the advantages of using models incorporating the RFH to forecast downstream prices are in some cases not very large, although statistically significant. Nevertheless, even an apparently inconclusive outcome can be informative to the forecast user, since it conveys the message that the choice of a model with or without RFH should not be limited to its statistical forecasting performance, rather it should be extended to other factors, such as computational simplicity, interpretation of parameters, and relationship with economic theory.

[2] We thank an anonymous referee for suggesting to compare the empirical performance of the same models using both WTI and Brent as the reference oil spot price.

[3] Results based on the Brent spot price are presented in Section 5.

[4] Retail prices excluding taxes are used in the analysis. To save space a more detailed description of the dataset, including construction of the price series and their plots, is presented in Appendix A.

[5] Results available from the authors show that all price series are integrated of order one and that gasoline and diesel prices are co-integrated with the price of crude oil.

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