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Rockets and feathers meet Joseph: Reinvestigating the oil–gasoline asymmetry on the international markets

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ABSTRACT

We reinvestigate the "rockets and feathers" effect between retail gasoline and crude oil prices in a new framework of fractional integration, long-term memory and borderline (non)stationarity. The most frequently used error-correction model is examined in detail and we find that the prices return to their equilibrium value much more slowly than would be typical for the error-correction model. Such dynamics is usually referred to as "the Joseph effect". The standard procedure is shown to be troublesome and we introduce two new tests to investigate possible asymmetry in the price adjustment to equilibrium under these complicated time series characteristics. On the dataset of seven national gasoline prices, we find no statistically significant asymmetry. The proposed methodology is not limited to the gasoline and crude oil case but it can be utilized for any asymmetric adjustment analysis.

1. Introduction

Gasoline prices shoot up like rockets and fall down slowly like feathers — such is a popular belief and a feeling of retail customers at gasoline stations. Increasing gasoline prices in the last decade have made such notion even more relevant to general public as well as to policy makers. The study of Bacon (1991) has coined the term "rockets and feathers" into the literature and since then, the topic has attracted much attention. The price of gasoline, after controlling for taxes, is primarily driven by the crude oil prices, even though such effect is indirect as there are usually several steps from the oil rigs and wells to the retail customers. Although the passthrough of the oil price to the retail gasoline prices might take relatively a long time, due to economic reasons such as transportation, menu costs, storage and others, the price adjustment should be symmetric whether the oil prices are going up or down. Mandelbrot and Wallis (1968) refer to such long-term dynamics as the Joseph effect inspired by the biblical story of Joseph (son of Jacob) who interpreted a dream of the Egyptian pharaoh about upcoming seven years of plenty followed by seven years of famine (Chapter 41 of the Book of Genesis). The dream-telling had been rewarded and Joseph served as the pharaoh's vizier. The years of plenty and the years of famine represent long periods when time series are above or below their long-term mean. From an econometric standpoint, this is represented by a slow decay of autocorrelation function of the long-term correlated[1] (long-range correlated, or persistent) series (Beran, 1994; Samorodnitsky, 2006).

Even though the parallel between price adjustment and the Joseph effect might be vivid and straightforward, it does not reflect the approach taken in majority of the empirical literature investigating the "rockets and feathers" effect in the gasoline market. In Section 2, we present a comprehensive literature review of the asymmetric price adjustment between gasoline and crude oil and we show that the studies usually begin with the assumption of the long-term equilibrium relationship between retail gasoline (or diesel in some cases) and crude oil. Specifically, the cointegration relationship is being built upon. This is well grounded both theoretically and empirically. However, the next step usually stems in estimating some form of an error-correction model. The deviation from equilibrium, represented by the error-

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[1] Specifically, the autocorrelation function $\rho(k)$ (with lag k) of long-term correlated series decays as $\rho(k) \propto k^{2H-2}$ for $k \to +\infty$. Hurst exponent H represents a strength of the long-term correlations. A time series is standardly labeled as long-term correlated for $H > 0.5$. Such process follows long-lived deviations from its mean, yet still reverts back to it for $H < 1.5$ (a random walk process has $H = 1.5$). This type of a process has been historically labeled as "the Joseph effect" (Mandelbrot and Wallis, 1968) due to its long-term behavior, similar to the biblical reference.

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correction term in the cointegration equation, is thus assumed to return to zero, i.e. the equilibrium state, rather quickly. We describe the cointegration and error-correction models methodology in Section 3. There, we also introduce the analyzed dataset, which comprises of the gasoline markets of Belgium, France, Germany, Italy, the Netherlands, the UK and the USA, and we focus on the basic dynamic properties of the series as well. We show that the gasoline markets are indeed cointegrated with crude oil. However, we also show that gasoline prices return to their long-run equilibrium very slowly. Specifically, we show that such dynamics can be attributed to long-term correlations and hence the Joseph effect rather than to the rapidly adjusting error-correction model. We argue that such a strong memory makes the standard error-correction models and their variants infeasible. As a solution, we propose two new tests for examining asymmetry in the cointegration framework. In Section 4, we present results of the asymmetry testing on the international gasoline markets and we show that there is no statistical evidence of the "rockets and feathers" dynamics towards equilibrium, and we also outline possible directions of future research in this area. Section 5 concludes.

2. Literature review

The term "rockets and feathers" has been connected with crude oil and retail gasoline since 1991 when Robert Bacon published his famous article (Bacon, 1991). Since then, vast research focusing on the (a)symmetric behavior of prices "at the pump" has been performed. Its motivation is to explain this phenomenon and understand whether any policy would improve the current market situation. As the literature on the topic is quite broad, we summarize the reviewed articles in Table 1 while focusing mainly on the analyzed time period, location and possible asymmetry.

The most common econometric approach investigating the asymmetry is the error-correction model (ECM). We focus on this dominant branch of the literature. All the ECMs are based on the two step Engle and Granger (1987) procedure that exploits the long-run equilibrium relationship between, in our case mostly, crude oil and retail gasoline. Various ECM specifications could be put into three groups — asymmetric ECM (used by most studies), threshold autoregressive ECM (Al-Gudhea et al., 2007; Godby et al., 2000) and ECM with threshold cointegration (Chen et al., 2005). For more detailed analysis, see the work of Grasso and Manera (2007) who study the sensitivity of various ECM models in order to understand how the choice of a particular model influences the results.

Existing literature differs by a country, a sample period and a data frequency, an econometric model and a research question. Paper of Borenstein et al. (1997) has influenced all subsequent papers and it serves as the reference point until now. The study is focused on the US market in 1986–1992 and its findings are based on ECM. The authors provide evidence for a common belief that after a crude oil price changes, gasoline prices rise faster than they fall. They try to identify the stage where the asymmetry occurs but is seems to be spread over all stages. The paper also offers an explanation for the asymmetric retail price adjustment (sticky prices, production lags, and inventories).

Balke et al. (1998) extend the previous study using several different model specifications and they confirm the asymmetry and conclude that the findings are sensitive to model specifications but not to the sample period. Bachmeier and Griffin (2003) use daily (spot) prices from the US market and find no evidence of asymmetry in wholesale gasoline prices. Analysis of Borenstein et al. (1997) is performed on weekly and biweekly data and that is how Bachmeier and Griffin (2003) explain different results — broader interval can result in a significant bias.

The literature on the "rockets and feathers" phenomenon can be viewed and compared from many different angles. Firstly, the studies can be divided according to a country of interest. Most of the studies focus on the US market, some on Canada and the UK, few on Western European countries, other countries like Chile (Balmaceda and Soruco, 2008) or New Zealand (Liu et al., 2010) are studied only rarely. According to Duffy-Deno (1996), the asymmetric effect depends also on the market size, and conclusions made based on local markets' data cannot

Table 1
Summary of the "rockets and feathers" literature.

Reference	Period	Country	Model/method	Results
Al-Gudhea et al. (2007)	1998–2004	USA	TAR, M-TAR, VECM	Asymmetry
Bachmeier and Griffin (2003)	1985–1998	USA	ECM (asymmetric)	Symmetry
Bacon (1991)	1982–1989	UK	Quadratic quantity adjustment function	Asymmetry
Balke et al. (1998)	1987–1996	USA	ECM (asymmetric)	Asymmetry
Balmaceda and Soruco (2008)	2001–2004	Santiago, Chile	ECM	Asymmetry
Bettendorf et al. (2003)	1996–2001	the Netherlands	ECM (asymmetric)	Neutral
Borenstein and Shepard (2002)	1985–1995	USA	LAM, PAM and VAR	Asymmetry
Borenstein et al. (1997)	1986–1992	USA	ECM	Asymmetry
Chen et al. (2005)	1991–2003	USA	ECM (threshold)	Asymmetry
Deltas (2008)	1988–2002	USA (separate states)	ECM (various)	Asymmetry
Douglas (2010)	1990–2008	USA	ECM	Depends on outliers
Duffy-Deno (1996)	1989–1993	Salt Lake City, USA	Markup model with first differences	Asymmetry
Eckert (2002)	1989–1994	Windsor, Ontario, Canada	ECM (reduced)	Asymmetry
Galeotti et al. (2003)	1985–2000	International (DE, ES, FR, IT, UK)	ECM (dynamic)	Asymmetry
Godby et al. (2000)	1990–1996	Canada (13 cities)	TAR within EC framework	Symmetry
Grasso and Manera (2007)	1985–2003	International (DE, ES, FR, IT, UK)	ECM (asymmetric, threshold)	Asymmetry
Honarvar (2009)	1981–2007	USA	ECM (crouching)	Asymmetry
Johnson (2002)	1996–1998	USA (15 cities)	ECM	Asymmetry
Karrenbrock (1991)	1983–1990	USA	Markup model with first differences	Symmetry
Kaufmann and Laskowski (2005)	1986–2002	USA	ECM (restricted and unrestricted)	Asymmetry
Lewis (2011)	2000–2001	San Diego, CA, USA	Consumer search model (with EC term)	Asymmetry
Liu et al. (2010)	2004–2009	New Zealand	ECM (asymmetric)	Asymmetry
Nagy Eltony (1998)	1980–1996	UK and USA	ECM (dynamic)	Asymmetry
Oladunjoye (2008)	1987–2004	USA	ECM (asymmetric)	Symmetry
Panagiotidis and Rutledge (2007)	1996–2003	UK	VECM	Symmetry
Radchenko (2005)	1993–2003	USA	ECM, VAR and PAM	Asymmetry
Reilly and Witt (1998)	1982–1995	UK	ECM (unrestricted dynamic)	Asymmetry
Tappata (2009)	Theoretical	General	Consumer search model	Asymmetry
Verlinda (2008)	2002–2003	USA	ECM	Asymmetry

Abbreviations: ECM (error-correction model), M-TAR (momentum threshold autoregressive model), PAM (partial adjustment model), LAM (lagged adjustment model), TAR (threshold autoregressive model), VAR (vector autoregression), and VECM (vector error-correction model).