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Asymmetric pricing behaviour of retail petrol and diesel markets in the UK

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Declaration of original work

This declaration is made on September 6, 2021.

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Abstract

This paper investigates asymmetrical pricing behaviours of retail petrol and diesel markets. The aim of this investigation is to see if there exists any variation in the responsiveness of retail fuel prices to changes in wholesale prices of fuel. The econometric analysis/modelling will centre around fitting an error correction model to the long term and short term characteristics of the time series. This however is not possible due to the nature of the time series relationship and thus a linear model is used to test the 'rockets and feathers' hypothesis that prices adjusted faster to positive price changes in wholesale markets and react sluggishly to falls in price, suggesting firms possess some level of price-setting power. Overall this paper finds some differences in the responsiveness of pass through rates in the different regions.

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Chapter 1

Introduction

Due to the global pandemic there has been much focus on global oil demand, specifically highly volatile prices caused by a collapse in global trade and travel which in turn has caused massive over supply in the market. industry demand has collapsed due to the introduction of social distancing and urging of households to stay indoors. the department of transport reported that vehicle traffic decreased by 20.9% from January til September 2020 compared to the previous 9 month period. The oil and gas sectors were just starting to recover from a global collapse in oil prices in 2015-16 due to efficiency gains in US shale oil production. The further decrease in global prices due to the pandemic will again affect activity levels for UK producers, as well as prices ultimately paid by consumers.

Data from the RAC foundation[4] shows that the London closing price of Brent Crude was £10.95 ($13.59) in April 2020. This was a fall of just under 80% from a high of £53.05($69.82) in January of the same year. During the same period, petrol fell by just under 14% and diesel by 12.8%. This comparison is naive as it does not consider the effects of taxation (specific and ad-valorem) on prices as well as the suitability of comparing fluctuations in crude prices to retail fuel prices. The latter is due to crude containing fuels and oils other than petroleum and diesel oils. A more suitable proxy would be to look at the refinery price of wholesale petrol and diesel.

Asymmetries can arise for a number of reasons. The most commonly occurring reason is due to lack of competition in the market. Basic economic theory dictates that in a market without perfect competition, firms can retain some level of price setting power. This does not necessarily mean that they control prices. In fact consumers in the UK are already aware of 'premium' fuel brands such as BP and Shell, who charge significantly more for fuels than supermarket chains, thus can avoid these brands if they do not want to spend more on 'quality' fuels with a higher detergent additive. Retaining some price setting power can allow firms to delay price falls in order to exploit potential arbitrage. Prices eventually fall in-line with crude prices as retailers do not want to be undercut. Another theory first suggested by Borenstein et al. (1997) as source of this behaviour can be due to delays in price changes affecting prices paid for inventories. This is further explained in the next section.

Pass-through rates of oil prices onto consumers is what this paper will be investigating, and to see if there are any differences at the more local level in the UK. We will be Looking at 12 regions in the UK: Northern Ireland, Scotland, Wales, North East, North West, Yorkshire and Humberside, West Midlands, East Midlands, Essex and East Anglia, London, South East, South West. We will also assess the UK as a whole for comparison and as a robustness check.

The structure of this paper is as follows: Section 2 will look at previous literature in this field, looking at the types of models used, in what markets they were used in and the results from these papers. Section 3 will cover the data that will be used for this study, which will be retail and wholesale prices of ultra low sulphur diesel (ULSD) and ultra low sulphur petrol (ULSP) at a monthly level, and also weekly level as a robustness check of our findings. Section 4 will cover formalising and fitting the data to the model. Section 5 will discuss the results and potential issues with the models and the data characteristics. Finally section 6 will summarise the findings of this paper and show that although there are some evidence of asymmetries in some ares, the scale of it varies for different regions.

Chapter 2

Literature on oil prices

The main motivation for this paper and other similar literature is the notion of asymmetric price adjustments named 'rockets and feathers'. The theory suggests that when faced with increases in cost of production/cost of supplies, firms rapidly increase their prices to reflect this change, however when costs fall, firms react more sluggishly to these price falls and this allows for temporary increases in profits. One of the earliest reports on this was by the monopolies and mergers commission (MMC (1990) paras. 4.69-4.79)[6] which assessed the delays in price adjustments to increases and decreases in costs. They found no evidence that the average time taken to adjust prices following cost increases or decreases were dissimilar. This rejected the 'rockets and feathers' hypothesis however utilised a graphical analysis of weekly data from the period 1987-89 and did not employ econometric framework for this.

Borenstein et al. (1997)[7] investigated asymmetric pricing behaviour in US petrol(gasoline) markets from 1986-92. They found evidence to suggest that retail prices of gasoline adjust faster to crude oil price increases than decreases. They suggest this partially occurred from the marginal cost of changing inventory levels. Assuming low levels of gasoline inventories, a fall in the price of gasoline may not be passed on to consumers straight away due to the relative scarcity of supply. They argue that retailers view the value of the short-run scarcity to exceed the price fall thus do not actually achieve arbitrage through sluggish price adjustment. Deaton and Laroque (1992) found similar price characteristics while studying the price of 13 commodities so this is a well supported theory.

Although many studies are conducted in the US, there have been some studies in the euro area. Meyler (2009)[5] investigated the pass through rates of oil prices onto consumer liquid fuel prices. This was done for countries in the euro area where the data from 12 member states was aggregated. Meyler (2009) found that oil prices pass through very quickly, with 90% of the pass through occurring within 3 to 5 weeks. They also found no significant asymmetry in pricing behaviour and where there was statistically significant asymmetry, it was not economically significant (would not affect consumers much). The European central bank confirms this study stating that "there is little significant evidence of substantial asymmetry between the pass-through of oil price increases and oil price decreases".

The most commonly accepted model for asymmetric pricing behaviour is the threshold error correction model. The error correction model allows for the separation of the long run relationship between two-time series, so that we can focus and model on the short run effects. The most recent research into asymmetric pricing using this model was done by Colin. B and Derry. O (2011)[2], in which they mainly focused on liquid fuel pricing in Ireland and made comparisons to data from the UK market. To separate long run characteristics of the oil market, they used an error correction model to isolate the long term cointigration of consumer and refinery prices. They also pioneered a multi-regime TAR model where conflicting price pressures from the long run error correction and short run price shocks were modelled in a separate regime. The results showed that in all but one case, the 3 regime model outperformed the 2 regime model. Overall the conclusion was that there is no significant evidence to support the 'rockets and feathers hypothesis' in UK or Irish markets, however due to the models in some cases showing modest levels of asymmetry, they cannot rule out the possibility of asymmetry at a more local level due to perhaps lack of competition in those markets. This is where the scope of this paper lies: in investigate asymmetric pricing at a more local level in the UK.

2.1 Retail fuel structure in the UK

The oil and gas industry is divided into three sections. The first, upstream, is focused on looking for underground/underwater oil deposits and exploring and bringing to fruition, ways to extract these deposits to the surface. The UK in 2020 produced over 1 million barrels daily and is able to meet 90% of its oil demands according to a government issued report on the supply of oil and oil products[3]. The rest is mostly fulfilled by imports from Norway who also supply the UK with around 50% of our natural gas. Once the oil has been extracted it must be transported to the refineries which is the mid-stream component. The UK transports crude oil through 3 major pipelines. Unlike for example Ireland who have no onshore pipelines, this helps lower transportation costs and thus less cost is passed onto consumers. Lastly we have the downstream component which consists of refining Crude into liquid fuels. The UK has 6 major refineries and one smaller refinery across the UK. The positioning of these refineries could potentially have effects on the price consumers eventually pay due to delivery costs changing depending on how far tankers have to travel from a storage site. Our analysis does not take differences in transportation costs into account as there is no regional data on this and any estimates cannot have their accuracy verified. on average the delivery costs to petrol filling stations is about 2 pence per litre.

As of 2020, there are 8380 petrol filling stations (PFS) in the UK. This is down from 13107 in 2000. The vast majority of these are owned by large cooperation's, the largest of which is BP who own 1229 of PFS as of 2020. This is closely followed by Esso and then Shell. One interesting thing to note is that consumers are clearly aware that larger 'premium' brands do charge more for fuel and justify this by adding detergents which are specially designed to clean components such as injectors from carbon build up in cars. Regardless of this technology, consumers favour cheaper supermarket fuels such as Tesco and Morison's who are the two largest supermarket woners of PFS in the UK. Sainsbury's for example, own 315 PFS as of 2020 and sold 11,768 kilolitres of fuel in November 2019. By comparison BP sold 4,317 kilolitres whilst having over 3 times the number of PFS. This can be explained by the idea of cross-subsidisation, whereby supermarkets subsidise cheaper fuel through sales of groceries as their forecourts are on the grounds of existing stores. This trend has been continued through to the larger chains. EG group is a good example of this as they focus on providing a 'high quality experience' to consumers stopping to fill up by offering a wide variety of food and beverage like the supermarkets can but also offering space on forecourts to fast food chains such as subway and Greggs in order to boost sales of non-fuel items. This will help cross-subsidize fuel and attract customers to their forecourts. Although this is a continuing trend, it is limited to large towns and cities, and the vast majority of rural PFS will not be able to subsidise fuel with non-fuel sales due to their remote locations and lack of large quantities of customers in the area.

Chapter 3

Overview of the data

Part of the data required will be retail petrol and diesel prices paid by consumers at the pump. This is sourced from the AAs monthly fuel price report from 2013 to 2021. This includes prices from 12 UK regions (Northern Ireland, Scotland, Wales, North East, North West, Yorkshire and Humberside, West Midlands, East Midlands, Essex and East Anglia, London, South East, South West) and has data including gallons sold, proportion taken as tax, average UK supermarket price and similar data for other European countries. The data is data sourced from Experian Catalist[1], a business data analytics company who measure the average of mid-month prices from the respective regions. The retailer price includes product cost, fuel duty, delivery and distribution costs, retail margins (forecourt costs and retailer's profit) and VAT.

The collection method of retail prices is not ideal as a monthly average would be better suited for this since it would give a better indication of what the average price was in the region. However, since there is not much data of this nature we are forced to use it. The accuracy of our results can be improved by ensuring that the monthly wholesale price collection method is similar so that the data is matched in terms of when it was recorded. This is done by using the mid monthly spot pirices if wholesale fuel to match the mid-monthly retail prices, ensuring the two readings are from as close as possible. Another limitation of this data is that prices for the London region are missing observations for 11 periods, from February-December 2016. The reason for these missing observations has not been explained in the AAs report, so to overcome this, an average over the 11 remaining regions was taken and substituted for the missing values. Again this is not ideal however we still have good data from 11 regions so we can continue with this dataset. All data in pence per litre.

Next we need to decide between using Crude oil prices or refined oil prices. Crude oil is a good proxy for fuel costs to PFS and wholesellers, however crude oil demand is affected by many things such as airline jet fuel demand, maritime fuel oils and hydrocarbons used for in the manufacturing of goods; all these products have an effect on the prices of crude oil so may not follow retail prices as closely as will be required for our model. The data needs to be closely cointigrated with retail prices. The RAC foundation collects data on wholesale prices of refined petrol and diesel. These prices are at the refinery gate, so are what distributors pay for refined petrol before transportation costs. This is what we use as it is the closest proxy for retailer's costs. These prices are again inclusive of fuel duty and VAT.

The data is specified on a monthly basis. Ideally we would like the values to be recorded at a higher frequency of weekly data. This is currently not available for regional data in the UK. The RAC foundation again provides data from 2015 till 2018 at an almost daily rate. This may be difficult to model as there would be too much noise/auto-correlation in the lags due to such a large frequency. Changes in refined prices will take longer than a few days for consumers to see at the pumps so we average this data over 7 day periods to give an approximate average weekly price. This is then used for a robustness check against our monthly data model.

Both data sets have prices specified inclusive of taxation. We want to assess the pass-through rates of wholesale to retail prices. Fuel duties, which are a fixed taxation, have been frozen since 2011 at a rate of 57.95 pence per litre for both petrol and diesel. On top of this, 20% VAT is charged on the fuel price and on the fuel duty. Due to the nature of the tax, the lower the price the higher the proportion of taxation paid by consumers and the opposite is also true. If we want to assess pass-through rates, it will depend on the actual price levels of the fuel so we specify the prices pre-tax. This is done by simply: [(fuel price)*(1/1.2)] - 57.95. Summary statistics are available in the appendix.

Chapter 4

Model selection

The rockets and feathers theory dictates that we use a model that can separately model positive and negative changes in input costs. The model of choice is a threshold model where a threshold value is used to distinguish a change in behaviour of values predicted by the model. In this case our threshold value will the change in wholesale prices at zero, thus capturing positive and negative effects.

To assess asymmetry in the market, the pass through rates of changes in wholesale price to changes in the price consumers have to pay are modelled. Using the first differences we get the short run relationship:

$$\triangle RP_t = \delta_0 + \delta_1 \triangle WP_t + \gamma_t \tag{4.1}$$

where $\triangle RP_t$ is the change in retail prices at time t, $\triangle WP_t$ is the change in wholesale prices at time t and γ_t is the error term. This is a basic model that we could use to identify short run asymmetry using a threshold, however if there exists a cointigrating relationship between and such that:

$$RP = \alpha + \beta WP \tag{4.2}$$

then this can be embedded into our model to separate the long term relationship between retail prices and wholesale prices. This will allow us to focus on modelling the sort run relationship between these two values. Asymmetrical pricing behaviour will occur in the short run due to factors such as short term price setting power and inventory effects that cause a period of higher margins as explained previously. In the long term there will always be price pressures where the time series is trying to converging back to its long run mark-up rate. The mark-up rate is the amount PFS add onto the wholesale price that they purchase the fuel for. This is to cover the costs of delivery, rent for the site, other costs and a profit margin.

The effect this has on our model assumptions is that our observed RP_t may be different to the equilibrium value suggested by the relationship in equation 4.2. By separating the long run cointigration in our model, the price pressures from this relationship trying to correct itself can be observed for the different thresholds. Below we have an equation to show how retail prices are affected by wholesale prices at time t but also wholesale prices at t-1 to capture longer periods of adjustment to $\triangle$WP. There also may be a dependence on the previous value of retail prices and the dependence of this is captured in the μ parameter.

$$RP_t = C + \delta_1 WP_t + \delta_2 WP_{t-1} + \mu RP_{t-1} + v_t \tag{4.3}$$

We are interested in the changes in price so the first difference are taken on the LHS and RP_{t-1} is subtracted from the RHS.

$$RP_t - RP_{t-1} = C + \delta_1 WP_t + \delta_2 WP_{t-1} - (1-\mu) RP_{t-1} + v_t \tag{4.4}$$

Next, by manipulating equation 4.5 we get our basic error correction model with the long run relationship embedded in the model. Where $\lambda = 1 - \mu$, and the coefficient for WP_{t-1} has been simplified to β.

$$\triangle RP_t = C+\delta_1 WP_t-\delta_1 WP_{t-1}+\delta_1 WP_{t-1}+\delta_2 WP_{t-1}-(1-\mu)RP_{t-1}+v_t \quad (4.5)$$

$$\triangle RP_t = C' + \delta_1 \triangle WP_t - \lambda(RP_{t-1} - \alpha - \beta WP_{t-1}) + v_t \quad (4.6)$$

Parameters α and β are estimated using the parameters from the long run relationship through running the linear model $RP_t = \alpha + \beta WP_t + \epsilon_t$. More lags of the wholesale prices can be added in to test for/model any dependence on further lags. The final error correction model gives us:

$$\triangle RP_t = \gamma + \phi ecm_{t-1} + \sum_{i=0}^{n} \eta_i WP_{t-i} + v_t \quad (4.7)$$

where ϕ is the error correction term, and ecm is the error correction term: $RP_t - \alpha - \beta WP_t - 1$. Currently this model is symmetric, as it does not account for positive and negative changes in the wholesale price.

To model asymmetry, as mentioned previously, a threshold model is used in conjunction with the error correction model. The model will assess the thresholds around $\triangle WP_t = 0$. This allows for different responses of the coefficients in the model for positive and negative price changes. To do an this an indicator variable is defines as:

$$I_t = \begin{cases} 1 & \text{if } \triangle WP_t \quad < \quad 0 \\ 0 & \text{if } \triangle WP_t \quad \geq \quad 0 \end{cases} \quad (4.8)$$

Using this indicator variable, the model can be specified as:

$$\triangle RP_t = \gamma_1 + \phi_1 ecm_{t-1} + \sum_{i=0}^{n} \eta_{1i} \triangle WP_{t-i} + v_t, \quad if I_t = 0 \quad (4.9)$$

$$\triangle RP_t = \gamma_2 + \phi_2 ecm_{t-1} + \sum_{i=0}^{n} \eta_{2i} \triangle WP_{t-i} + v_t, \quad if I_t = 1 \tag{4.10}$$

This model can capture asymmetry in the error correction mechanism where one of the regimes may take longer to error correct to the long run equilibrium, and model asymmetry in the lags of wholesale price, which is the short run dynamic.

The coefficient on the error correction term will be between 0 and -1. The intuition behind this is that for a certain value of RP at time t, the models shows that $\phi\%$ of the error is eliminated in each time period on average. This means that for a value of -0.5, it would take exactly 2 time periods on average to converge back to the theoretical equilibrium level as modelled by the long run cointigration relationship. According to the rockets and feathers case, we would expect the error correction term to be smaller in absolute terms for negative price changes as the theory suggests firms will react sluggishly to exploit higher margins in the short term. The negative coefficient ensures that eventually the prices do actually converge according to the LR relationship. The same is true for the lags of wholesale prices. Larger coefficient values suggest that retail prices will more closely follow changes in the wholesale prices and we expect to see smaller coefficients in the negative regime in support of the rockets and feathers literature.

Colin. B and Derry. O (2011) introduced a model where a separate regime was used to model conflicting price pressures in the error correction model and the positive/negative regimes. If the ecm value at time t is negative, it means that it is below its expected long term equilibrium value, thus retail prices face upwards pressure. However, if in the same period, wholesale prices have fallen, then firms will face pressure to reduce the retail prices. This is true for a positive ecm value and a price increase. Two more regimes can be introduced to capture the effect of conflicting pressures.

4.1 Testing the data

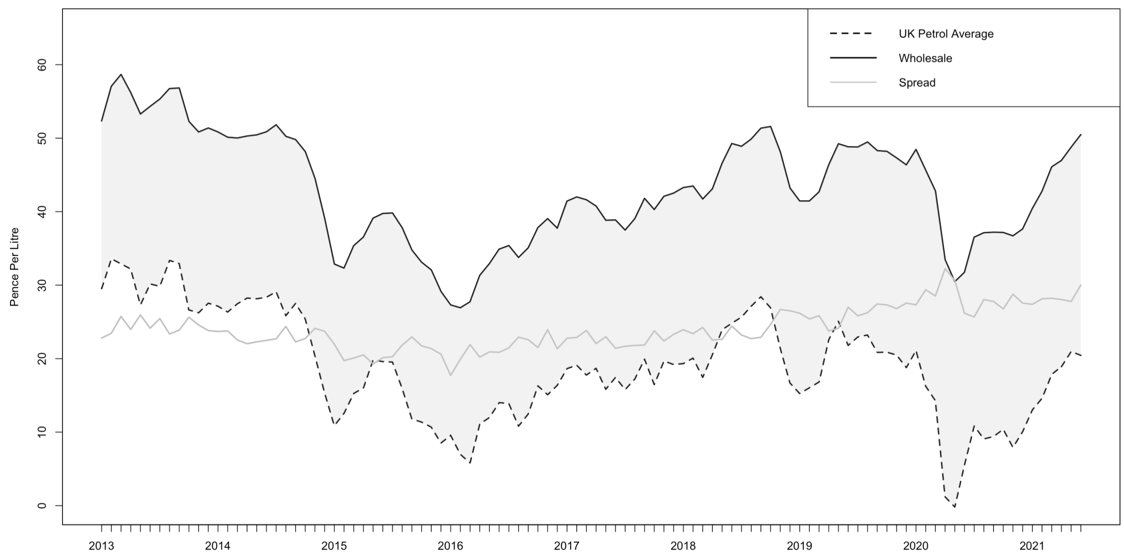

Figure 4.1: Retail and wholesale petrol prices from 2013 to June 2021

Figure 1 shows the retail prices of Petrol, wholesale prices and the spread term. The raw levels data looks to be closely cointigrated as the lines follow each other closely.However, the spread term does not seem to stay consistent. There is a clear drop around 2015-16 and then margins increase from 2019 to 2021. To test for cointigration we use the engle-granger two step procedure. This tests the residuals of the long term cointigration relationship for stationarity. If these residuals are stationary, the two series are indeed cointigrated. Clearly it can be seen from figure 2 that these residuals are not symmetric around zero thus non-stationary. This is a relatively new phenomena for fuel prices as other studies have not encountered this. There are several possible reasons for this. Firstly, most studies were done pre 2014, before crude oil prices crashed due to increases in efficiency and thus oversupply to the market. This is seen by the largely negative residuals around 2015-16. The residuals then become completely

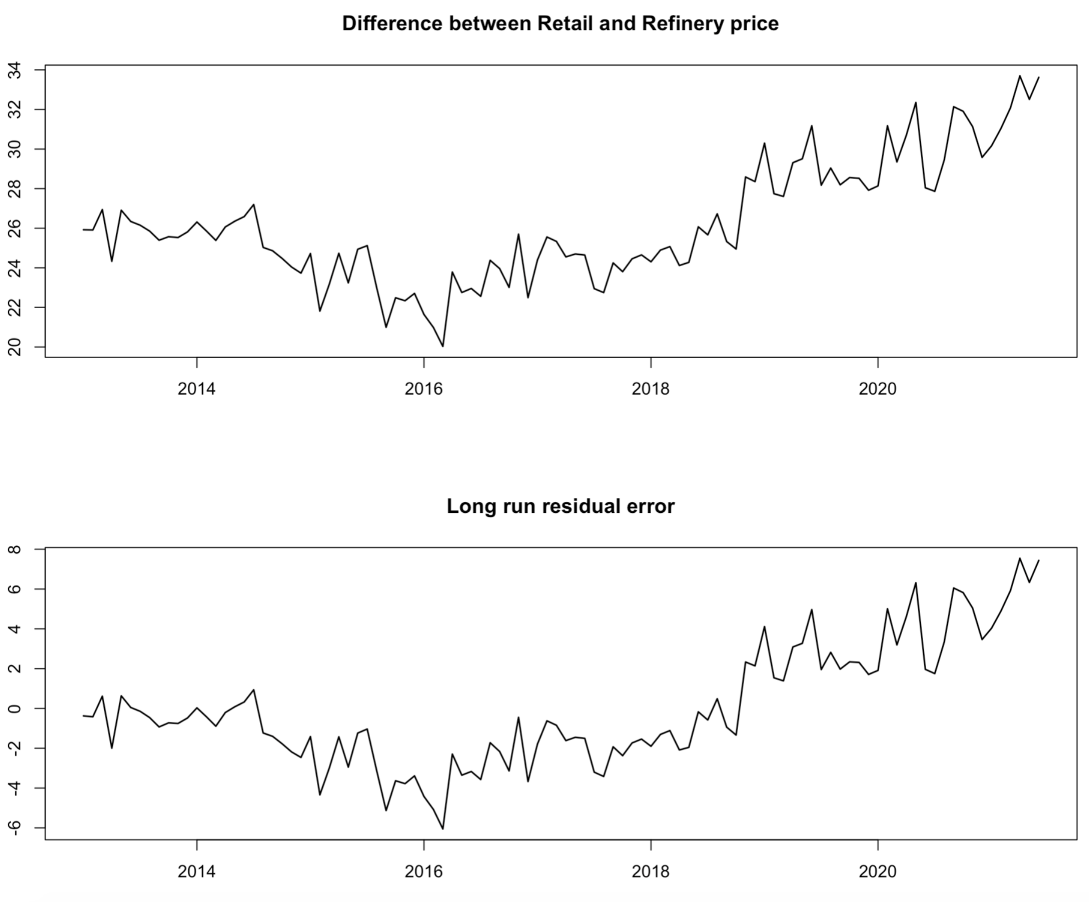

Figure 4.2: Spread term between retail-refinery prices, residuals from the long term model

positive after 2019. This effect on prices has been more sustained and is the main reason for the long run relationship breaking down. Indeed if the long run model is calculated for values restricted to pre 2018, the residuals are stationary and thus the series can be modelled as cointigrated. however this will restric the number of observations we have and will not allow us to use timeseries modelling. A reason for the breakdown in the long run equilibrium spread may be due to PFS not being able to subsidise liquid fuel sales through non-fuel sales due to the national lockdowns. This resulted in retailers increasing margins on fuel sales to make up for this. Also the reduction in the quantity of fuel sold would also have forced retailers to do the same. A way around this would be to increase the time period further back to perhaps 2000. This would average out recent shocks in the market over the last 7 years and thus make the residuals stationary, however this data is not available currently and may not have ever been recorded by any agency.

The threshold error correction model cannot be fitted to the regional data. Instead a sort run model can be fitted, which will still capture differences between the regions, but cannot distinguish if the asymmetry is coming from the lags or the long run relationship. This analysis still allows us to compare differences in the regions so achieves the goal of this paper.

Chapter 5

Results

5.1 Weekly data model

Firstly, the weekly model for petrol and diesel is computed. A symmetrical model is also computed to compare fit. A symmetric model in this case is a model without separate thresholds and is modelled on the whole data without splitting. The lags of these models are decided by minimising the Akaike information criterion(AIC) and the Bayesian information criterion(BIC). The adjusted R squared of the symmetrical model is greater than the R squared of the 4 regime asymmetric models in the diesel case. In terms of model fit, the symmetrical model fits better than the asymmetrical model, initially suggesting that there is no asymmetry in the market. This is consistent with some findings in various papers however our goal is to assess localised sources of asymmetry and these initial models are to compare our regional models to.

Table 1: Symmetric no threshold model

Regressor	**Petrol model**		**Diesel model**	
	Coeff	Std.dev	Coeff	Std. dev
ecm_{t-1}	-0.137	0.016	-0.195	0.019
$\triangle WP_{t-2}$	0.103	0.025	0.209	0.035
$\triangle WP_{t-3}$	0.110	0.026	061	0.030
$\triangle WP_{t-4}$	0.229	0.030	0.123	0.029

All coefficients are significant to at least 10% level unless stated otherwise

Table 2: Weekly zero threshold diesel model

Regressor	Coeff	Std.dev
ecm^1_{t-1}	-0.132	0.069
ecm^2_{t-1}	-0.200	0.045
ecm^3_{t-1}	-0.146	0.052
ecm^4_{t-1}	-0.145	0.075
$\triangle WP^1_{t-2}$	0.415	0.102
$\triangle WP^1_{t-3}$	0.166	0.076
$\triangle WP^1_{t-4}$	0.282	0.085
$\triangle WP^2_{t-2}$	0.247	0.057
$\triangle WP^2_{t-4}$	0.126	0.046
$\triangle WP^2_{t-6}$	0.148	0.042
$\triangle WP^3_{t-2}$	0.192	0.053
$\triangle WP^3_{t-3}$	0.029	0.046
$\triangle WP^3_{t-4}$	0.136	0.050
$\triangle WP^4_{t-1}$	0.158	0.074
$\triangle WP^4_{t-2}$	0.240	0.068
$\triangle WP^4_{t-3}$	0.131	0.063

All significant to at least 10% level unless stated.

Results are displayed in table 1 and table 2 for the symmetric and asymmetric diesel models respectively. The error correction coefficient for the symmetric model shows that 19.5% of equilibrium error is eliminated in the following time period. This is a relatively slow adjustment, however weekly data is being used here so this is to be expected. For comparison, in other studies with monthly data spanning longer periods, models would return upto 50% error correction so a coefficient of -0.195 weekly is consistent with other studies. Our asymmetric model for diesel returns ecm coefficients of -0.132, -0.200, -0.146 and -0.145 for regimes 1, 2, 3 and 4. Regime 1, the negative regime, has an ecm term of 13.2% whereas the positive regime 2 is 20% showing there is some asymmetry coming from the error correction mechanism. This is consistent with the rockets and feathers theory as it shows that the error correction mechanism eliminates more equilibrium error during price rises than during price falls. When asymmetry in the lags are assessed, the opposite is true. The sum of the coefficients for the lags of the negative regime is 0.862, and 0.521 for the positive regime. This shows that actually when wholesale prices decrease, retail prices follow these price changes more closely than during wholesale price increases. An explanation for this can be that there are actually opposing asymmetric characteristics of price adjustments present in the market in both the error correction mechanism and lags, and on average the market is actually not characterised by a zero threshold. This is supported by the better R squared value of the symmetric model over the asymmetrical one. Overall, there is no solid evidence in support of the rockets and feathers theory. This does not rule out, at a more local level, the existence of asymmetric pricing in the diesel market.

Table 3: Weekly zero threshold Petrol model

Regressor	Coeff	Std.dev
ecm^1_{t-1}	-0.176	0.053
ecm^2_{t-1}	-0.091	0.048
ecm^3_{t-1}	-0.019	0.048
ecm^4_{t-1}	-0.135	0.076
$\triangle WP^1_{t-2}$	0.198	0.057
$\triangle WP^1_{t-3}$	0.111	0.044
$\triangle WP^1_{t-8}$	0.097	0.047
$\triangle WP^2_{t-1}$	0.253	0.046
$\triangle WP^2_{t-3}$	0.185	0.043
$\triangle WP^2_{t-4}$	0.170	0.037
$\triangle WP^3_{t-1}$	0.276	0.064
$\triangle WP^3_{t-2}$	0.286	0.051
$\triangle WP^3_{t-3}$	0.189	0.053
$\triangle WP^4_{t-1}$	0.174	0.085
$\triangle WP^4_{t-2}$	0.202	0.080
$\triangle WP^4_{t-3}$	0.135	0.062

All signigicant to at least 10% level unless stated

The symmetric, no threshold model for petrol again has a better fit to the data than the asymmetric zero threshold model. A similar pattern is found for the asymmetric model where the error correction term and the lags for wholesale prices are showing conflicting price effects. The error correction coefficients are -0.175, -0.091 and -0.135 for regime 1, 2 and 4 respectively. The ecm coefficient for regime 3 was not statistically significant and is close to 0. These ecm coefficients are the opposite of what the rockets and feathers literature suggests however as with the diesel model, the lags on the wholesale price coefficients show the contrary. The sum of the negative regime lags is less than the sum of the positive regime lags. Again since the symmetric model has a better adjusted R squared value for to the data, we can assume this is just the model is capturing the fact that there is no difference between the positive and negative regimes in the petrol market.

5.2 Regional results

Table 3 contains the values for the regional models for the Diesel market. For all regions, the majority of the price adjustment comes from the first period lag shown by the larger coefficiens for $\triangle WP_t$. This is consistent with the findings in the weekly analysis which showed that the lag adjustment was greater for the earlier lags compared to the later ones. For the UK average, the sum of the coefficients in the positive and negative regimes is 0.977 and 0.919 respectively. This is consistent with the level of cointigration we have between retail and wholesale prices, as the time-series closely follow one another. The smaller coefficient sum on the negative regimes is consistent with the rockets and feathers literature as it indicates lower pass through rates of wholesale prices to retail prices.

Table 4: Coefficients for regional zero thresholds diesel model

		Positive regime		**Negative regime**	
Region	Regressor	Coeff	Std.error	Coeff	Std.error
UK average	$\triangle WP_t$	0.618	0.113	0.649	0.078
	$\triangle WP_{t-1}$	0.359	0.051	0.271	0.064
NI	$\triangle WP_t$	0.656	0.106	0.642	0.074
	$\triangle WP_{t-1}$	0.356	0.048	0.279	0.061
SCOT	$\triangle WP_t$	0.629	0.114	0.652	0.078
	$\triangle WP_{t-1}$	0.368	0.051	0.284	0.064
WALES	$\triangle WP_t$	0.617	0.114	0.666	0.076
	$\triangle WP_{t-1}$	0.370	0.051	0.258	0.063
NE	$\triangle WP_t$	0.622	0.117	0.667	0.083
	$\triangle WP_{t-1}$	0.356	0.053	0.253	0.068
NW	$\triangle WP_t$	0.621	0.118	0.638	0.078
	$\triangle WP_{t-1}$	0.360	0.053	0.278	0.064
YH	$\triangle WP_t$	0.606	0.115	0.632	0.082
	$\triangle WP_{t-1}$	0.346	0.052	0.279	0.068
WM	$\triangle WP_t$	0.644	0.114	0.652	0.081
	$\triangle WP_{t-1}$	0.361	0.052	0.264	0.067
EM	$\triangle WP_t$	0.617	0.112	0.666	0.079
	$\triangle WP_{t-1}$	0.354	0.051	0.283	0.065
E_EA	$\triangle WP_t$	0.578	0.115	0.643	0.077
	$\triangle WP_{t-1}$	0.364	0.052	0.282	0.063
LON	$\triangle WP_t$	0.618	0.122	0.638	0.081
	$\triangle WP_{t-1}$	0.349	0.055	0.253	0.067
SE	$\triangle WP_t$	0.619	0.117	0.648	0.082
	$\triangle WP_{t-1}$	0.368	0.053	0.265	0.068
SW	$\triangle WP_t$	0.587	0.111	0.641	0.080
	$\triangle WP_{t-1}$	0.358	0.050	0.270	0.066

Constant value omitted for brevity. All values significant at least 1%.

The largest variations in the two terms was for prices in the West Midlands and Northern Ireland. Northern Ireland have fewer PFS per capita than the mainland United Kingdom which causes less competition in the Northern Irish market, explaining why they have the largest variation between positive and negative regimes. Furthermore, Ireland as a whole have no oil/refined oil pipelines in the country and only one refinery in the republic of Ireland, so everything has to be transported by freight and by road. This increases transportation costs and may contribute to its slower pass through rates. London has the lowest coefficient sum for the negative regime. London is similar to Ireland in that it has the lowest number of PFS per-capita in the United kingdom. This will dramatically affect competition in this area and the model indicates that these firms may still hold some short term price setting power. Along with this, London is also burdened with the highest land costs in the UK as well as higher delivery costs due to congestion, higher pay and in some areas restrictions on the times deliveries can be made. This illustrates why firms in this region may be sluggish to pass through decreases in wholesale prices onto consumers.

Essex and east Anglia have the smallest difference between the sums of the positive and negative regimes. When the logistics of the geography of the area is assessed however, it can be seen that the government pipelines and storage systems (GPSS) pipeline runs through this region, as well as another privately owned pipeline. Storage tanks are located just outside the border around Skegness, where the refined oil is distributed from. This will reduce transportation costs, thus allowing firms to increase margins without needing to exploiting falls in wholesale prices.

Overall, the diesel regional analysis shows that pass through rates are lower for negative price changes than for positive price changes, consistent with the rockets and feathers theory. We also find that in some areas this effect is larger than other regions, confirming the idea of local differences in pass through rates.

Table 5 contains coefficients for the regional Petrol models. All coefficient sums are larger for the negative regime except for the North east where the positive sum of the coefficients are larger by 0.023. This is completely opposite to the rockets and feathers literature, and shows that's if asymmetry does exist in some regions, it would actually be working in the opposite direction to the economic theory. Even though there are differences in these effects for different regions, it is opposite to what is suggested by economic theory.

Overall, the models shows that there are some differences in pricing between the different regions although more data will have to be collected to perform a longer term analysis and to embed a long term error correction term aspect into the model. This is because it will help to identify if these asymmetries are as a result of the error correction mechanism or because of the lags of the changes in wholesale prices. From the models we can confirm some asymmetries supporting economic theory exist in the diesel market however none evident in the petrol market.

Table 5: Coefficients for regional zero thresholds petrol model

		Positive regime		**Negative regime**	
Region	Regressor	Coeff	Std.error	Coeff	Std.error
UK average	$\triangle WP_t$	0.629	0.077	0.691	0.052
	$\triangle WP_{t-1}$	0.288	0.045	0.265	0.036
NI	$\triangle WP_t$	0.659	0.076	0.731	0.054
	$\triangle WP_{t-1}$	0.319	0.045	0.288	0.038
SCOT	$\triangle WP_t$	0.664	0.078	0.720	0.052
	$\triangle WP_{t-1}$	0.283	0.046	0.266	0.036
WALES	$\triangle WP_t$	0.641	0.078	0.753	0.055
	$\triangle WP_{t-1}$	0.272	0.046	0.239	0.038
NE	$\triangle WP_t$	0.672	0.085	0.674	0.052
	$\triangle WP_{t-1}$	0.290	0.050	0.265	0.036
NW	$\triangle WP_t$	0.591	0.081	0.705	0.056
	$\triangle WP_{t-1}$	0.304	0.048	0.249	0.039
YH	$\triangle WP_t$	0.658	0.080	0.682	0.053
	$\triangle WP_{t-1}$	0.277	0.047	0.268	0.037
WM	$\triangle WP_t$	0.609	0.078	0.691	0.053
	$\triangle WP_{t-1}$	0.280	0.046	0.262	0.037
EM	$\triangle WP_t$	0.62	0.079	0.701	0.054
	$\triangle WP_{t-1}$	0.274	0.047	0.261	0.038
E_EA	$\triangle WP_t$	0.621	0.081	0.637	0.053
	$\triangle WP_{t-1}$	0.299	0.048	0.285	0.037
LON	$\triangle WP_t$	0.610	0.083	0.631	0.056
	$\triangle WP_{t-1}$	0.283	0.049	0.269	0.039
SE	$\triangle WP_t$	0.604	0.079	0.658	0.054
	$\triangle WP_{t-1}$	0.288	0.047	0.272	0.038
SW	$\triangle WP_t$	0.594	0.079	0.708	0.054
	$\triangle WP_{t-1}$	0.291	0.047	0.255	0.037

Constant value omitted for brevity. All coefficient values significant to at least 1%.

Chapter 6

Summery

Although there have been studies into asymmetric pricing of retail fuel markets in the UK and in Europe, there have been no studies into localised sources of asymmetries in the UK. The general consensus has been that UK retail fuel markets remain competitive and sources of asymmetry are modest if at all significant. The weekly analysis in this report shows that symmetric models fit better to the data from 2015-18 and that asymmetric models show conflicting sources of asymmetry which indicates that the model on the aggregate is showing a symmetrical response to price increases and decreases. This is the same for conflicting price pressures which are modelled in separate regimes but show the same effect.

Localised sources of asymmetry can arise due to areas with lower levels of competition or with higher costs of transportation. In our analysis we find that there exists asymmetry in the diesel market. it is more prominent in areas with potential sources of low competition and higher costs of business. In the regional models for petrol, we see that where there is asymmetry, it is in the opposite direction of the economic theory thus can conclude no evidence in support of the rockets and feathers theory in this market.

This analysis was done over an unprecedented time period for global demand for oil and also demand at a local level. Margins increased in all regional markets post 2019 so this still makes our models valid as it is comparing between regions, so any differences in these margins have been picked up in the coefficients of the models. The global crisis has hindered this investigation however as it has not allowed us to separately model the long term and short term effects separately. As international markets return to normal, more studies can be done in the future to see if these local differences were due to these international oil price shock and domestic lock-downs or if they hold over longer periods of a more normal economic climate.

Queen Mary University of London
12^{th} August 2019

Appendix A

Summary statistics for the data

Weekly Summary Statistics

	Mean	Std. Error	Min	Max
Wholesale prices of Diesel	17.68	5.67	4.96	31.99
Change in Wholesale prices	0.08	0.90	-2.14	2.50
Retail prices in Diesel	40.32	6.61	26.17	55.83
Change in retail prices	0.08	0.59	-1.86	1.79
Wholesale prices of Petrol	17.06	4.87	6.62	28.04
Change in Wholesale prices	0.07	0.86	-2.18	2.45
Retail prices of Petrol	38.55	6.04	26.87	51.69
Change in retail prices	0.09	0.56	-1.85	1.48

These summary statistics are for weekly UK average data from 2015 till August 2018. During this period the mean diesel retail and wholesale price is higher than for the petrol equivalent. The price movements were also more volatile as shown by the higher standard deviation values of diesel. Diesels wholesale price reached a high of 31.99 and low of 4.96 pence per litre during this period whereas the retail price was 55.83 and 26.17 respectively. Petrol's retail price hit 28.04 and a low of 6.62 pence per litre. Its retail price reached 51.69 and 26.87 respectively.

As for other patterns, there is no obvious seasonal patterns in the data. More fuel is used in winter months however this is probably already anticipated by refineries who adjust their output accordingly. Due to this there may be a seasonal pattern in consumption however none is present in the prices.

Regional change summary statistics

	Mean	Std. Error	Min	Max
Northern Ireland				
Change in retail Petrol prices	-0.05	2.39	-10.83	4.58
Change in retail Diesel prices	-0.10	2.14	-7.17	3.83
Scotland				
Change in retail Petrol prices	-0.02	2.40	-9.75	5.08
Change in retail Diesel prices	-0.06	2.20	-7.08	4.25
Wales				
Change in retail Petrol prices	-0.03	2.39	-10.17	4.92
Change in retail Diesel prices	-0.07	2.19	-6.83	4.25
London				
Change in retail Petrol prices	-0.01	2.28	-8.17	4.50
Change in retail Diesel prices	-0.05	2.15	-6.83	4.20
Wholesale				
Change in retail Petrol prices	-0.09	2.90	-13.08	5.77
Change in retail Diesel prices	-0.13	2.41	-8.26	4.55

Above we have the summary statistics for 4 regions in the data: Northern Ireland, Scotland, Wales, London as well as the wholesale prices. All regions seem to be very similar in their volatility.

Appendix B

Additional graphs

Figure B.1: Retail and wholesale Diesel prices from 2013 to June 2021

For the UK average diesel prices, we see the same pattern in the spread series where there seems to be a divergence from the margins of around 22-23 pence around 2019.

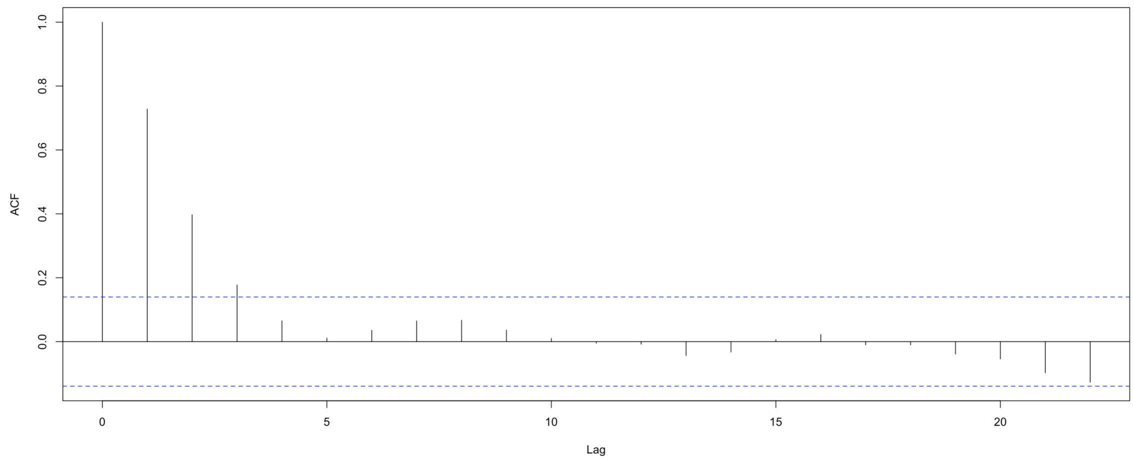

Figure B.2: Auto-correlation of the change in weekly prices

The above shows the auto-correlation in the weekly price changes of retail prices. Due to the time it takes for prices to pass through, it is not uncommon for there to be this level of correlation even after the first differences. This level of auto correlation happens within the monthly data as well, however is averaged out to get one monthly observation.

Below is the Residual analysis done for the UK average negative regime. As we can see the residuals are symmetrical around 0 and not serially correlated. They also form well under the bell curve distribution. This is done for all the residuals in each model and all residuals were symmetric around zero and did not show signs of correlation. Some had slightly skewed residuals however this is to be expected with only 100 observations.

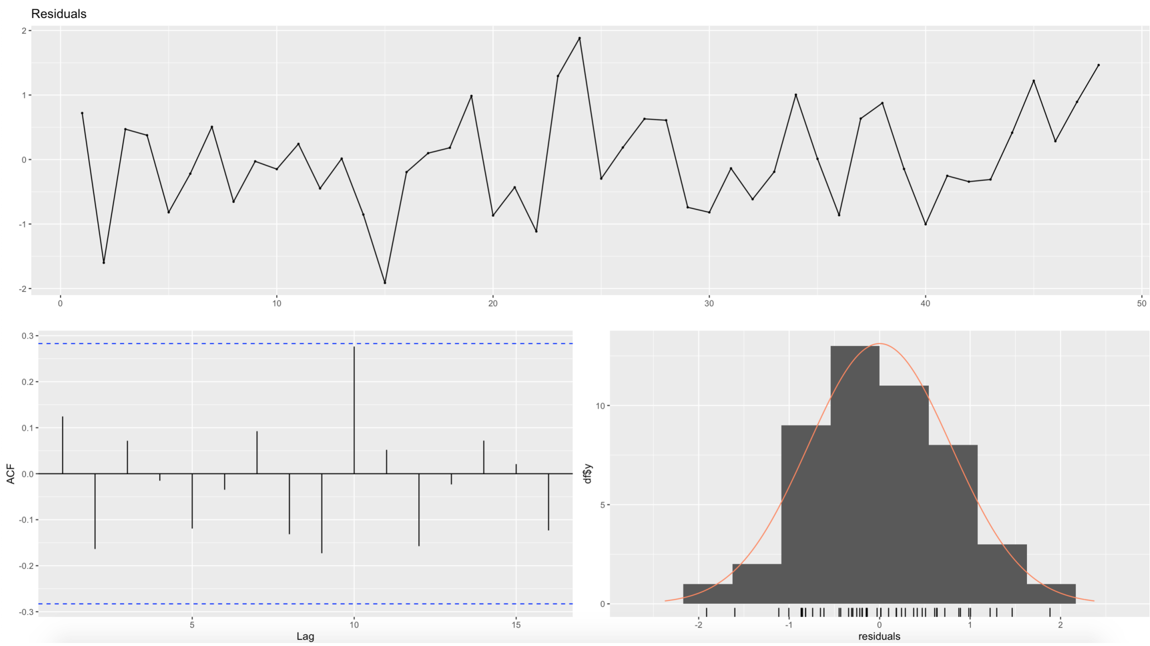

Figure B.3: Residual analysis

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