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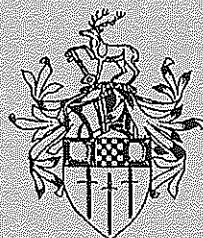
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Petrol Price Asymmetries Revisited

Barry Reilly and Robert Witt

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PETROL PRICE ASYMMETRIES REVISITED

Abstract

An error correction model is fitted to monthly data on net retail prices for the United Kingdom over the period January 1982 to June 1995 in order to examine the short-run response of retail petrol prices to changes in input costs and the exchange rate. The hypothesis of a symmetric response by petrol retailers to crude price rises and falls is rejected by the data over the period examined. A similar hypothesis in regard to the exchange rate is also rejected by the data.

JEL Classification: D40 Q43

Key Words: Petrol prices, Asymmetry, Exchange rate

1 INTRODUCTION

The most recent Monopolies and Mergers Commission (MMC) inquiry into the pricing policy of petrol retailers (see HMSO, 1990) concluded that the behaviour of companies was not characterised by an asymmetric response of retail pump prices to changes in crude prices. This finding has been contested recently by a number of studies for the United Kingdom which have attempted to explore econometrically the relationship between net retail prices and crude prices (see Sumner (1990) and Bacon (1991)). The conclusions drawn by these studies is that the hypothesis that retail petrol prices adjust more rapidly to increases in crude prices than to decreases cannot be rejected by the data. In particular, Bacon (1991) analysed fortnightly data from 1982 to 1989 and found evidence of a faster and more concentrated response of pump prices to cost increases whilst Sumner (1990), using monthly data from March 1981 to December 1989, detected similar responses. These findings are resonant of those of Manning (1991), who exploited monthly data on gross retail petrol prices from an even earlier period (1973 to 1988), and concluded that price asymmetries, though present, are short-lived¹.

A potentially important issue in the analysis of petrol price asymmetries is the role played by the dollar/sterling exchange rate. Rotterdam remains the major market for the purchase of crude in Europe. The open-market prices quoted in Rotterdam are expressed in dollar terms. Movements in the dollar/sterling exchange rate are thus likely to be important in explaining some of the movement in net retail prices. This relatively important issue appears to have been neglected in the work of Sumner (1990) and Manning (1991). In contrast, Bacon (1991) exploits non-linear estimation techniques to inform on the response of petrol prices to crude price changes and to changes in the relevant exchange rate. Bacon rejects

the hypothesis of symmetric responses in the short-run for both crude prices and the exchange rates.

This paper seeks to establish the presence or otherwise of petrol price asymmetries in regard to both the crude price and the dollar/sterling exchange rate. In contrast to Bacon (1991) who used a non-linear partial adjustment model, our study exploits an error correction mechanism (ECM) framework to inform on the asymmetric issues of interest. Adoption of this approach does not necessitate use of non-linear estimation and may be theoretically motivated by a quadratic cost adjustment model (see Nickell (1985)) and may be viewed as a generalized version of a partial adjustment model. In addition, the long-run equilibrium relationships between the variables of interest can be explored by use of cointegration techniques. In this regard, our paper possesses some similarities with the work of both Sumner (1990) and Manning (1991).

The structure of the remainder of this paper can now be outlined. The following section briefly details the data used. Section 3 outlines the empirical model and discusses the results and section 4 provides some conclusions.

2 DATA

The variables in our analysis are monthly series for the crude oil price (C), the net UK retail petrol price (P), and the dollar/sterling exchange rate (X). The sample period is from January 1982 to June 1995. Brent crude oil price data are obtained from the *British Petroleum Company*, reported on the basis of monthly averages in cents per litre. The net UK retail petrol price is the gross monthly four star leaded petrol price in pence per litre less value added tax (VAT) and less excise duty. The gross price is the representative price paid (inclusive of VAT and duty) at the pump on or

about the 15th of each month. Value added tax has been either 15% or 17.5% of the price plus duty throughout the sample period, whereas excise duty changes annually in the Budget. The price of four star petrol (including taxes) and excise duties are obtained from the *Digest of UK Energy Statistics*. The dollar/sterling exchange rate is the average monthly rate in dollars against sterling obtained from *Financial Statistics*. The natural logarithmic transformations of these variables will be denoted by lower case letters. Thus, c is $\ln(C)$, p denotes $\ln(P)$ and x is $\ln(X)$ where $\ln(\cdot)$ denotes the natural logarithmic operator.

3 EMPIRICAL MODEL AND RESULTS

An unrestricted dynamic error correction model can be exploited to model the relationship between the net retail petrol price, the crude price and the exchange rate. This model, in its simplest form, may be expressed as follows:

$$\Delta p_t = \alpha + \beta_1 \Delta c_t + \beta_2 \Delta x_t + \gamma_1 p_{t-1} + \gamma_2 c_{t-1} + \gamma_3 x_{t-1} + \mu_t + \varepsilon_t \quad [1]$$

where Δ is the first difference operator, t is a deterministic time trend included to capture the effects of other costs on the retail petrol price, and ε_t is an error term for which the standard assumptions are made. The contemporaneous treatment of the first difference regressors follows from the assumption of weak exogeneity for both the crude price and exchange rate variables. This is a relatively innocuous assumption given our particular setting. The set of β coefficients provides information on the short-run effects of crude prices and the exchange rate on the net retail price of petrol with long-run information retrievable from the set of γ parameters.

In order to inform on the potential asymmetric relationship between crude prices, the dollar/sterling exchange rate and the net retail price in the United Kingdom, equation [1] is slightly modified. Two binary variables are defined to capture whether the growth in crude prices and the exchange rate are positive. Thus, dc adopts a value of unity if $\Delta c_t \geq 0$ and zero otherwise, and dx adopts a value of unity if $\Delta x_t \geq 0$ and zero otherwise. Equation [1] is now augmented by the inclusion of the crude price variable interacted with the dc binary variable, and the exchange rate variable interacted with the dx binary variable. This augmented equation is now expressed as:

$$\Delta p_t = \alpha + \beta_1 dc \times \Delta c_t + \beta_2 \Delta c_t + \beta_3 dx \times \Delta x_t + \beta_4 \Delta x_t + \gamma_1 p_{t-1} + \gamma_2 c_{t-1} + \gamma_3 x_{t-1} + \mu_t + \varepsilon_t \quad [2]$$

It is important to emphasise the interpretation that now attaches to the set of β coefficients. The β_1 coefficient on the interactive crude price variable provides an estimate of the differential in the effect on net retail petrol prices of increases and decreases in crude oil prices. This coefficient and its standard error, therefore, provide the basis for a statistical test of the symmetry hypothesis in regard to crude prices. The β_2 coefficient provides an estimate of the effect of crude price falls on net retail prices. The point estimate for the effect of crude price rises on net retail prices is obtained by summing the β_1 and β_2 coefficients. Analogous reasoning can be applied to the interpretation of the β_3 and β_4 dollar/sterling exchange rate coefficients. The β_3 coefficient and its standard error provide a statistical test for the symmetry hypothesis in terms of exchange rates, and β_4 provides an estimate of the effect of a fall in the dollar/sterling exchange rate on net retail prices.

We now turn to our empirical results. The logarithmic level variables p , c , and x are all found to be difference stationary processes and integrated of order one on the basis of augmented Dickey-Fuller (ADF) tests². The basic model implied by equation [2] was estimated by OLS over the period from March 1982 to December 1993³. Eighteen additional observations (from January 1994 to June 1995) were withheld to assess the forecasting properties of the empirical model. After some experimentation, the estimated dynamic model reported below as [3] was found to provide a reasonable representation of the data. It should also be noted that all restrictions imposed are found to be data admissible.

$$\begin{aligned}
 \Delta p_t = & -0.280 + 0.224dc \times \Delta c_t + 0.190 \Delta c_t \\
 & (0.051) \quad (0.124) \quad (0.079) \\
 & + 0.688 [dx \times \Delta x_t + dx \times \Delta x_{t-3}] - 0.500 [\Delta x_t + \Delta x_{t-3}] + \\
 & (0.264) \quad (0.156) \\
 & 0.129 [\Delta p_{t-1} - \Delta p_{t-3}] \\
 & (0.042) \\
 & - 0.438p_{t-1} + 0.254 [c - x]_{t-1} + 0.0007t \\
 & (0.059) \quad (0.037) \quad (0.0002) \quad [3]
 \end{aligned}$$

(OLS standard errors are reported in parentheses).

Adjusted- $R^2 = 0.549$; $\sigma = 0.044$; $N=140$ Months; ECM t-test = -7.53.

Lagrange Multiplier Chi-Squared Tests:

RESET (DF=1) = 0.26 [prob-value= 0.61];

Serial Correlation (DF=12) = 10.18 [prob-value = 0.60];

ARCH (DF=12) = 19.61 [prob-value = 0.08];

Heteroscedasticity (DF=1) = 0.23 [prob-value = 0.63];

Normality (DF=2) = 2.99 [prob-value = 0.22];

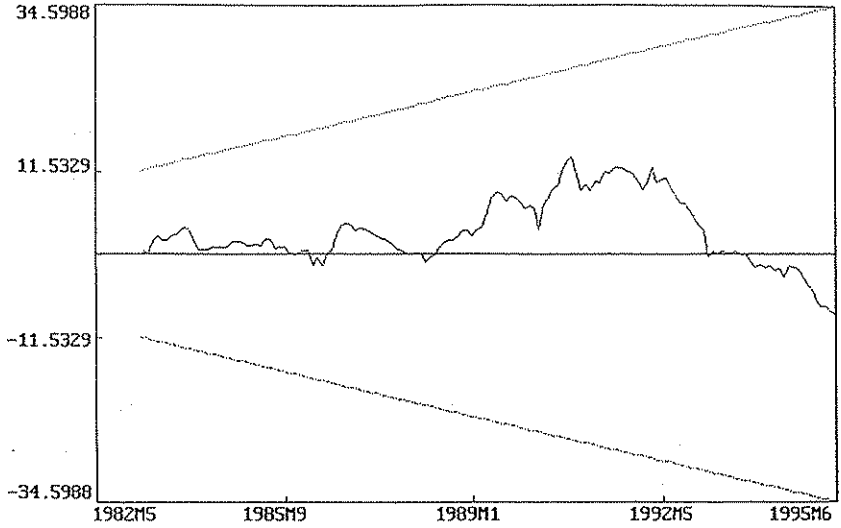
Predictive Failure Test (DF=18) = 16.89 [prob-value = 0.53].

[Note: The prob-value is the observed significance level of the test under consideration].

All the estimated coefficients are found to be statistically significant at the 10% level or better using two-tailed tests but it should be borne in mind that the t-ratios on the lagged level terms are invalid given the presence of a unit root in these series. The broad range of diagnostics suggests a reasonably well specified empirical model although some evidence of autoregressive conditional heteroscedasticity is detected which may have implications for the efficiency of the model's estimates. The forecasting power of the estimated model was also assessed by calculation of one-step-ahead forecast errors and their corresponding t-ratios for the final eighteen observations withheld from estimation (see Salkever (1976)). On the basis of the individual t-ratios, no statistically significant forecast errors are detected for the model over the period January 1994 to June 1995. This is also confirmed by reference to the one-step-ahead Chow tests reported below.

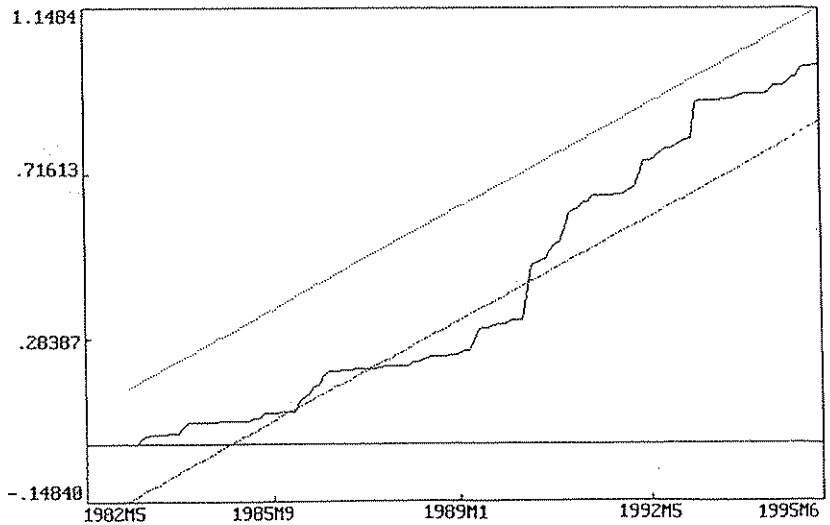
The overall stability of the estimated relationship was initially examined by reference to CUSUM and CUSUMSQ techniques (see Brown, Durbin and Evans (1975)) which in our application exploit the model's recursive residuals and should be viewed primarily as procedures that facilitate a visual inspection of potential structural breaks. Figures 1 and 2 plot respectively the CUMSUM and CUSUMSQ recursive residuals. The latter figure in particular suggests potential instability around the period covering the late eighties and early nineties.

Figure 1: Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure 2: Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

A more formal statistical test of stability is provided by the calculation of one-step-ahead Chow tests over the full sample period. Using the first five years of data for the purposes of initialisation, figure 3 plots the Lagrange Multiplier Chow test values scaled by the 0.01 chi-squared critical value over the period January 1987 to June 1995. Only three observations (March and April 1990 and March 1993) feature as strong outliers. The results reported for equation [3] contain impulse dummies that control for these three outliers. The substantive results of this paper, however, are not altered by the inclusion of these impulse dummies but their exclusion encounters a failure in the normality diagnostic. It should be noted in passing that in March 1990 pump prices fell by 15%, in April 1990 pump prices rose by 21%, and in March 1993 pump prices fell by 15%.

The estimates on the levels variables in [3] can be used to solve numerically for the long-run relationship. The long-run solution, normalising on net retail prices, is given by:

$$p = -0.639 + 0.580[c - x] + 0.002t \quad [4]$$

The long-run estimate capturing the effect of crude prices (adjusted for the exchange rate) on net retail prices is dimensionally close to the long-run estimate of 0.46 reported by Sumner (1990) but is clearly not in agreement with the long-run estimate of unity reported by Bacon (1991). Equation [3] can be used to provide the basis for a test of the unit restriction. If the estimated coefficients on p_{t-1} and $[c - x]_{t-1}$ are found to be equal but opposite in sign, the hypothesis of a long-run unit relationship between the two variables cannot be rejected by the data. Using equation [3] the Wald chi-squared value for the test of this one restriction is 37.2 suggesting a decisive rejection of a unit relationship between net retail prices and costs in the long-run. In contrast to Bacon, we find no evidence of a full passing on of costs in the long-run.

The equilibrium errors obtained from the long-run solution of [4] provide the error correction mechanism term (ECM) which can be used to test for cointegration. This procedure is advocated by Kremers, Ericsson, and Dolado (1992) given it may have greater power than the Dickey-Fuller statistic conventionally applied to the OLS residuals from a static levels equation in the traditional two-step Engle-Granger procedure (see Engle and Granger (1987)). The ECM t-test value is then compared to the critical values reported for the Dickey-Fuller test in McKinnon (1991). Our ECM t-test provides evidence in support of cointegration and hence for the existence of a long-run statistical relationship between the net retail and crude petrol price variables (adjusted for the exchange rate)^{4,5}.

The short-run estimates of equation [3] provide evidence of an asymmetric response among retailers to changes in both crude prices and the exchange rate. On average over the estimation period, retail prices are seen to exhibit a larger response to rising than to falling crude prices within a given month. On the basis of the short-run point estimates reported, a 10% fall in crude prices leads to a 1.9% fall in retail prices whilst a corresponding rise in crude prices leads to a 4.1% rise in retail prices. The effect of a rise in the crude cost is statistically significant at the 1% level with the differential response significant at the 7% level on the basis of a two-tailed t-test. It should be recalled that the long-run point estimates suggest that a 10% rise in crude prices yields a 5.8% rise in retail prices. The size of the estimated short-run response in relation to the long-run suggests that most of the effect of a crude price increase appears to be passed on within the month with the response to crude price falls distributed over a somewhat longer period.

Our dynamic modelling strategy suggests that the short-run exchange rate variables are best captured by an equally weighted three month moving average. An increase (decrease) in a three month moving average

of the dollar/sterling exchange rate suggests a decrease (increase) in the cost of crude oil imports. On average over the estimation period, retail petrol prices register a well determined response to falls (or devaluations) in the dollar/sterling exchange rate. Our point estimate suggests that a 10% fall (or devaluation) in the exchange rate, rendering imported crude oil more expensive in terms of sterling, raises retail petrol prices by about 5%. The implicit long-run point estimate for a 10% fall in the exchange rate on net prices is of a comparable magnitude and, on the basis of a t-ratio, is not statistically different from the short-run effect. This suggests that the response of pump prices to devaluations of the exchange rate are broadly similar between the short- and the long-run.

A sizeable and statistically significant positive coefficient is estimated for the interactive exchange rate variable ($dx \times \Delta x_t$). This provides evidence in support of retail pricing asymmetry in regard to exchange rate movements. The sum of the coefficients on the interactive term and on the exchange rate variable itself provides a point estimate for the effect of an exchange rate rise on net retail prices. On the basis of a t-test, however, this effect is not found to be statistically different from zero at a conventional level (the prob-value of the t-test is 0.14). Our data suggest, therefore, that retailers in the short-run are somewhat reluctant to pass on cost reductions that originate through a favourable upward movement in the dollar/sterling exchange rate preferring to hold prices in the face of exchange rate revaluations. This is in contrast to their pricing behaviour in the light of exchange rate devaluations.

The estimated coefficient on p_{t-1} in equation [3] provides an estimate of the error correction coefficient and hence the speed at which any disequilibria are eliminated. The estimate suggests that over 40% of any deviation from the long-run relationship described in [4] is eliminated each month. Thus, disequilibria appear short-lived and most is eliminated

within a three month period. Our estimated speed of adjustment is marginally higher than that reported for Sumner (1990) but is totally at variance with Manning's (1991) conclusion that departures from the steady state equilibrium take over two years to be fully corrected⁶.

The stability of the asymmetric responses is now assessed using recursive OLS estimation techniques. Figures 4 and 5 plot the recursively estimated OLS coefficient on the crude term ($dc \times \Delta c_t$) and on the exchange rate term ($dx \times \Delta x_t + dx \times \Delta x_{t-3}$) respectively. The recursively calculated t-ratios suggest statistical significance at conventional levels over the time period covering January 1987 to June 1995 for both variables. From late 1991 onwards, the estimated asymmetric effect for crude oil appears relatively stable and, over this period, is persistently estimated at between 0.25 and 0.3. The perceptible rise exhibited by this response between the middle of 1990 and early 1991 may be explained, in part, by the Gulf war. In a comparison of the estimates pre- and post-Gulf war, there is some evidence for the post-war period of an upward shift in the asymmetric effect. In terms of figure 5 and the exchange rate effect, there is little evidence for a stable coefficient over the time period covered. The broad pattern displayed in figure 5 is of a rising asymmetric effect in the exchange rate over time.

Figure 3: One-Step-Ahead Chow Tests

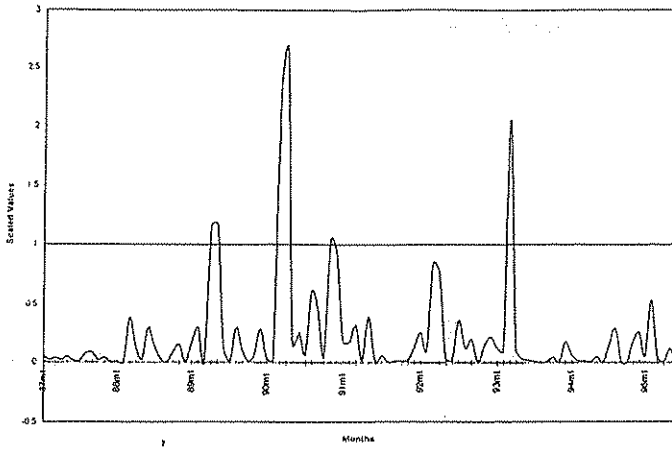


Figure 4: Plot of Recursive Coefficients for Crude Oil Asymmetry

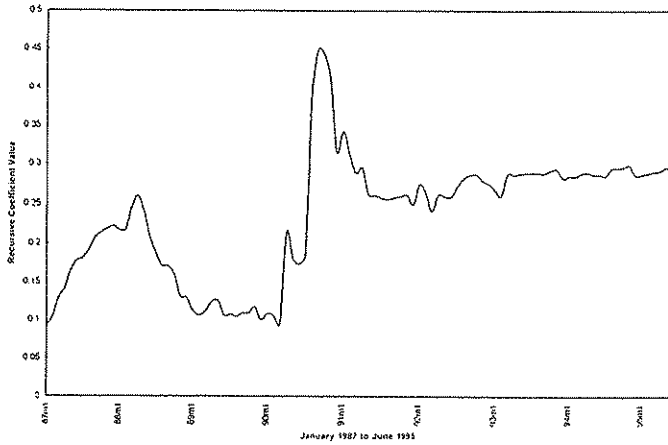
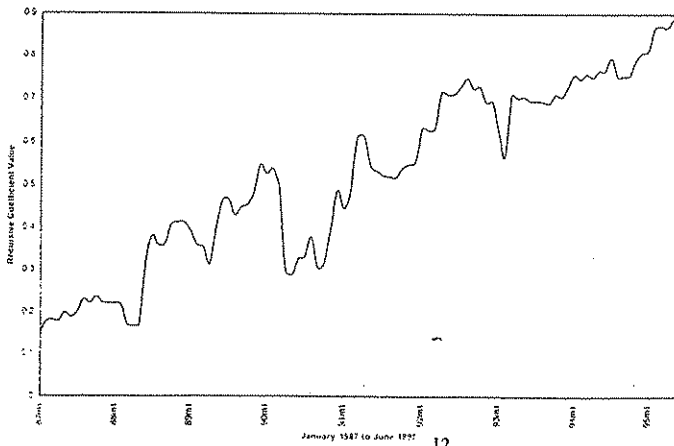


Figure 5: Plot of Recursive Coefficients for Exchange Rate Asymmetry



4 CONCLUSIONS

This paper attempts to re-examine the issue of petrol price asymmetries in the United Kingdom using an unrestricted error correction model over the time period January 1982 to June 1995. Our empirical model was found to possess relatively good forecasting properties and, once a small number of outliers are controlled for, exhibited a reasonable degree of stability over the time period considered. In regard to crude prices, our analysis provides strong and clear evidence supporting asymmetric pricing behaviour on the part of petrol retailers in the United Kingdom. Most of the increase in crude prices appears to be passed on within a given month and for the post-Gulf war period, on the basis of our recursive estimates, a relatively stable and stubborn asymmetric effect is seen to emerge.

The evidence on the exchange rate is less clear-cut. In the short-run, devaluations in the three month moving average of the dollar/sterling exchange rate are passed on as cost increases with an effect that is comparable to the long-run effect. Revaluations of the exchange rate, on the other hand, do not translate into reduced costs at the pump for consumers. The recursive estimates for the asymmetric effect suggest a rising effect over time with little evidence of stability for this particular parameter.

In contrast to Bacon (1991) we find no evidence to suggest that changes in crude prices and the exchange rates are fully passed on into retail prices in the long-run. Other long-run cost factors are clearly important in the long-run determination of the retail price. We do find, however, short-run exchange rate effects operating with a longer lag than crude prices which is resonant of Bacon (1991). In addition, any shocks to the long-run steady state relationship are found to be eliminated quite rapidly, most within three months, a result at variance with Manning's (1991) conclusion

of disequilibria that persist over two years but broadly in comport with the findings of Sumner (1990).

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ENDNOTES:

1 In contrast to the United Kingdom evidence, the empirical work on asymmetries from the United States appears more mixed. Borenstein, Cameron and Gilbert (1992) reported asymmetric retail pricing using semi-monthly data from January 1986 to December 1990 but Shin (1994) concluded that wholesale petrol prices adjusted symmetrically to changes in crude prices. In addition, he detected a rather counter-intuitive result that suggested wholesale prices adjusted to crude oil price falls faster than to crude price rises.

2 The Augmented Dickey-Fuller Tests (ADFs) are specified to include a drift term and a deterministic time trend. The following results relate to an ADF with 1,2 and 3 lags respectively. p (the natural logarithm of UK net retail petrol prices): -2.86, -3.09, and -2.64; c (the natural logarithm of Brent crude prices): -3.44, -2.95, -3.44; and x (the natural logarithm of the dollar/sterling exchange rate): -2.72, -2.41, and -2.65. The critical value is -3.44. The corresponding results for their first difference counterparts are; Δp : -8.72, -8.08, -6.65; Δc : -8.66, -6.30, -6.91; Δx : -8.45, -6.00, -5.77. The critical value is again -3.44.

3 All estimation was carried out using Microfit Version 3.0 (see Pesaran and Pesaran (1991)).

4 It is important to note in small samples that the long-wave or low-frequency components of the data may be poorly reflected rendering it difficult to identify a cointegrating relationship. This does not appear to

have been a problem in our particular case despite the relatively short run of data available for our analysis (just twelve years).

5 The estimated coefficient on the ECM term using the Kremers *et al.* (1992) approach is -0.44. This concurs, not unsurprisingly, with the estimate obtained on the p_{t-1} term in equation [3] in suggesting that any disequilibria are mostly eliminated within three months.

6 The conflict in results may be partially explained by the different specifications adopted. Sumner (1990) posited a long-run relationship between net retail prices, crude prices and labour costs while Manning (1991) specified a long-run relationship between gross retail petrol prices, crude prices and excise duty.

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