
THE IMPACT OF OIL REFINERY MARKET POWER ON RETAIL FUEL PRICES IN THE EUROPEAN UNION

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Abstract. *The present study investigates the degree to which imperfect competition in the oil sector affects end retail prices. Specifically, we test how positive and negative price shocks in the oil market translate to final retail prices for petrol, diesel, and heating oil prices, focusing on the asymmetry of the price changes. We assume that the higher the level of imperfect competition, the more asymmetric the price change between the initial oil and final retail products will be. In addition, we also test the degree to which uncertainty, or oil price volatility, affects the final prices for these same products. We find that our proxy for market power does affect retail price asymmetries and that increasing volatility lowers retail price asymmetries.*

Keywords: *Imperfect Competition, Oil industry, Retail fuel price, Price asymmetry, Petrol, Heating oil, Diesel*

1. Introduction

The following study investigates the imperfection in the oil market in an effort to answer the following question: Are oil refiners abusing their market power? We begin with a discussion of the factors that have an influence on the final retail prices of petrol (gasoline) and other refined oil products. Isolating the contribution of market power to the final price is difficult; thus, we also discuss the different ways in which market power is measured. Following this, we study how market power and uncertainty aversion affect the refining industry. Our analysis focuses on the ratio of retail (net-of-tax) price and crude oil price as opposed to looking at a linear relation. The motivation is based on the idea that changes in these ratios should only be driven by technological breakthroughs. Any deviations subject to market condition changes would imply abnormal pricing policy and, hence, abuse of market power.

We conduct our study using a panel of 29 European Union countries with 373 weekly observations for each individual country from January 2009 till the end of December 2015. We find that market power has a substantial influence on the output-to-input price ratio. We also find evidence that an increase in oil price volatility decreases the output-to-input price ratio.

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2. Background

The intensity and the frequency of the discussion about the market power of major oil refiners strongly correlates with the movements of the retail gasoline price (RGP). The main reason for this focus in the public discussion is the assumption that these vertically integrated fuel refiners are organised in an oligopoly, giving them the opportunity to overcharge the end consumers. The common belief that the RGP reacts faster to increases of the crude oil price than to decreases has been supported by several authors (Borenstein et al. (1997); Bumpass et al. (2015); Rahman (2016)). However, time lags in the price mechanism do not *per se* explain or prove the existence of price-fixing agreements. For example, Grasso and Manera (2007) found evidence that short-term price asymmetries mainly occur at the distribution stage and cannot be confirmed in the long run.

In order to eventually test whether gasoline prices are being affected by market power, we must first disentangle the varying factors that have an influence on the retail price of gasoline. From the supply side, crude oil acts as the most important factor for the production of refined gasoline. The crude oil price depends, to a large extent, on the wellbeing of the world economy, as crude oil is (directly and indirectly) one of the main input factors for many industries. In other words, the quantity of gasoline supplied to the market is affected by the demand for other products that are also made from crude oil.

An additional cost factor affecting the RGP is the refining process, which is relatively capital intensive. Oil refining mostly takes place in industrial countries, but faces significant utilisation problems due to the volatility of the demand for its final products. Utilisation problems may also stem from risks associated with natural disasters. For example, in 2005, the year Hurricane Katrina hit the Gulf Coast of the United States, half of the Gulf of Mexico's oil production capacity disappeared. This eventually resulted in one of the most sudden weekly increases of the gasoline price in US history (EIA).

Price differences between countries can mostly be explained by the differences in the taxation of gasoline. Generally speaking, three taxation systems can be identified. The first group consist of countries where governments subsidise (negative tax) gasoline. This group has to be subdivided into ones which directly subsidise gasoline (e.g., Venezuela, Trinidad and Tobago or Egypt) and ones which indirectly subsidise gasoline by financially supporting the oil industry (e.g., Canada or India). The second group consists of countries that tax gasoline to different degrees (e.g., Spain, Norway or Sweden). The motives range from simple revenue tax collection to Piguovian environmental taxation (OECD, 2014). The third group applies a mixture of both systems, often subsidising the industry but taxing the final product to the consumer (e.g., Russia or the United States).

Another factor that is often forgotten by consumers is the power of states to influence the supply of crude oil, with OPEC being the most notable example. The extent to which OPEC is a textbook model of a cartel is an open debate in the academic community. Huppmann et al. (2015) suggest that OPEC serves as an example of a non-cooperative

oligopoly due to the different interests of its member states. Despite its own mission statement – trying to increase the income of producers and to stabilise the oil market – OPEC has been losing market share on the world stage. The shale oil boom and the weak market demand of the last years has hit OPEC by surprise, suggesting that the role of the organisation and its impact to be rather limited. States may also seek to increase the supply of crude through the release of strategic oil reserves. A recent example was the release of US-oil reserves to reduce the pressure on the oil price after the hurricane disaster of 2005. However, several sources indicate that the success of state interventions has proven to be ineffective (Mouawad and Romero, 2005).

More recent studies suggest that speculation is becoming a more important factor in the price swings of oil. Abdolvand and Liesener (2009) suggest that the pre-2008 bubble was mainly caused by the weak US-Dollar and by crude oil price hedging. A general belief that the price increase is a result of the higher demand of the emerging markets pushed the market even further. The inflow of money by speculation was stopped by massive pressure applied by the US Senate and the Commodity Futures Trading Commission on institutional investors (Abdolvand and Liesener, 2009).

3. Measuring the Imperfect Competition in the Retail Sector

According to theory, there are various ways to estimate the market power of corporations within a sector. Having a high degree of market power does not necessarily mean that firms will abuse it, but it is a necessary condition for imperfect competition. The following section will briefly describe the literature as it pertains to measuring market concentration, and is based on the works of Newbery et al. (2004), Twomey et al. (2006), and Schwarz et al. (2007). Market structure indices, behavioural indices, simulation models, as well as transmission contracts are suggested methods to measure market power.

Among the two most often used indices that measure market structure is the market share concentration ratio (the percentage of market share of the largest in companies within an industry) and the Hefindahl-Hirschman Index (the sum of the squares of the individual market shares). The main reason for choosing the Hefindahl-Hirschman Index (HHI) over the relatively simplistic market share method is that the later one is not able to assess the impact of a company that holds, for example, a 24% market share. In fact, 24% might indicate a market dominant position if all other companies have less than a 1% market share. The HHI suggests that the market is not concentrated if its score is below 1000 and highly concentrated if the score is above 1800. In order to cover not only supply conditions, the Pivotal Supplier Indicator (PSI) tries to assess the ability of an individual supplier to cover demand. In case the (extra possible) supply capacity of all other producers is not enough to cover the production of this individual supplier, structural market power exists. As the index is a binary indicator, a value of “one” suggests a pivotal role, “zero” non-pivotal status. Those preferring a continuous scale may use the Residual Supply Index (RSI). The RSI is calculated by deducting the relevant capacity of

an individual firm from the total capacity of the market and dividing this number by the total demand of the market. Any number bigger than 1 suggests that the remaining companies have enough capacity to supply the pivotal demand. Values below 1 indicate market power. These indicators only measure the potential for abusing market power, and thus can only provide limited speculative conclusions.

Unlike the indices that help determine (potential) structural market power, behavioural indicators may be used as evidence for actual market power. The main challenge is to conclude if the presence of high prices alone indicates market power or not. In order to make a proper assessment, individual bid prices would have to be analysed, which are often a matter of confidentiality. One of the indicators that would require insider-knowledge is the price-margin cost analysis (bid-cost margins). Comparing the marginal costs of an individual market player with the market price for its product may indicate market power. Two ways to measure this are the Lerner Index (LI) and the Price-Cost Margin Index (PCMI). Whereas the Lerner index ranges from 1 (high market power) to 0 (no market power), the PCMI indicates a higher probability for market power for larger deviations. One of the main flaws of both indices is that they require the precise and continuous determination of the marginal costs of production. These are difficult to obtain/audit and require a discussion of short-run vs. long-run marginal costs. For the sake of simplicity, many researchers suggest using the Net Revenue Benchmark Analysis (NRBA) to estimate market power. Despite a common agreement that high revenues alone are not a safe indicator of market power, the general assumption is that a competitive market does not allow super-normal profits, as new market players would enter the market and drive the prices down.

A third group of methods to assess market power are simulation models. The Competitive Benchmark Analysis (CBA) assumes that producer prices are lower if a competitive market exists. The aim of CBA is to simulate a hypothetical competitive market by evaluating the marginal costs of all individual producers in order to estimate a supply curve. An alternative would be to explore market power by using a game theory framework through the Oligopoly Simulation Models (OSM). Some of the most popular models are the Bertrand model of oligopoly and the Cournot competition model. The Bertrand model assumes that market players compete based on price setting behaviour, while in the Cournot model they compete based on quantity setting behaviour.

In reality, the determination of market power is extremely difficult. One of the more recent studies concerning oligopolistic behaviour has been provided by the German Bundeskartellamt (an independent competition authority whose task is to protect competition in Germany). In their final report, (Bundeskartellamt 2011) presented in May 2011, the authority states that the market is indeed organised in the form of an oligopoly; however, they were not able to prove cartelistic behaviour. Hastings (2000) took the opportunity to observe changes in the RPG during a large acquisition process in Southern California. Her findings indicate that the decrease of independent stations results in a higher RPG

level; however, changes in market shares of refiner-owned and operated brand stations do not have a significant impact. Deltas (2008) found evidence that US states with large margins/higher local market power have slower price adjustments than states with small margins/local market power of oil retailers. Pennerstorfer and Weiss (2013) investigated the impact of a merger in the Austrian gasoline retail market and found that an increase in spatial clustering (the increase of market power) significantly reduces the degree of competition between firms and increases equilibrium prices. Similar findings were presented for the Canadian market, where the merger of two chains resulted in a significant increase of the retail price (Houde 2012).

4. Methodology

The January 2016 drop in the global crude oil price level due to structural changes on the production side and uncertainty regarding global growth prospects created a unique and interesting opportunity to evaluate the price transition mechanism from the raw material price to retail prices. If there is a well-functioning market, absent of the abuse of market power, then we would expect to see changes in crude oil prices to be symmetrically translated into retail prices. Testing for price asymmetry as a means of gauging market power abuse has been a popular methodology applied by several other authors, i.e. (Bumpass et al. 2015; Bremmer and Kesselring 2016). We propose using the same method in our study in order to compare our results to the most state of the art studies on the topic. A proper evaluation of this problem requires us to identify a sample market or markets with persistent preferences and a structure such that retail prices would be deviating mostly due to changes in input prices. In addition, the influence of technological progress on the good must be limited over the window of analysis.

The analysis of price dynamics in individual countries has been done by numerous studies, but we propose to use a large panel of countries to increase the asymptotic properties of our research. However, we are also interested in choosing a sample that is not too disparate. As a result, we focus on the dynamics of 29 European countries with regards to national level retail gasoline pricing power. Retail fuel prices consist of multiple cost components that are country or region specific. It is reasonable to assume that retail price can be disentangled into two relevant pieces: $RP_t = \alpha_t W_t + (1 - \alpha_t) C_t$, where W_t is the global crude oil price level and C_t represents the other remaining costs that are not attributed $\alpha \in \alpha_t \in [0, 1]$ to the price. The degree to which these two factors affect the retail price is described by α_t and RP_t is the retail price of petrol or diesel.

In our analysis, we focus directly on the relation between retail prices and crude price ($E(RP_t | W_t)$) as deviations in other exogenous factors are of minor interest and are affected by highly endogenous factors prevailing in the region. This sole focus allows us to disentangle the marginal effect that the crude oil price plays on the retail price.

It is reasonable to assume that high crude prices lead to high retail prices and social tensions as well as political pressure. This heightened political pressure should dissuade

or constrain firms from abusing their market power. On the other hand, low input prices will create an opportunity to induce slackness and increase profit margins, as there is limited incentive for Bertrand competition in oligopolistic market with high sunk costs.

In addition to testing for asymmetric price adjustments, we also propose to test for the effect that crude price volatility has on retail prices as done by Rahman (2016). The idea here is that if input prices are highly volatile in the last two months and the price difference is large in magnitude, producers would push input price risk towards the end consumers.

The relation of interest is estimated by dividing both sides of our regression equation by W_t and applying a linear model on our data. The dependent variable is thus $RP_{t,i}/W_t$ and serves as a proxy for the perceived market power of the industry by outsiders: the larger the ratio, the more market power in the industry.

We will refer to this as the output-to-input ratio for future use. The resulting equation is defined as follows:

$$\frac{RP_{i,t}}{W_t} = const + \sum \beta_i F_{i,t} \tag{1}$$

$$F_t \in \left\{ \frac{1}{W_t}, CPI_{t,c}, std(W_{t-4:t}), MD_t \right\}$$

Where terms in brackets would capture the percentage influence of crude prices on retail prices: *const* captures all other effects not captured by exogenous factors that are attributed to the marginal effects. Crude price (W_t) is converted to its corresponding value in euros in order to match the main currency used for retail prices. The inverse of the crude price ($1/W_t$) reflects the pricing power of the producers. When input prices are high, the inverse relation should have a small effect on our dependent variable, reflecting the idea of producers being unable to increase profit margins. As there is also evidence which points to the fact that the impact which crude price has on retail prices depends on the direction of the price change (Bremmer and Kesselring 2016), we will separate the data depending on the direction of the price change. $CPI_{t,c}$ is the consumer price index of the country, c, and is used to adjust for possible inflationary effects on the retail price; $std(W_{t-4:t})$ is the standard deviation of the global crude price in the last 5 weeks; the variable MD_t represents various business climate survey indicators. This last indicator set is not considered in the general analysis as they are observed only on yearly levels and obtained from the Euromonitor International database. The set consists of the Business Freedom Index (BF), the Control of Corruption Index (CoC), the Corruption Perceptions Index (CP), the Ease of Doing Business Index (EDB), the Global Competitiveness Index (GC), the Government Effectiveness Index (GEI) and the Regulatory Quality Index (RQI). The improved parameterisation relies on looking at log-level and log-log versions of the previous model to account for possible asymmetries in the relation of interest. As a result, the log-log model is of the primary interest and subsequent ones are of secondary interest.

The analysis in this work tests the claim that retail prices adjust to changes in world crude oil prices almost instantaneously (in the subsequent week). This claim will be evaluated by testing the following hypotheses and assessing their influence on the fractional relation:

- H1: The retail price adjustment factor is not influenced by the market power proxy.
- H2: The oil price volatility factor ($std(W_{t-4:t})$) has no influence on the final retail prices, thus the oil markets are long run competitive.

5. Data

The dataset in the analysis is structured as a panel and consists of 29 European Union countries with 373 weekly observations for each individual country from January 2009 till the end of December 2015. The crude price (W_t) is obtained from the St. Louis Federal Reserve Bank database. The consumer price index ($CPI_{t,c}$) is measured by HICP from Eurostat. Summary statistics of the variables presented in Table No. 1 show adequate variability in all factors of interest. With regards to retail prices, we include data for the petrol, heating oil, and diesel markets.

TABLE No. 1. Summary Statistics

	Mean	Std	Min	Max
Retail Pet. to Cr.	9.870	3.765	5.877	41.008
Retail Die. to Cr.	10.576	4.433	6.319	46.496
Retail Hea. to Cr.	9.247	1.993	4.331	26.024
Log(Pet.) – Log(Cr.)	-0.370	0.519	-2.105	2.011
Log(Die.) – Log(Cr.)	-0.305	0.526	-1.741	2.118
Log(Hea.) – Log(Cr.)	-0.413	0.498	-2.008	1.260
1/Crude	0.016	0.006	0.010	0.039
CPI	97.564	5.370	81.260	120.580
Crude Std.	0.959	0.400	0.272	2.581
CoC	0.986	0.817	-0.300	2.500
GEI	1.142	0.577	-0.400	2.300
RQI	1.199	0.429	0.300	1.900
BF	79.633	9.679	55.800	99.700
CP	33.115	22.951	1.000	94.000
EDB	35.835	23.385	3.000	102.000
GC	4.733	0.507	3.900	5.600
Log(1/Crude)	-4.164	0.300	-4.569	-3.237
Log(CPI)	4.579	0.054	4.398	4.792
Log(Crude Std.)	-0.126	0.413	-1.303	0.948
Log(COC)	-0.135	0.919	-2.303	0.916
Log(GEI)	0.035	0.608	-2.303	0.833
Log(RQI)	0.106	0.409	-1.204	0.642
Log(BF)	4.370	0.123	4.022	4.602
Log(CP)	3.115	1.055	0.000	4.543
Log(EDB)	3.313	0.808	1.099	4.625
Log(GC)	1.549	0.106	1.361	1.723

The estimates are obtained using dynamic panel methods as proposed by Windmeijer (2005). This method is adequate, as multiple variates could be argued to be endogenous by construction (e.g., the crude oil price is included on both sides of the regression equation). The dynamic component is determined by optimising with respect to Schwarz information criterion and to pass the Arellano-Bond test for the autocorrelation. We use robust standard errors and in all cases, the Sargan test identifies instruments as adequate.

Overall, the economic dynamics presented in Figure No. 1 show that the sample covers a wide range of conditions. More specifically, the periods of early 2009 and late 2015 that are dominated by low crude prices in different global environments, ensures robustness to data snooping. A close relation is observed between the pre-tax processed crude prices and the prevailing crude prices in the market as expected. A general pattern of underperformance is visible when comparing petrol, diesel and heating oil prices to overall crude price dynamics, which can most likely be attributed to crude price hedging that would cause retail products to respond slower to increases in the crude price as observed in the period from 2009 till around 2014. On the other hand, the unexpected Saudi decision not to target production price would be perceived as unsustainable in the future, causing severe contagion and resulting in slackness of retail prices.

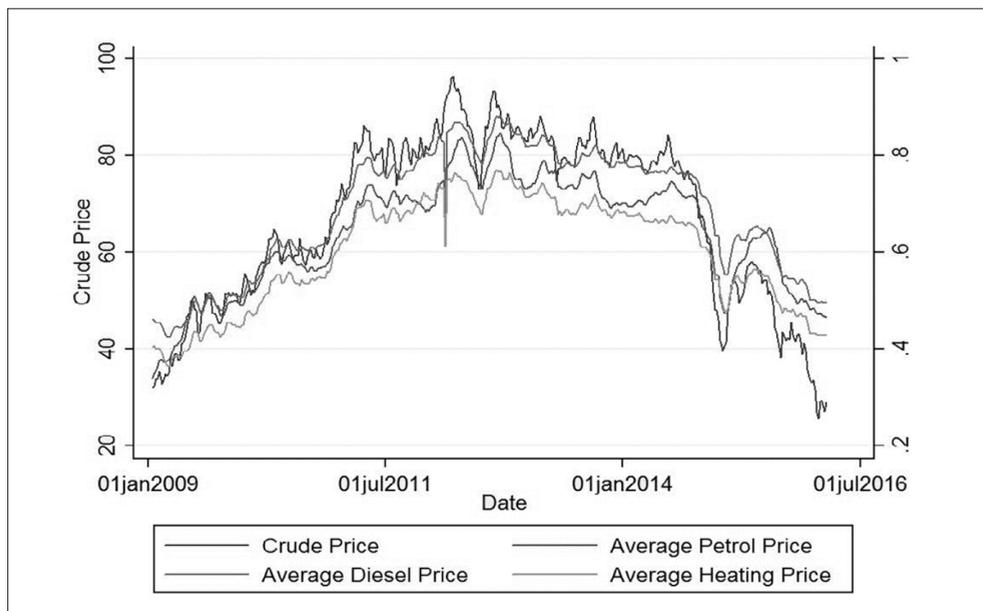


FIG. No. 1. Average retail prices of petrol, diesel and heating oil in a given period plotted over time overlapped with crude prices. Values are in euros and retail prices are before taxation. Sampling frequency is one week.

Figures Nos. 2 and 3 present the changes of our endogenous variables over time to give a visual impression of the evolving differences and ratios between input and output prices. The overall level comparison shows highly similar dynamics in both cases, but due to the theoretical reasons and the ability to be interpreted as a proxy for elasticity, the log relation will be used as a base model for analysis, and the ratio results will be used for a robustness evaluation. In general, the difference between prices has widened only in recent periods and convergence to the long-term mean is visible only around 2009. It is a warning sign of a potential cycle that is not fully observed in this sample due to data not being available in a weekly frequency for earlier years. A recent positive market supply shock has caused a substantial increase in the price spread between crude prices and retail prices, suggesting an increase in profit margins for the refining industry if material risk would not have been hedged. The argument for this claim comes from the ability of the refining industry to directly transfer the cost risk onto consumers and, as a result, hedging the risk is not required in this setting.

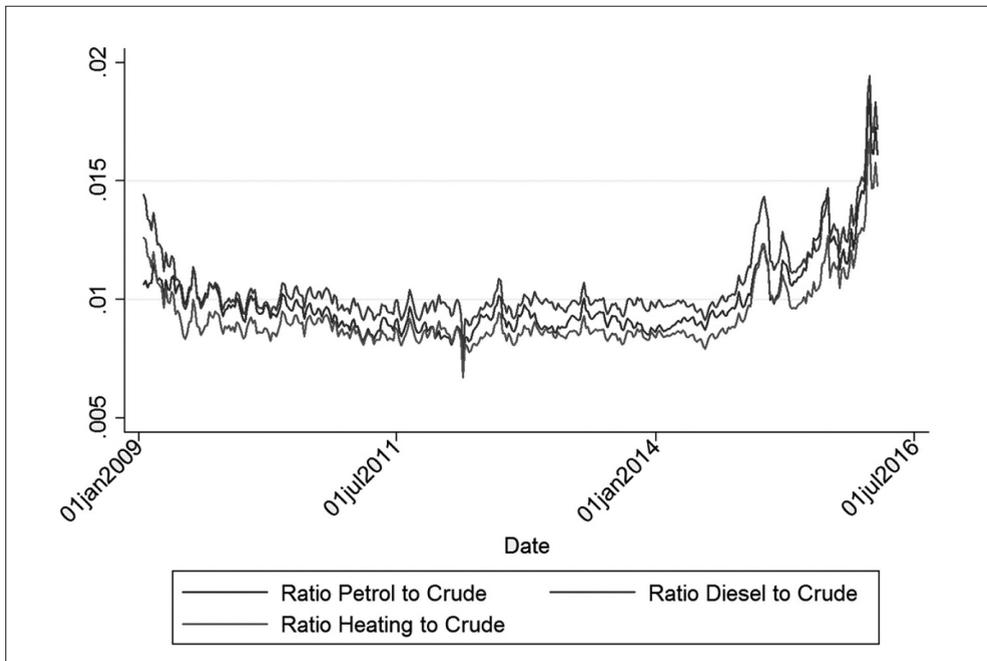


FIG. No. 2. Transformed versions of retail prices by taking a ratio of retail price to crude price averaged over countries in corresponding time period.

6. Results

TABLE No.2. **Log Ratio Model Dynamics with Logs**

	Log(Pet.)-Log(Cr.)	Log(Die.)-Log(Cr.)	Log(Hea.)-Log(Cr.)
log(1/Crude)	0.303***	-0.293***	-0.357***
log(1/Crude.neg)	-0.033***	-0.030***	-0.034***
log(CPI)	0.102	0.121	0.034
log(CrudeStd)	-0.805***	-0.784***	-0.847***
log(CrudeStd.neg)	0.030**	0.018	0.018
log(COC)	0.000	0.004	0.108
log(GEI)	-0.064	-0.017	-0.096
log(RQI)	-0.177	-0.163	-0.083
log(COR)	-0.110	-0.111	-0.055
log(CP)	0.249	0.291	0.100
log(EDB)	-0.322	-0.339	-0.260
log(GC)	0.396	0.361	0.033

Standardized beta coefficients

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table No. 2 displays our primary empirical findings. The market power proxy $\log(1/Crude)$ displays persistent influence across all products considered with exceptional statistical significance. The proxy has an asymmetric influence as we observe for the effect focusing on only positive crude price changes ($\log(1/Crude)$) to have a tenfold stronger effect when compared to the case focusing only on negative changes ($\log(1/Crude_{neg})$). It is striking that a percentage point change in the market power proxy will cause a reduction of around 0.3 percentage points on the output-to-input ratio. In other words, the effect of a crude price drop on the market power proxy is offset by an even bigger reduction of retail product prices. The strength of market competition can be inferred from the size of the component capturing the marginal influence of negative changes ($\log(1/Crude_{neg})$), as negative crude price changes only mildly affect the whole factor. Tacit collusion arguments raised by Lewis (2015) are supported by our findings as overall market power strength factors ($\log(1/Crude)$) and ($\log(1/Crude_{neg})$) have a substantial effect on the output-to-input ratio.

The uncertainty in the input market factor $\log(CrudeStd.)$ is a surprising finding, contradicting H2. It is reasonable to expect an uptick in the retail product market when volatility increases in the crude oil price. In our setting, we observe the opposite effect: a percentage point increase in the volatility causes an input-to-output ratio reduction. Only in the case of petrol is the factor ($\log(Crude_{neg})$) statistically significant. It shows that petrol sector products are being priced more aggressively (the retail price increases to reflect uncertainty) but the same effect was not observed in other sectors. We may

compare these results with those of Rahman (2016), who found that the oil price volatility has a positive effect on retail gasoline prices. A possible explanation for this is that he uses monthly data from the United States over a long time frame (1978-2014), using a differing empirical model from ours. We should also point out that a major earlier work (Radchenko 2005) found that the increasing oil price volatility reduces retail price asymmetries, just as we did. Thus, our results support those of Radchenko (2005), in that the oligopolistic coordination theory could explain how increasing oil volatility reduces price asymmetries.

Purchasing power and business climate has no significant influence on the fractional ratio. It is reasonable to infer that the European refining market is homogenous with respect to its retail products pricing policy. Robustness checking results are presented in Tables Nos. 3-6. Results show substantial sensitivity to the symmetry of the investigated relation. The semi-elasticity findings in Table No. 4 display a lack of relation to the market power factors. In addition, crude market uncertainty proxies fail to scale adequately when compared to Table No. 2. Similar findings are observed in Table No. 3. In Table No. 5, we take the logs of the price variables and use the values from the indices in levels because log transformations of indices are inherently meaningless. Also, in Table No. 6, we drop many of the indices as they were found to be statistically insignificant in previous regressions.

7. Conclusions

In the preceding study, we have investigated the behaviour of the European refining market in the presence of crude oil price changes. In general, it has been documented that there is a lot of slackness in retail product prices when changes in the input market are observed. To investigate this claim from the industry perspective, we have focused on the output-to-input ratio as opposed to focusing on the resulting price.

In our study, market power proxies have a substantial influence on the output-to-input price ratio. This finding adds evidence to the debate about the degree to which the market for retail oil products is a perfectly competitive market, and is in line with much of the previous existing literature. With regards to uncertainty, we find evidence that an increase in oil price volatility decreases the output-to-input price ratio, which supports the oligopolistic coordination theory. Both of these findings contradict our initial hypotheses, that the retail oil markets are free of market power abuse. However, we should stress that our findings do not prove the existence of market power abuse either. It is possible that as the least productive firms increase their mark-ups, firms that are more productive just follow them in collecting rents.

The findings also suggest that business climate factors have no significant influence on the retail oil industry. It is reasonable to assume that the market is highly homogenous

across Europe and is mature. Considering that the countries observed are all members of the European Union/European Single Market, where free movement of customers is guaranteed, these findings are not surprising. An alternative explanation would be either due to intense cross-border competition or tacit collusion on the national level.

The novelty of this study is that we use a large panel of European countries to test for asymmetric price adjustment of crude oil prices to retail petrol, heating oil, and diesel prices over the period of the great recession. The majority of other studies have focused on single countries or single retail sectors, while some of the more recent ones have also included the time period of the great recession.

With regards to policy makers in the European Union, these results imply that there is still more which could be done to increase the competitiveness of retail markets in the oil industry. It is interesting to note that the EU, with its long history of actively intervening in to stop the abuse of market power, has not done more in this specific market. While we have found evidence that there is a general trend of what could be considered abuse of market power, we do not provide direct evidence that may be linked to any specific firm. It may also be the case that large firms with market power may be more efficient than smaller firms, especially given the economies of scale in the oil industry. Thus, breaking up the industry into smaller players to encourage more competition may lead to higher prices for consumers.

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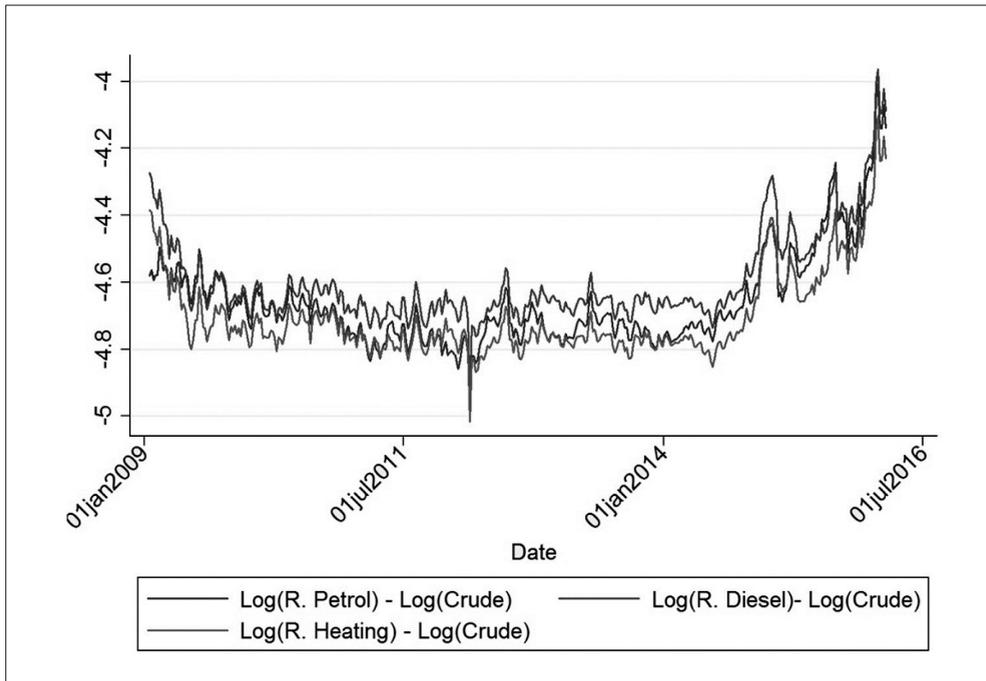


FIG. No. 3. Transformed versions of retail prices by taking a logarithmic difference between retail product price and crude price averaged over countries in the corresponding time period.

TABLE No. 3. Ratio Model Dynamics

	Retail Pet. to Cr.	Retail Die. to Cr.	Retail Hea. to Cr.
1\Crude	0.050	-0.001	0.048
1\Crude.neg	-0.015	0.007	0.016
CrudeStd.	-0.035***	-0.022**	-0.055**
CrudeStd.neg	0.095***	0.061**	0.155**
CPI	0.015	-0.004	0.015
CoC	-0.086	-0.049	-0.034
GEI	0.028	0.015	0.045
RQI	-0.036	-0.019	-0.033
BF	-0.006	0.002	0.010
CP	0.006	-0.011	0.035
EDB	-0.010	-0.002	-0.021
GC	0.115	0.045	0.042

Standardized beta coefficients

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

TABLE No. 4. Log Ratio Model Dynamics with Levels

	Log(Pet.)-Log(Cr.)	Log(Die.)-Log(Cr.)	Log(Hea.)-Log(Cr.)
1/Crude	-0.304	-0.274	-0.321*
1/Crude.neg	-0.043	-0.044	-0.023
CrudeStd	-0.794***	-0.775***	-0.816***
CrudeStd.neg	0.091	0.082	0.063***
CPI	0.079	0.107	0.092
CoC	-0.299	-0.312	-0.014
GEI	0.123	0.146	0.128
RQI	-0.154	-0.160	-0.070
BF	-0.040	-0.024	0.005
CP	0.058	0.126	0.188
EDB	-0.052	-0.068	-0.083
GC	0.447	0.485	0.091

Standardized beta coefficients

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

TABLE No. 5. Log Ratio Model Dynamics with Levels and Logs

	Log(Pet.)-Log(Cr.)	Log(Die.)-Log(Cr.)	Log(Hea.)-Log(Cr.)
log(1/Crude)	-0.331***	-0.313***	-0.357***
log(1/Crude.neg)	-0.039***	-0.033***	-0.035***
CPI	0.024	0.060	0.040
log(CrudeStd.)	-0.820***	-0.801***	-0.852***
log(CrudeStd.neg)	0.028***	0.020	0.018***
CoC	-0.389	-0.415	-0.144
GEI	0.142	0.181	0.144
RQI	-0.154	-0.170	-0.088
BF	0.006	0.004	0.045
CP	0.011	0.037	0.112
EDB	-0.037	-0.020	-0.069
GC	0.469	0.486	0.131

Standardized beta coefficients

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

TABLE No. 6. Reduced Log Ratio Model Dynamics

	Log(Pet.)-Log(Cr.)	Log(Die.)-Log(Cr.)	Log(Hea.)-Log(Cr.)
log(1/Crude)	-0.315***	-0.326***	-0.363***
log(1/Crude.neg)	-0.040***	-0.035***	-0.035***
CPI	0.064	0.063	0.073
log(CrudeStd.)	-0.804***	-0.784***	-0.828***
log(CrudeStd.neg)	0.024***	0.017**	0.019**

Standardized beta coefficients

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$