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# Exploring the life of fuel price responses in retail markets. The effect of cross-sectional aggregation

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ABSTRACT

Empirical studies on vertical price transmission in retail fuel markets commonly use average group data of petrol stations. In this paper a simulation approach is employed to illustrate that, in this case, the persistence of price responses tends to be overestimated. To explore the real extent of the problem, we apply the mean group (MG) and the mean group with common correlated effects (MG-CCE) estimators to individual data from petrol stations. When heterogeneity in the pricing dynamics is captured by MG and MG-CCE estimators, persistence of retail price responses becomes considerably lower than the typical OLS estimations from average group data would suggest.

## 1. Introduction

Since the seminal paper by Bacon (1991) there has been an increasing interest in knowing the speed of fuel price responses to input price shocks (e.g. (Borenstein et al., 1997; Polemis, 2012; Contín-Pilart et al., 2009; Remer, 2015; Asane-Otoo and Schneider, 2015)). Much of the effort in this field has been devoted to testing possible asymmetries in the speed of response to upward and downward shocks,[1] while little attention has been paid to knowing to what extent the degree of aggregation underlying the data commonly used could affect these estimates. However, it is well known that aggregation over time or over individuals in dynamic models, like those used in this research area, could imply substantial bias.

A reduction of information from temporal aggregation could preclude model specification from properly capturing the intertemporal lag distribution of the real phenomena (Geweke, 1978). This is a type of omitted variables problem that has been revealed to be clearly significant in the estimation of the fuel price adjustment towards long-run equilibrium through Error Correction Models (ECMs). For instance, in the early paper by Bachmeier and Griffin (2003),[2] the coefficient of the adjustment from weekly data is about five times higher than that obtained from daily data. Thus, the use of daily frequencies is recommended insofar as they are available to researchers (Bachmeier and Griffin, 2003). On the other hand, several theoretical papers have demonstrated that cross-sectional aggregation to build average group data could cause a reduction in the estimated speed of responses and, therefore, an overestimation of the dynamics of the aggregate phenomena studied. This sort of bias, which is critically dependent on the behavioural heterogeneity of the individuals involved in the analysis (e.g. (Pesaran, 2003; Stoker, 1993)), is revealed to be especially significant under application of ECMs (Lippi, 1988). Given that the behaviour of petrol stations could be quite heterogeneous (Haucap et al., 2017), undermining the consequences of cross-sectional aggregation by appealing to the representative-agent paradigm could be, in this case, an unsuitable strategy which deserves special attention as highlighted by Faber (2015).[3]

The present paper aims to conduct a comprehensive investigation of the extent to which estimates from average group data of petrol stations could be overstating the life of retail fuel price responses. From a literature search we can see that, in spite of the potential bias commented above, most of the evidence on fuel price responses is based on data at weekly or lower frequencies which, in turn, are aggregated to build data averaged by country. With the purpose of trying to isolate the possible impact of cross-sectional aggregation on the previous analyses,

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[1] For a complete meta-analysis at this regard see, for example, Perdiguero-García (2013).
[2] The aim of this paper is to re-examine, by using an ECM, the previous results from Borenstein et al. (1997) based on weekly data.
[3] In this paper it is indicated that the pooled estimation, where parameters are restricted to be equal across individuals, is not suitable to analyze the market as a whole. Then, the author advocates the use of a separate analysis for each individual station.

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we will focus on those works that include estimates of the adjustment towards long-run equilibrium based on daily data.[4] These papers offer us results from different degrees of cross-sectional aggregation, which can be usefully exploited for a preliminary exploration of the importance of the problem.[5]

First, we can consider two papers that employ data at country level. With the aim of illustrating the length of the dynamics in each case, let us now to use a synthetic measure. Concretely, we are going to pay attention to the average number of days needed to adjust 95% of the retail price deviations from the long-run equilibrium after an input price shock from the wholesale-refined fuel market.[6] Thus, in the work by Al-Gudhea et al. (2007), which provides estimates for USA, around 464 days are required to fill this percentage of the gap after a shock. The results from Balaguer and Ripollés (2012) concerning Spain would imply that, following a shock in international fuel markets, about 251 days are needed to close this percentage of the gap. Considering the surprising number of days required in both cases, we might suspect that aggregation across petrol stations could be causing a relevant overestimation of the life of price responses, at least, when it is performed at country level.

Second, we can take into account the paper by Bettendorf et al. (2009). In this case, retail prices are aggregated for the Shell brand in the Dutch petrol market. Authors indicated that competing oil companies in the Netherlands could easily monitor and follow the pricing policy of this company with the largest market share (30%), although it is recognized that differences in pricing strategies may exist between the firms operating in that market. From the results of the estimations of this leader company, we obtain that the period needed to adjust 95% of the retail price deviations from the equilibrium is only 27 days. Hence, evidence may suggest that data disaggregation by brand (which presumably involves relatively homogeneous sellers) could be contributing significantly to reduce overestimation in the life of price responses.

Third, the recent papers by Remer (2015) and Balaguer and Ripollés (2016) are based on data from individual petrol stations with the usual purpose of testing asymmetries in the response of prices. In the first of the two cases, the retail price observations belong to petrol stations from several states in USA (New Jersey, Maryland, Virginia, Philadelphia and Washington). From the estimates, we find that adjustments would need about 43 days until 95% of the gap was closed. From the second of the papers we can observe the period required to close this percentage of the gap for the two greater metropolitan areas in Spain. Specifically, we are referring to Madrid and Barcelona, for which 25 and 27 days were required, respectively. It is clear that the lengths of price responses in the last three papers contrasted with those where data are aggregated at country level, which suggests the importance of the problem when different operating brands with singular pricing strategies are disregarded. At this point, we further ask ourselves whether aggregation at brand level could be considered a reasonable empirical strategy to prevent an important part of the overestimation of the length of the dynamics.

[4] To our knowledge, this is the maximum degree of data disaggregation available in this research area. Probably because of the difficulty in obtaining daily information on retail fuel prices, few papers with this temporal disaggregation have been published to date.

[5] Some papers that employ daily data, but do not involve data aggregation across petrol stations, are not included. This is, for example, the case studied by Bachmeier and Griffin (2003), where shocks from crude oil prices to wholesale petrol prices are analysed and, therefore, the behavioural heterogeneity of sellers operating in the retail market is not a relevant issue.

[6] This can easily be derived from the estimated coefficients of speed of adjustment towards the long-run equilibrium provided in each of the papers. The period necessary to adjust 95% of the deviations is obtained from the natural logarithm of 0.05 divided by the value of the speed adjustment coefficient. When the adjustment is split in order to distinguish the effect of upward and downward shocks, for the sake of simplicity, we will consider the average coefficient.

The rest of the paper is organized as follows. In Section 2, we start by describing the baseline model. Following, we will discuss a set of results obtained by simulations to draw attention to the problem statement. In Section 3, we present an application on Spanish diesel prices that have been collected daily to prevent, as much as possible, temporal aggregation bias. Then, we will compare the empirical results from heterogeneous panel estimates with those derived from the common OLS estimates based on cross-sectionally aggregated data. First, we will perform this comparison using the entire sample. Thus, we try to examine to what extent aggregation across a large diversity of brands, which probably hides a high degree of behavioural heterogeneity, affects the accuracy of the estimation results. Second, we further focus on a sub-sample of the leader's petrol stations. The purpose will be to know whether the extent of the problem would persists through this empirical strategy. In Section 4, we test the robustness of the results. Finally, in Section 5, we present our concluding remarks.

## 2. The analytical framework

### 2.1. Model specification

It is well known that, in the case of cointegration between non-stationary time series, implementation of an ECM specification can be a particularly useful strategy to describe dynamics between variables (Engle and Granger, 1987). This empirical strategy is mostly being adopted by studies on vertical price transmission in fuel markets. Here, we adopt this approach by introducing the possible heterogeneity of the behaviour of each of the firms ($i = 1, 2, ..., N$):

$$\Delta p_{it} = \sum_{m=1}^{M} \beta_{im} \Delta p_{it-m} + \sum_{j=0}^{J} \delta_{ij} \Delta wp_{t-j} + \theta_i (p_{it-1} - \alpha_i - \phi_i wp_{t-1}) + \epsilon_{it} \quad (1)$$

where $\Delta$ is the first-differences operator, $p_{it}$ is the retail price of the $i$-th firm at time $t$ ($t = 1, 2, ..., T$), and $wp_t$ is the corresponding wholesale fuel price at time $t$, which is common for all operating firms. The speed of adjustment towards the level of equilibrium is captured by $\theta_i$, characterizing the long-run dynamics of the model. Lastly, $\epsilon_{it}$ is a random disturbance term, which is assumed to be *iid*.

Second, we also consider a restricted version of Eq. (1) as follows:

$$\Delta \overline{p}_t = \sum_{m=1}^{M} \beta_m \Delta \overline{p}_{t-m} + \sum_{j=0}^{J} \delta_j \Delta wp_{t-j} + \theta (\overline{p}_{t-1} - \alpha - \phi wp_{t-1}) + \epsilon_t \quad (2)$$

where $\overline{p}_t = \frac{1}{N}\sum_{i=1}^{N} p_{it}$, and the subscript $i$ in coefficients and the random disturbance term is disregarded. Then, the specification from Eq. (2) implies some degree of cross-sectional aggregation as is usual in this research area.

### 2.2. Simulation

With the aim of illustrating the problem statement, let us obtain artificial series of retail fuel prices based on Eq. (1). For this purpose we consider, as the wholesale price series ($wp_t$), spot prices of refined diesel fuel. Specifically, we consider the wholesale spot prices at Amsterdam-Rotterdam-Antwerp (Euros/litre), which represent the principal and direct raw material cost in the European retail markets for diesel. These prices are provided by Platts of the McGraw-Hill Company and correspond to a sample period that ranges from 10 June 2010–25 November 2012.[7] A preliminary analysis of time series indicates that it follows an I(1) process. Namely, in accordance with the Augmented Dickey-Fuller test (ADF) proposed in Dickey and Fuller (1979), wholesale price series are non-stationary in levels (ADF = − 1.59) but their first differences can

[7] Missing values resulting from closure of the spot markets at weekends and in holidays have been filled in with prices from the day before.

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