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Asymmetries, outliers and structural stability in the US gasoline market

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ABSTRACT

By using a recently developed nonlinear cointegration methodology, and a sample that encompasses more than thirty years of monthly data, we investigate whether the transmission of crude oil price variations to gasoline prices in the US market is asymmetric, i.e.,depends on the sign of the change in the explanatory variable, considering both the long- and the short-run. The model is further extended by taking separately into account the effects of extreme and mild changes in crude oil prices. This allows us to verify whether and to what extent the size and shape of any observed asymmetry in pricing is affected by the presence of outliers. Moreover, given the substantial length of the sample considered, we test for the possible presence of multiple structural breaks of unknown timing in the cointegrating vector. Our results indicate that the relationship between the prices of gasoline and crude oil has undergone a single structural break in the late 2008, and that after the break extreme observations have a non-negligible role in shaping asymmetry.

1. Introduction

Asymmetric gasoline price adjustment in response to crude oil price changes has been a controversial subject in the scientific literature andpublic debate. Most analyses have focused on the US market (e.g.Balke et al., 1998; Borenstein et al., 1997; Honarvar, 2009; Kaufmann and Laskowski, 2005), due among other things to its relative size and to the weight of fossil fuels in the US consumption basket. Energy Information Administration data (EIA, 2015a) indicates that the US averaged over 40% of total world gasoline consumption in the last decade; according to the Bureau of Economic Analysis, the average share of gasoline and other motor fuels in total US expenditure ongoods was 9.3% (BEA, 2015); according to the Bureau of Labor Statistics, the relative importance of gasoline in the CPI index was 4.5% (BLS, 2015).

Asymmetric pass-through of crude oil price changes to gasoline prices has been confirmed by a large majority of studies, thus becoming almost a stylized fact (Perdiguero-García, 2013). However, some recent studies find mixed support for asymmetry, typically suggesting that the asymmetric behaviour observed may be a statistical artefact resulting from a relatively small number of exceptional events, while in normal times gasoline pricing behaviour is roughly symmetric. In particular, Douglas (2010) claims that the observed asymmetry may be a spurious phenomenon, caused by the impact of extreme variations in crude oil prices. According to his study, once outlying observations are correctly dealt with, the pass-through to gasoline prices appears to be symmetric. Fosten (2012) presents evidence showing that asymmetric pricing behaviour only emerged after the strong exogenous shock of 2008. Ina similar vein, Zhang et al. (2015) find that after accounting for structural breaks in long-run parameters, the relation is "almost symmetric".

A common feature of these studies is that they do not allow for asymmetries in the long-run coefficients of the estimated models. Moreover, while the issues they consider are distinct (possible dependency of price response on shock size, and structural stability of model parameters), they are interrelated. Their results are therefore conditional on the validity of untested assumptions, which may lead to biased results. For instance, ruling out asymmetries in long-run coefficients amounts to assuming that asymmetry is an intrinsically short-run feature of the process of adjustment to an exogenous shock, thus implicitly defining an untested constraint on model long-run parameters. Along

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the same lines, observed outliers may depend on structural shifts in estimated parameters, which will not be apparent if one imposes the untested constraint of parameter constancy.

In order to cope with these possible shortcomings, we address the empirical issue of pricing asymmetries in a comprehensive modelling framework, which takes into account the possibility of long-run asymmetries, dependence of the response on shock size, and the structural stability of the estimated equation. We build on the recent study by Atil et al. (2014), who analysed gasoline pricing asymmetries using a nonlinear autoregressive distributed lag model (NARDL), allowing for the possibility of asymmetries in the long-run parameters, and extend it along the lines suggested by Greenwood-Nimmo et al. (2011), whose threshold-ARDL (TARDL) model allows for an unknown number of multiple regimes. This allows us to consider any possible dependence of the gasoline price response to crude price shocks exceeding endogenously determined thresholds, and hence to deal with the outlier issue stressed by Douglas (2010). The estimated equations are tested for multiple structural breaks at unknown dates, using the method proposed by Bai and Perron (1998, 2003). This allows us to determine whether any evidence of asymmetric adjustment may depend on ignoring structural breaks in the equation's parameters (as put forward by Fosten, 2012 or Zhang et al., 2015).

The paper is organised as follows. Section2 provides a review of the literature focused on recent contributions regarding the US fuels market. The method used in this study is described in Section3. The main results of our analysis are reported in Section4 and discussed in Section5, which also includes a series of robustness checks. The conclusions are drawn in Section6.

2. An overview of the recent literature

Previous studies on asymmetric pricing in the fossil fuels markets have produced mixed results, though most of them indicate that adjustment of gasoline price to cost shocks is indeed asymmetric; see,for instance, the summaries contained in Wlazlowski et al. (2008), Clerides (2010), Polemis (2012), Perdiguero-García (2013) and Kristoufek and Lunackova (2015).

Among recent studies regarding the US market, Atil et al. (2014) apply the NARDL model (Shin et al., 2014) to estimate short- and long-run effects of variations in the price of crude oil on gasoline and natural gas prices. Using monthly data over a sample ranging from January 1997 to September 2012, they find no statistical evidence of long-run asymmetry in the response of gasoline price to crude oil price shocks. Regarding the short-run response, they find that negative crude oil variations have a greater impact on gasoline prices than positive ones. In short, their result is an indication of *negative short-run asymmetry*: the impact of a negative change in crude oil price is almost twice that of a positive variation (1.32 and 0.74, respectively). A broadly similar result was previously obtained by Adilov and Samavati (2009) using a different modelling approach. They found that although no asymmetric price adjustment can be observed for the average USgasoline price, the situation is heterogeneous across its various states, with negative asymmetry occurring in about one third of cases.

Contrary to most consumers' intuition, negative asymmetries in pricing are frequently observed (Dhyne et al., 2005) and have theoretical foundations (e.g. Ellingsen et al., 2006; Dhyne et al., 2011). The intuition is that in the presence of menu costs, if inflation is thriving, firms will not react to a negative shock to their costs by adjusting prices, because competitors' prices will drift upwards relatively quickly. Inthis way, the danger of predatory pricing policies is averted. On theother hand, if inflation is low, the firm will react more quickly to negative than to positive shocks to its costs in order to maintain its market share.

The theoretical and empirical literature stresses the fact that price adjustment may be size-dependent(Ball and Mankiw, 1995). However, the standard NARDL model only considers two regimes (defined by positive and negative changes in the explanatory variable), and as such it does not allow the effect of extreme observations to be taken into account. Pal and Mitra (2015) improve this approach by considering multiple-thresholdNARDL models. The thresholds are determined by quintiles and deciles in the distribution of the explanatory variable, thereby defining five and ten regimes, respectively, each containing an equal proportion of observations. They find *positive long-run asymmetry* to large cost shocks, whereas the response to smaller ones is almost symmetric, especially in the five-regimeNARDL model.[2] The picture that emerges once extreme observations are dealt with therefore differs from that of Atil et al. (2014).[3] However, while improving on the latter's methodology, Pal and Mitra's (2015) study suffers from two possibly related shortcomings: firstly, thresholds are determined arbitrarily and no formal testing is performed to assess the best number of regimes for data fit; secondly, estimates of single coefficients are generally statistically insignificant, suggesting overparameterisation (especially in the ten-regimes model). Moreover, while they report “overall” asymmetry tests, i.e. they test whether *all* coefficients are equal, no *pairwise* tests (symmetry tests for positive and negative shocks of comparable size, i.e. within a given regime) are reported. This is an important weakness of their analysis, since for instance the overall test could lead to rejection of the null hypothesis even when only a single coefficient is statistically different from the others, i.e. even when substantial symmetry prevails across most regimes.

Douglas (2010) deals with the issue of the arbitrary determination of thresholds using Tsay's (1989) method to estimate a threshold autoregressive error correction model (TAR-ECM) that allows endogenous determination of thresholds by looking at the deviation of gasoline price from its long-term equilibrium.[4] Each extreme regime contains on average nearly 7% of all available observations, so that the two inner regimes account for almost 86% of observations. Douglas computes the cumulative response function of a 10 cent positive and negative variation in the upstream price and finds that the difference in the predicted responses is not statistically significant. He then repeats the exercise with variations of ± 25 cents: in this case, the retail price increase is significantly greater than the decrease. He also finds that prices adjust more rapidly and more asymmetrically in the extreme regimes, i.e. far from equilibrium. In short, Douglas (2010) finds *positive short-run asymmetry* but only to large crude price changes. He then estimates a standard two-regime model (where the single threshold is set at zero) and obtains a positively asymmetric price adjustment, i.e. the price of retail gasoline responds more strongly to cost increases than decreases. Douglas's conclusion is that in “normal” circumstances the adjustment to crude price is symmetric, and that the evidence of asymmetry found in estimating standard models (i.e. models that do not account properly for the existence of outliers) is driven by a relatively small number of outlying observations.

A potential weakness of Douglas's study is that estimation of the TAR-ECM is conditional on a single linear cointegration vector, thus ruling out any asymmetric long-run response. Consequently, its results may be biased whenever the implied assumption of long-run symmetry is violated by the data generating process (DGP). Nevertheless, it has the merit of stressing the role of outliers, which can be expected to be crucial in a market subject to many exogenous shocks due to events ranging from conflicts to natural disasters in oil exporting countries.[5]

[2] Pal and Mitra (2015) estimate their models using price levels and do not report the estimated elasticities. We calculate the implied elasticities, as explained below.

[3] This difference may also depend on the different frequency of the data (weekly vs. monthly), as well as on inclusion of an additional control variable (volume of petroleum products).

[4] The estimated thresholds define the following regimes: $(-\infty; -14.21]$, $(-14.21; 1.94]$, $(1.94; 13.10]$ and $(13.10; \infty)$. These regimes indicate when retail price-cost margins are very low, moderately low, moderately high, and very high, respectively. It should be noted that the central threshold does not coincide with zero.

[5] A brief history of the evolution of oil prices during 1947–2000 can be found in Adelman (2002); historical oil shocks since 1850s are discussed in Hamilton (2011).