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" Symmetric or asymmetric gasoline prices? A meta-analysis approach"

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Abstract

The analysis of price asymmetries in the gasoline market is one of the most studied in the energy economics literature. Nevertheless, the great variability of results makes it very difficult to extract conclusive results on the existence or not of asymmetries. This paper shows through a meta-analysis approach how the industry segment analysed, the quality and quantity of data, the estimator and the model used may explain this heterogeneity of results. We also note how there may be some degree of publication bias in the analysis of asymmetries in the gasoline market, especially contemporaneous impact asymmetries (COI). These results should be considered in future studies on asymmetries in the fuel industry.

JEL classification:. L11, Q4, C25.
Keywords**:** Price asymmetry, meta-regression analysis, gasoline prices.

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1. **Introduction**.

How the gasoline market works, and in particular the pricing strategies that companies follow, has been analysed by economic science on numerous occasions. Within this analysis, one element which has received a great deal of attention is the possible existence of asymmetries in the gasoline market. More specifically, there is a vast literature that aims to determine whether the prices in a given segment of the gasoline market respond symmetrically or asymmetrically to movements in the prices of its input. There are a huge number of papers that have examined, at an empirical level, whether prices of petroleum products incorporate cost increases more rapidly than decreases, with no unanimous results.

The existence of price asymmetry is not an issue exclusive to the gasoline market and has received attention from numerous authors in many markets. As noted by Peltzman (2000), there is a perception by consumers that there are asymmetries in the way costs are absorbed by the final prices in many markets. This perception is particularly important in the case of the gasoline market because there exists a high level of consumption, a great frequency in consumption and a greater transparency in prices than in other markets. It is common for consumers to attribute these possible asymmetries to uncompetitive behavior in the markets and even the existence of collusion, although Borenstein et al. (1997) show how there is a whole set of reasons that could explain the asymmetries when firms compete in the market.

Despite the great attention that this topic has attracted, the empirical results on the existence of asymmetries in gasoline prices are mixed. The use of different methodologies, models, frequencies and periods of data, and the application to different countries, may be behind this heterogeneity of results. Some of the papers published in this area have noted the importance of specific factors in obtaining a particular result. For example, Kirchgässner and Kübler (1992) obtained opposite results for the 70s and 80s, and in the analysis by Bettendorf et al. (2003), the result depended on the day of the week data prices were collected. The application of a meta-analysis is therefore of great interest to show us the existence of systematic patterns in obtaining one result or another[1]. However, this methodology has not been applied in this topic.

The only application of this methodology to asymmetric gasoline prices is Frey and Manera's (2007), although that study does not focus only on the gasoline market. They analyse a group of industries: food, agriculture and gasoline. The aim of this paper is to try to fill the gap and explain the heterogeneity and sensitivity of empirical results.

In contrast to the previous literature - especially the study by Frey and Manera (2007), the only one that covers this issue - this paper presents a set of innovations. Firstly, as already noted, this is the first time that meta-analysis methodology has been implemented specifically for asymmetries in the gasoline market. Secondly, the database used in this paper incorporates a broader set of studies than that used previously. There has been an unusually broad review of the empirical literature looking at this aspect, including not only articles published in scientific journals but also unpublished working papers and reports by government institutions. Thirdly, we have included a set of variables not previously used that will allow us to draw further conclusions as to the relationship between the result of asymmetry and the market and study characteristics. The analysis of the gasoline market specifically allows us to introduce more specific variables for this particular market and draw specific conclusions.

This study shows that there are characteristics of the studies that significantly affect the results. The year of publication, the industry segment analysed, the quality and quantity of data, the estimator and the model used can explain the different results in the literature.

[1] It is surprising that this methodology has not been applied to analyse asymmetries in gasoline prices, especially considering that meta-analysis has been applied on numerous occasions in the energy industry. Good examples are Espey (1998) and Brons et al (2008) in the analysis of the elasticities of demand for gasoline; Subdqvist (2004), which analyses the negative externalities in electricity production; Koetse et al (2008), which analyses the elasticity in capital-energy substitution; and finally Kuik et al (2009), where the subject for analysis is the costs of greenhouse gas mitigation policies.

The paper is organized as follows. After the introduction, Section 2 discusses in detail the data and variables used in econometric specifications. In Section 3 we show the results obtained, and finally the conclusions are presented in Section 4.

2. Data and empirical approach.

To configure the database we have collected through EconLit all the articles that have analysed the existence of asymmetries in the gasoline market, and to accompany these we have working papers and reports obtained through the Google Scholar search engine. This search brings us a set of 48 documents. Because studies generally show more than one analysis, the number of observations amounts to 338. Unfortunately not all papers provide all the information, so there are variables with fewer than 338 observations. The variable with the smallest number of observations is actually the number of observations used in each study. This variable is obtained on only 240 occasions. Introducing this variable may cause a selection of the sample, so various empirical approaches were made with and without it.

The following is a detailed description of the different variables that have been used in the econometric analysis.

Dependent variable

As far as the dependent variable is concerned, a element common to all the approaches in our study is that they are logit estimations where the endogenous variables are dummy variables that take value 1 if the study has found the existence of asymmetry (or a certain type of asymmetry) and 0 otherwise. This empirical approach differs from that used by Frey and Manera (2007), where the authors used the F-statistic value to test the existence of asymmetry. This paper has chosen not to take this approach because the number of studies that do not report information on the F-statistic is very high, which reduces our sample and could cause problems of sample selection. This problem is a factor that could very significantly bias our results. Indeed Frey and Manera (2007) pointed out in their analysis the limited number of papers that present this information: "*Among the 70 papers cited in this survey, we select the contributions which provide complete information on the calculated F-statistic* *for price symmetry for a total of 29 articles and 462 observed F test*". Therefore, the use of the F-statistic reduces the sample to just over 40% of the papers, thereby generating a possible problem of sample selection. We therefore consider it more appropriate to use a dummy as the dependent variable and do not select the sample to a small subset of studies.

There are three dependent variables that we will use in the different specifications. The asymmetry variable takes on a value of 1 if the study finds any kind of asymmetry. The two remaining dependent variables are related to the two types of asymmetries defined by Frey and Manera (2007), particularly with regard to whether or not the papers analyse COI (contemporaneous impact) and DLE (distributed lag effect) types of symmetry.

Moderator variables

In this subsection we specify the set of moderator variables that explain the different results obtained in the asymmetric analysis.

- Types of asymmetries discussed in the article. We introduce a set of dummy variables that take value one if the study analyses the existence of a certain type of asymmetry and zero otherwise. Following Frey and Manera (2007), we have specified eight types of asymmetry: COI (contemporaneous impact), DLE (distributed lag effect), CUI (cumulated impact), RT (reaction time), EAP (equilibrium adjustment path), MEAP (momentum adjustment equilibrium path), RE (regime effect) and REAP (regime adjustment equilibrium path).

- Year of publication of the study. This variable takes the value of the year the study was published.

- Industry segment that the study analyses. We introduce a set of dummy variables that take value one if the study analyses a particular segment of the oil industry and zero otherwise. We considered six different segments within the industry: 1) the relationship between the price of crude and the retail price paid by consumers; 2) the relationship between the price of crude oil and the wholesale price; 3) the relationship between spot prices in international markets and the wholesale price; 4) the relationship between the spot price in the international market and the price paid by consumers; 5) the relationship between the price of crude oil and the spot price in the international markets; and 6) the relationship between the wholesale price and the price paid by consumers.

- Average year analysed in the study. This variable takes the value of the arithmetic average of the years analysed in the study.

- Type of fuel. We introduce a dummy variable if the study analyses diesel and zero in the case of any kind of gasoline.

- Geographical variables. We divided the studies into four geographical areas, depending on whether the analysis is performed in Europe, the U.S., Canada or elsewhere. Four dummy variables have been created that take value one if the study examines any of these areas and zero otherwise.

- Tax on fuel. We introduce a dummy variable that takes value one if the prices used in the study include taxes and zero if they do not.

- Number of observations. We include a variable that takes as its value the number of observations used in the econometric analysis. This variable will be key for analysing the possible existence of publication bias. As indicated by Stanley (2005), an important element to be analysed in the meta-analysis is the possible existence of publication bias. He shows that: "*Publication selection exists when editors, reviewers, or researchers have a preference for statistically significant results*". Although he presents a set of statistical tests to detect and quantify the presence of publication bias, they are all based on the statistical t-student, so they cannot be applied in this case. However, we can approximate the possible existence of publication bias through the variable number of observations. If we assume that the studies with a greater number of observations are more efficient in approaching the real value of the parameter, the significance of this variable approximates the existence of publication bias. In the case that the variables are significant and positive, this would indicate that there is some bias towards publishing articles with a significant result of symmetry. However, the presence of a negative significant coefficient would indicate a bias towards publishing studies that show the asymmetry of prices[2].

- Frequency of the data. Another element to consider is the periodicity of the data. Therefore we create a set of dummy variables that take value one if the study used this periodicity in the data and zero otherwise. Two categories are constructed: papers that use monthly data and papers with more frequency data.

- Area analysis. These variables seek to distinguish whether the analysis is performed in a given city or in a broader geographic region such as a metropolitan area or if the study covers the entire country. To reflect this property we include a dummy variable that takes value one if the geographic scope of analysis is the whole country.

- Type of estimator. Different studies have analysed asymmetric behavior in the gasoline market through various estimators, but mainly two: least squares (which includes ordinary least squares) (LS) and maximum likelihood (ML). We created three dummy variables corresponding to these two estimators and a dummy variable containing all others.

- Type of model. Following Frey and Manera (2007), the main methodologies used to analyse the existence of asymmetries in the market have been identified and five groups created: the autoregressive distributed lag model (ARDL); the partial adjustment model (PAM); the error correction model (ECM); the regime switching model, stochastic regime switching model and deterministic regime switching model (RSM-SRS-DRS); and the vector autoregressive model, vector error correction model and vector regime switching model (VAR-VECM-VRSM). Again, we created five dummy

[22] To see an application of the different tests to detect publication bias see Stanley (2008)

variables that take value one if the study used this particular methodology and zero otherwise.

- Analysis of cointegration. We created a dummy variable that takes value one if the study made a cointegration test to check the existence of a long-term causal relationship between the two sets of data, and zero otherwise.

- Type of publication. A final element that we believe may explain the difference in results is the type of publication which presents the studies. We divided the studies into five groups: 1) if the study is published in a review of energy (Energy Economics, Energy Policy, International Journal of Energy Research and OPEC Review); 2) studies published in journals of industrial organization (International Journal of Industrial Organization, Journal of Industrial Economics, Review of Industrial Organization); 3) studies published in other scientific journals indexed in the Social Sciences Citation Index (SSCI); 4) articles published in other journals that are not indexed in the SSCI; 5) studies that are still working papers and commissioned studies and/or reports published by institutions or public organizations.

The following table presents the descriptive statistics.

Table 1. Descriptive statistics.

	No obs	Mean	Std. Dev.	Min	Max
Asymmetry	338	0.598	0.491	0	1
COIA	338	0.663	0.473	0	1
DLEA	338	0.618	0.487	0	1
CUIA	338	0.115	0.320	0	1
RTA	338	0.198	0.399	0	1
EAPA	338	0.101	0.301	0	1
MEAPA	338	0.044	0.206	0	1
REA	338	0.130	0.337	0	1
REAPA	338	0.003	0.054	0	1
Year Pub.	334	2003.162	4.225	1991	2010
Cr to R.P.	338	0.402	0.491	0	1
Cr to Spot	338	0.107	0.309	0	1
Spot to W.P.	338	0.041	0.200	0	1
Spot to R.P	338	0.178	0.383	0	1
Cr. To W.P.	338	0.038	0.193	0	1
W.P. to R.P.	338	0.234	0.424	0	1

Av. Year Study	334	1194.528	4.527	1975.5	2006
Gasoline	337	0.961	0.193	0	1
Diesel	337	0.039	0.193	0	1
USA	338	0.388	0.488	0	1
Europe	338	0.331	0.471	0	1
Canada	338	0.133	0.340	0	1
Other regions	338	0.148	0.356	0	1
Without tax	338	0.565	0.496	0	1
With tax	338	0.420	0.494	0	1
No obs	240	707.733	1559.627	35	8319
No monthly data	338	0.536	0.499	0	1
Monthly data	338	0.465	0.499	0	1
No country data	335	0.522	0.500	0	1
Country data	338	0.473	0.500	0	1
LS	338	0.722	0.420	0	1
ML	338	0.175	0.380	0	1
Other estimator	338	0.154	0.361	0	1
ARDL	338	0.095	0.293	0	1
PAM	338	0.024	0.152	0	1
ECM	338	0.692	0.462	0	1
RSM-DRS-SRS	338	0.133	0.340	0	1
VAR-VECM-VRSM	338	0.044	0.206	0	1
Cointegration	338	0.893	0.309	0	1
Energy Review	338	0.562	0.497	0	1
IO Review	338	0.068	0.252	0	1
Other SSCI reviews	338	0.074	0.262	0	1
Other non-SSCI reviews	338	0.296	0.457	0	1

In the table we can observe the mean, standard deviation, minimum and maximum of each of the variables used in the different empirical approaches presented in the next section. As shown in Table 1, our empirical approach covers a wide range of study characteristics, from the kind of asymmetry analysed to the type of publication in which the study was published.

In the next section we present the econometric results obtained using the dependent and independent variables specified above.

3. Results

Table 2 shows the results obtained when we use the full sample of the database. The first column specifies the most general case which includes all groups of dependent variables, while column two shows the variables as regards types of asymmetry. Columns three and four replicate exactly the same estimates without the variable number of observations. The reason for re-estimating the empirical model without this variable is because it is not available for a wide range of studies, so their inclusion might select our sample. Therefore this variable is removed from the empirical model and estimated with a larger number of observations. As can be seen, the results do not change significantly.

Table 2. Results obtained with the full sample.

Constant	217.327	628.656***	596.557***	604.377***
	(414.014)	(229.789)	(159.917)	(150.494)
COI	4.971**		1.126	
	(2.507)		(1.095)	
DEL	-4.757		-0.059	
	(3.312)		(0.982)	
CUI	-5.347**		-0.982	
	(2.592)		(0.844)	
RT	0.380		0.036	
	(1.987)		(0.669)	
EAP	0.862		-0.614	
	(1.628)		(0.709)	
MEAP	-0.036		-0.156	
	(0.813)		(0.766)	
RE	1.830		-5.144	
	(3860.035)		(20.693)	
Year Pub.	-0.133	-0.256*	-0.382***	-0.349***
	(0.232)	(0.135)	(0.126)	(0.122)
Cr to Spot	-1.730**	-1.877***	-1.395**	-1.459***
	(0.709)	(0.683)	(0.556)	(0.546)
Spot to W.P.	-0.041	-0.298	-0.073	0.013
	(1.366)	(1.287)	(0.799)	(0.773)
Spot to R.P	0.262	-0.167	0.009	0.105
	(0.691)	(0.605)	(0.482)	(0.460)
Cr. To W.P.	-6.263	-2.765	-2.012**	-2.005**
	(4.179)	(2.264)	(0.997)	(0.989)
W.P. to R.P.	19.747**	4.777**	2.171***	2.130***
	(8.542)	(2.369)	(0.818)	(0.727)
Av. Year Study	0.016	-0.060	0.084	0.046
	(0.162)	(0.132)	(0.110)	(0.109)
Diesel	-11.890**	-3.004	0.582	0.573
	(5.719)	(2.459)	(1.435)	(1.329)

Europe	1.753	-1.490	-0.227	-1.111
	(3.270)	(2.209)	(0.971)	(0.738)
Canada	9.990	-1.719	2.353	-3.487**
	(3860.036)	(3.209)	(20.672)	(1.673)
Other regions	14.458**	5.233	1.609	1.122
	(6.834)	(3.684)	(1.836)	(1.513)
With tax	4.911*	0.124	0.453	0.326
	(2.827)	(0.963)	(0.508)	(0.484)
No obs	-0.002**	-0.001*		
	(0.001)	(0.000)		
Monthly data	-2.838*	-2.299*	-0.967	-1.379*
	(1.750)	(1.213)	(0.849)	(0.742)
Country data	14.316**	5.032**	0.700	2.062***
	(6.756)	(2.555)	(1.191)	(0.800)
ML	6.299***	3.728***	3.099***	3.028***
	(2.020)	(1.079)	(0.894)	(0.772)
Other estimator	2.939	-0.213	-0.688	-0.762
	(2.018)	(0.793)	(0.806)	(0.660)
ARDL	4.582	-0.319	-2.376***	-2.291***
	(3.820)	(2.248)	(0.787)	(0.761)
PAM	-7.388**	-5.758*	-4.660***	-4.263**
	(3.360)	(3.081)	(1.765)	(1.696)
RSM-DRS-SRS		2.094		0.962
		(2.893)		(1.716)
VAR-VECM-VRSM	-4.818	-1.753	-3.013**	-2.156*
	(3.117)	(1.735)	(1.354)	(1.189)
Cointegration	-1.335	0.865	1.091	0.908
	(3.206)	(1.517)	(0.901)	(0.851)
IO	22.007***	9.114**	6.417***	5.896***
	(8.125)	(3.649)	(2.113)	(2.035)
Other SSCI reviews	14.857**	4.869**	1.171	1.585**
	(6.032)	(2.144)	(0.807)	(0.744)
Other non-SSCI reviews	5.856**	2.135**	0.229	1.328*
	(2.505)	(1.050)	(0.916)	(0.687)
No obs	234	235	330	330
Chi2	131.72***	121.22***	168.28***	163.59***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Pseudo R2	0.4092	0.3748	0.3778	0.3664

p-value (***1%, **5%, *10%)
Robust standard errors in brackets.

We present the main econometric results obtained for different groups of dependent variables:

- Type of asymmetry. Although in column one there are two statistically significant coefficients, column three shows how the type of asymmetry analysed in the study is not statistically related to the identification of asymmetries. This result coincides with that obtained by Frey and Manera (2007), which also found no statistical relationship between the type of asymmetry analysed and the result.

- Year of publication. This variable is negative in all specifications and statistically significant in three of them. Therefore it seems that there is a negative relationship between the year of publication of the study and obtaining asymmetry in the econometric analysis. This result indicates that studies published more recently have a greater probability of obtaining the result of symmetry. This can occur because the industry has gradually changed behavior or because the methodological refinements and better information available could alter the findings obtained in the econometric analysis. Since both of them are equally dependent variables in our analysis, we have to check that there are no problems of multicollinearity between the year of publication variable and the methodology and data variables used. The results show there is no high correlation between them, so we can reject the existence of a multicollinearity problem[3].

- Industry segment analysed in the study. These econometric results should be interpreted in relation to the dummy variable that is not introduced in the specification: the relationship between the price of crude and the retail price paid by consumers. The results show asymmetric behavior is less likely to be found in the higher segments of the industry, i.e. the relationship between crude oil and spot prices in international markets. However, it is more likely to be found in the last segment of the industry, i.e. the relationship between the wholesale price and the price paid by consumers. This result would indicate that it this last segment, usually more concentrated and potentially less competitive, where the existence of asymmetric behavior is more likely to be detected.

[3] There is a low level of correlation between the year of publication variable and the dummy variables for the different models. The highest value is the correlation with the ECM dummy, with a value of 0.499. In the case of data used in the papers, the correlation is lower than in the previous case. The highest value of correlation is between the year of publication variable and the country aggregate data variable, with a value of 0.374.

- Average of period analysed in the study. This variable is not significant in any case. The result of this variable seems to indicate that there is no change in industry behavior over time, and methodologies and dates would better explain the negative significant result of the year of publication variable.

- Type of fuel. The fact that diesel fuel instead of gasoline is analysed seems to have no significant effect overall, even though it has one negative significant coefficient. Considering that diesel consumers are more price sensitive and have a lower search cost (one of the features that could explain the existence of asymmetries in the price), it seems logical that the sign of the variable is negative. However, this does not seem to be one of the most important variables for explaining the differences in the results obtained by the studies.

- Geographical variables. With regard to the omitted dummy variable, which in this case is the United States, it seems that Europe has no different pattern, while Canada has one negative significant coefficient. The variable that comprises all other regions is positive and significant in one of the estimations. Therefore market performance may differ in different geographical areas, but again this does not seem to be an essential element for explaining the differences in results.

- Tax on fuel. The dummy variable on whether prices incorporate tax is positive and significant in one of the estimations, which would indicate that price asymmetries are more likely to be found when using prices with taxes. However, this conclusion is weak because in the other three empirical approaches the variable is not significant.

- Number of observations. The variable that shows the number of observations used in the studies is negative and significant in both regressions in which it is included. Therefore, studies using a larger number of observations are less likely to find asymmetries in prices. The significant result of this variable would indicate that there may be publication bias. Studies with a greater number of observations (and therefore more efficient in approximating the real value of the parameter) are more likely to find symmetries of prices.

- Frequency of the data. The monthly data variable is negative in all cases and significant in three of them. Therefore studies using aggregated data on a monthly basis are less likely to find price asymmetries than studies using more disaggregated level data.

- Area analysed. Regarding the area of analysis, econometric results show that studies analysing the whole country in aggregate are more likely to find asymmetries.

- Type of estimator. Studies that used a maximum likelihood estimator are more likely to find asymmetries than those studies using a least squares estimator.

- Type of model. All models, except RSM-DRS-SRS models, were less likely to show asymmetries than error correction models (ECM). This element is important because it suggests that the model chosen can significantly affect the results obtained.

- Analysis of cointegration. Performing a cointegration analysis to see if there is a causal long-term relationship does not seem to significantly affect the outcome of asymmetry.

- Type of publication. Regarding the type of publication, all the variables are positive and most of them are statistically significant. This result indicates that energy reviews, which is the variable not included, published significantly more articles which found the existence of symmetries. In other words, outside energy reviews there seems to be some bias in favor of papers that obtain an asymmetric result.

As we have seen in the previous paragraphs, there is a whole set of variables that affect the result obtained in the asymmetric analysis. It is less likely to find results of asymmetry if the article was published more recently, if the study examines the early stages of the industry (the relationship between the crude oil or spot price and the wholesale price), if it has a greater number of observations, if the data are aggregated on a monthly basis, and it also depends on the use of certain models (specifically ARDL, PAM and the vector autoregressive model). There is also a set of variables that shows a greater likelihood of asymmetric outcomes: an analysis of the last stage of the industry (the relationship between the wholesale price and the price paid by consumers), if the dataset is aggregated geographically at country level, if the maximum likelihood estimator is used, and publication in journals other than energy economic reviews.

Once the analysis for the full sample was carried out, we proceeded to present the analysis according to the type of asymmetry analysed in the study and the subgroup of studies that use the ECM model, the most popular by far. The first two columns of Table 3 show the results taking into account only those papers that analyse contemporaneous impact asymmetry (COIA). The third and fourth columns take into account papers that analysed distributed lag effects asymmetry (DLEA). Finally, columns five and six take into account the studies that use the ECM models. Inside every group the difference between the two estimations is the inclusion of the number of observations variable. As in the case of Table 2, the fact that the number of observations variable lacks observations may select our sample. I therefore prefer to estimate the same specification with and without this variable to check the robustness of my results.

Table 3. Results obtained with a sub-sample.

	COIA==1		DLEA==1		ECM==1	
Constant	453.132***	407.689	363.724	604.141	712.189***	378.286
	(152.982)	(294.728)	(271.575)	(430.001)	(276.064)	(306.366)
Year Pub.	-0.346***	-0.210	-0.164	-0.359**	-0.427***	-0.340**
	(0.124)	(0.148)	(0.175)	(0.176)	(0.169)	(0.167)
Cr to Spot	-0.772	-1.406	-0.725	-1.394	-1.522***	-1.989***
	(0.756)	(1.253)	(0.854)	(1.099)	(0.596)	(0.701)
Spot to W.P.	0.405	-0.241	0.524	-0.648	-0.155	
	(0.797)	(1.413)	(0.885)	(1.186)	(1.256)	
Spot to R.P	0.499	0.066	0.652	0.331	0.001	-0.481
	(0.608)	(1.050)	(0.718)	(0.988)	(0.533)	(0.648)
Cr. To W.P.	-1.516	-2.021	-0.998		-1.366	

	(1.009)	(2.203)	(1.039)		(1.269)	
W.P. to R.P.	3.343***	2.702	4.602***		1.654*	0.509
	(1.035)	(2.188)	(1.431)		(0.949)	(1.550)
Av. Year	0.120	0.006	-0.019	0.058	0.071	0.152
Study	(0.115)	(0.141)	(0.165)	(0.172)	(0.187)	(0.194)
No. Obs.		-0.0011*		-0.0003		-0.001
		(0.0006)		(0.0003)		(0.001)
Diesel	0.944	-2.412	0.788	1.050	0.369	-2.539
	(1.449)	(2.585)	(1.455)	(1.471)	(1.350)	(2.742)
Europe	-0.386	0.824	-1.635	-2.299	-1.205	1.103
	(0.781)	(1.904)	(1.405)	(1.941)	(0.935)	(1.531)
Other	0.457	7.141	-0.970		0.767	6.096
regions	(1.748)	(5.181)	(1.967)		(1.900)	(4.522)
With tax	0.077	-0.912	0.499	-1.583	0.427	-0.966
	(0.527)	(1.090)	(0.600)	(1.182)	(0.587)	(1.108)
Monthly data	0.154	-1.342	-1.895	-1.724	-1.296	-1.160
	(0.832)	(1.525)	(1.657)	(2.136)	(1.029)	(1.311)
Country data	0.563		3.434		2.227**	
	(1.096)		(2.546)		(0.944)	
ML	3.031***	2.726*	4.513***	3.640**	3.052***	2.343**
	(1.022)	(1.655)	(1.647)	(1.858)	(0.899)	(1.028)
Other	-0.318	-0.523	-0.749	0.263	-0.852	-0.900
estimator	(0.886)	(1.119)	(1.139)	(1.576)	(0.750)	(0.784)
ARDL	-2.264***	-1.016	-2.130**	-1.060		
	(0.821)	(2.550)	(0.867)	(2.002)		
PAM	-4.081**	-8.698*	-2.746	-3.779		
	(1.912)	(5.138)	(2.306)	(2.905)		
VAR-	-2.034	-0.895	0.089	-1.212		
VECM-	(1.282)	(2.033)	(1.933)	(2.650)		
VRSM						
Cointegration	1.139	0.760	0.971	3.535	1.697	0.262
	(0.855)	(1.550)	(1.052)	(3.123)	(1.644)	(1.552)
IO	6.312***	10.119*	6.028**	4.910*		
	(2.244)	(5.526)	(2.630)	(2.620)		
Other SSCI	1.184	2.615	1.490	0.809	1.491	2.954*
reviews	(0.958)	(1.855)	(1.328)	(1.216)	(0.965)	(1.686)
Other non-	1.241	0.771	3.261***		1.239	0.789
SSCI reviews	(0.915)	(1.120)	(1.290)		(1.096)	(1.252)
No obs	213	124	200	112	212	136
Chi2	111.21***	62.30***	108.62***	44.35***	94.54***	51.39***
	(0.0000)	(0.0000)	(0.0000)	(0.0005)	(0.0000)	(0.0000)
Pseudo R2	0.4218	0.4122	0.4415	0.3265	0.3376	0.2747

p-value (***1%, **5%, *10%)
Robust standard errors in brackets.

Table 3 shows the econometric results by dividing the sample according to the type of asymmetry analysed or the type of model used. The results are very homogeneous for both types of asymmetries and very similar to those obtained for the full sample. For both types of asymmetries significant positive effects are observed if studies look at the last segment of the industry (relationship between the wholesale price and the retail price paid by consumers), if they use the maximum likelihood estimator or if the study is published in journals of industrial organization. Also, both types of asymmetry are observed with lower probability when using the ARDL model.

As regards the number of observations variable, we can see this is negative and significant in papers that examine COI asymmetries, while it is not significant for DLE asymmetries. This result indicates that the possible existence of publication bias would occur especially in the analysis of COI asymmetries, which is the majority of analyses.

Finally, the analysis of the studies that use an ECM model shows similar results to those obtained in the analysis with the full sample. The year of publication is negative and significant; in the first stage of the industry (the relationship between the crude oil price and the spot price) there is less likelihood of finding asymmetries, whereas in the last stage (the relationship between the wholesale price and the retail price) it is more likely; geographical aggregation of data and use of the maximum likelihood estimator affect positively on the probability of finding a result of asymmetry. The lack of significant results in the type of review variables is very surprising considering this resulted in significant variables in the other approaches.

In the case of studies using an error correction model, it can be seen that the number of observations variable is not significant. It can therefore be concluded that there is no publication bias in this subgroup of studies.

4. Conclusions

The existence of price asymmetries in the gasoline market has been one of the most discussed issues within this energy industry. However, the huge disparity in results makes it very difficult to draw a consistent conclusion about this phenomenon. In this study we implement a meta-analysis to see if there are factors that explain this heterogeneity of results.

Empirical evidence shows that a set of factors that explain the difference in results obtained by empirical studies does actually exist. One of the factors to take into account is the year of publication, which indicates that in recent years it is more difficult to find results of price asymmetry. Another important element is the segment of industry being analysed; while the first segment of the industry is less likely to show asymmetry, the last segment (the relationship between the wholesale price and the retail price) has a greater possibility of showing price asymmetries.

Quantity and quality of data play an important role too. We can see that the studies that have a greater number of observations are less likely to find price asymmetries. However, studies that use aggregate data, either geographically (using averages of large geographic areas) or temporally (monthly averages) are more likely to find asymmetric behavior.

The estimator used is equally significant. Using a non-linear estimator like maximum likelihood increases the probability of observing asymmetric behavior in comparison to least squares estimators. This fact suggests that the latter estimates could be introducing linear constraints that have a significant influence on the results of the studies.

Like the estimator, the type of model can have a significant impact on results. The ECM model, the most popular, and PAM and ARDL models have a lower probability of finding asymmetry. The fact that the type of model may affect results should be considered in future research.

We were also able to observe how publications outside the field of energy economics tend to publish papers with results showing asymmetric behavior.

The last important conclusion obtained in the paper is that there might be a publication bias in the analysis of asymmetries. The negative significant result of the number of observations variable shows the possible existence of a publication bias in the sense that it is more probable for a paper to be published that shows a significant result of asymmetry.

All these results are very stable when the sample is divided by the type of asymmetry analysed or by the type of model used. The only important aspect in the divided sample is the existence of publication bias in the contemporaneous impact asymmetry (COIA), a result that is not observed in the distributed lag effect asymmetry (DLEA) or in the subsample of papers that use an error correction model (ECM).

These results allow us first to explain the wide dispersion of results present in the economic literature, and also to note those elements that can have a significant impact on results for future research. In the future, the analysis of price asymmetries in the fuel industry should take into account the fact that elements such as data quality, the industry segment analysed and the estimator and model chosen can significantly affect results.

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