Cointegration and US Regional Gasoline Prices: Testing market efficiency from the stationarity of price proportions

John Hunter, Seyedeh Asieh Tabaghdehi*
Department of Economics and Finance, Brunel University, School of Social Science, Uxbridge, Middlesex, UB8 3PH, UK

Abstract: It is well known that oil price shocks are a major concern to the health of the global economy. Unstable oil prices have a significant negative impact on consumer confidence and business decision making. As a result economic recovery may be longer and more complicated. Controlling the global oil price may not be possible, but a main concern of this research relates to energy market efficiency and as to whether relative price differences respond in an appropriate way across the region of one country. Here, the different

1- **INTRODUCTION**

Oil prices are currently of particular concern for the health of the global economy, oil price anomalies are likely to harm consumer confidence and business decision making. It has been suggested recently that oil prices have shifted from the control of OPEC to the global market for oil and as a result in recent times it can be viewed as being less susceptible to political intervention.

I

This research is primarily empirical and econometric with the innovation relating to the methods applied to detect what was termed by Forni (2004) in the context of regional milk prices in I ap (2004

Next this article considers the literature, then the methodology and then the results are analysed. Finally our conclusions are offered.

2- REVIEW OF ESSENTIAL LITERATURE

Considering the differences in taxes seen in plot 1, the gasoline prices are not exactly the same across regions of the US, but in a market that is informationally efficient then price shocks in one region should be reacted to another region as a result of arbitrage. Burke and Hunter (2011) show that when a price in one market reacts to a long-run equilibrium price target (LEPT), then this corresponds to all prices in the market responding in proportion or what has been termed parallel pricing by Buccirossi (2006). Gasoline is a relatively homogenous product and in this paper we evaluate such prices without considering technological differences across primary gasoline outlets across the United States.

The proposition that underlines the idea that the market is efficient is that all prices fully reflect all information across the system. One might consider the possibility of anomalies in the short-run, but in the long-run minor differences ought to be smoothed out. Hence one would anticipate prices should respond to the stochastic behaviour that underlines prices that operate in the market and this behaviour is summarized by a stochastic trend.

Some of the early literature on the nature of collusive behaviour suggested this would be indicated by strong correlations between prices (Maunder, 1972). Such price correspondence was seen as a signal of pricing decisions being made in concert and this would be suggestive of collusion especially with imperfect competition. Posner (1976) considered current price as a key factor in estimating the impact of mergers. A key aim of the most competition agencies is to recognize an active monopoly or detect collusion. To this

market power and increase the over-all price level in the market.

The emphasis has changed more recently as the similarity of price movements can also be considered as a signal of an effectively functioning market. The market efficiency proposition implies that commodity prices ought to fully reflect all information, while the associated concept of a

In the gasoline market it is suggested that the existence of refiners in a region can create differences in price levels. Hence, a further concern of this research is not the existence of such differences but the

Hosken and Taylor (2004) in their extended discussion of Forni (2004) suggest results from stationarity test could deceive the market analyst under two conditions. Firstly when the two series respond to a single common shock and secondly when the original price series are both stationary. The former suggests that the analyst be aware of the impact of a small number of large shocks one indication of which is non-normality. While, the latter problem does not arise in relation to the data used here, but should be detected by testing the univariate series for stationarity.

In addition to analysing the problem via the application of univariate stationarity tests the problem as compared with Forni (2004) is further analysed in a panel context. This is especially pertinent here as it might be imagined that the long-run characteristic of regional gasoline price series should have features in common. It would seem to make sense to compare the univariate analysis with a panel study. One feature that relates to price series is volatility and when the variance process is highly persistent then this may impact the extent to which the computed statistics obtain their asymptotic limit. Boswijk (2001) suggests that a maximum likelihood or least squares correction may be applied to the Dickey Fuller test when the mean and variance processes are independent. While Rahbek et al (2002) found that convergence to the asymptotic distribution might be relatively slow when the variance process has powerful autoregression. The same may not be the case were some extreme distributions selected to explain the data such as the Cauchy or stable Paretian distributions.

3- DATA AND METHODOLOGY

In this paper the stationarity properties of the US gasoline market is analysed using weekly oil price proportions across eight regions of the US: West Coast, Central Atlantic, East Coast,

is a p-1th order autoregressive model that relates to series that are stationary in first difference form. Accepting the one sided alternative hypothesis H_1: <0 implies y_t is stationary.

To confirm that what we are really considering a form of cointegration it is useful to transform the model underlying the ADF test into a dynamic model in the differential in log

null of stationarity can only be accepted at the 5% level in the case of Central Atlantic and Mid West, Central Atlantic and West Coast, East Coast and Mid West, Gulf Coast and West Coast, Mid West and West Coast, New England and the Rockies. The West Coast defines the broadest market being integrated with the Central Atlantic, Gulf Coast and Mid West and at the 1% level New England.

Finding a distinct or narrower market based on the analysis derived from the KPSS test in such regions contradicts the findings obtained from ADF and DF-GLS tests. There is some correspondence in these results with those of Forni (2004), except when the impact of the trend is considered.[3]

It has been suggested that the KPSS test performs poorly when the series are stationary, but the autoregressive coefficient is relatively large. While, Caner and Killian (2001) suggested that the KPSS test is not powerful especially in the light of possible moving average behaviour when compared with the ADF and DF-GLS tests. However, Forni (2004) found far less uniform results, though with many fewer observations observed at a lower frequency. Unlike Forni (2004) these results are consistent with the finding of a broad market when the ADF test can be relied on, but the results based on the KPSS test need to be viewed with some circumspection.

PANEL TESTS OF THE NON-STATIONARY/STATIONARY NULL AND COHERENT UNIVARIATE TESTS

In this section the problem is limited to a panel problem and a similar set of univariate tests. In the context of a system of error correction models then the analysis considers *N* price equations as arises when considering a vector autoregressive (VAR) model or a sequence of single equation error correction models. Forni (2004) provided good reasons as to why univariate methods were appropriate for testing long-run arbitrage. Neither the VAR nor th(p)11(r)-3(ov)11(i)-4(d restrictions on the coefficients. Hence, testing parallel pricing and stationarity/cointegration is unified and this approach can be seen as being efficient.

[Figure 3 goes here]

A further issue that arises in the context of testing stationarity of real exchange rates relates to cross rates and triangular arbitrage (Smith and Hunter, 1985). This follows from selecting alternative base currencies to determine whether the real exchange rate is stationary.

To further evaluate the argument in the above section the ADF, DF-GLS and KPSS test are applied to the log price differentials set out above and the results revealed in table 2.[4] According to these results it can be confirmed for the ADF and DF-GLS tests the null hypothesis of a unit root has been rejected in all cases apart from $y_{4.}$ The analysis is similar to that considered before. However, the results for the KPSS tests in table 2

It is shown in Hadri (2000) for the panel version of the LM test that the following finite sample correction follows a standard normal distribution in the limit:

$$Z_u \quad \frac{\sqrt{N}\,(LM_u \quad {}_u)}{{}_u}.$$

Hadri (2000) computes the Bartlett correction terms ${}_u$=1/6 and ${}_u^2$ = 1/45. For T>50 Hadri (2000) provides evidence based on Monte Carlo simulation that shows that the empirical size that may also be corrected for fixed and random effects. Individual ADF tests are computed for within mean adjusted data and the t-tests computed accordingly. The t-bar test statistic is considered as eight out of the nine univariate tests accept the stationary alternative as does the IPS test for a panel of eight price ratios. So on average when the ADF tests are to be 709.3 Tm[(s39r5[(a277 accepted, there is a broad market as in the long-run these price ratios are stationary; the tests based on autoregressive models appear able to distinguish between the highly persistent behaviour related to a random walk as compared with powerful autoregression.

If a similar approach is considered for the tests under the null of stationarity this corresponds in the case of regulation and competition to natural justice. T9[(a)stsv1 0 0 1 3s c1 0 0 1 462.7 633.46

REFERENCES

Beirne J., J. Hunter and M. Simpson (2007)

London Economics (2002) Study of Sectoral Price Inter-
Mededingingsautoriteit.

Markham J. (1951) The Nature and Significance of Price Leadership, American Economic Review, Vol. 41, pp. 891-905.

Maunder P. (1972) Price Leadership an Appraisal of its Quality in some British Industries, The Business Economist, Vol. 4, pp. 132-140.

Posner R.A. (1976) Antitrust law: an economic perspective, University of Chicago press, Chicago.

Slade M.E. (1986) Exogeneity tests of market boundaries applied to petroleum products, Journal of Industrial Economics, Vol. 34, pp. 291-303.

Smith R.P. and J. Hunter (1985) Arbitrage and Specification in Exchange Rate Models, Economics Letters, Vol. 18, pp. 375-376.

Stigler G.J. and Sherwin R.A. (1985) The Extent of a Market, Journal of Law and Economics, Vol. 28, pp. 555 585.

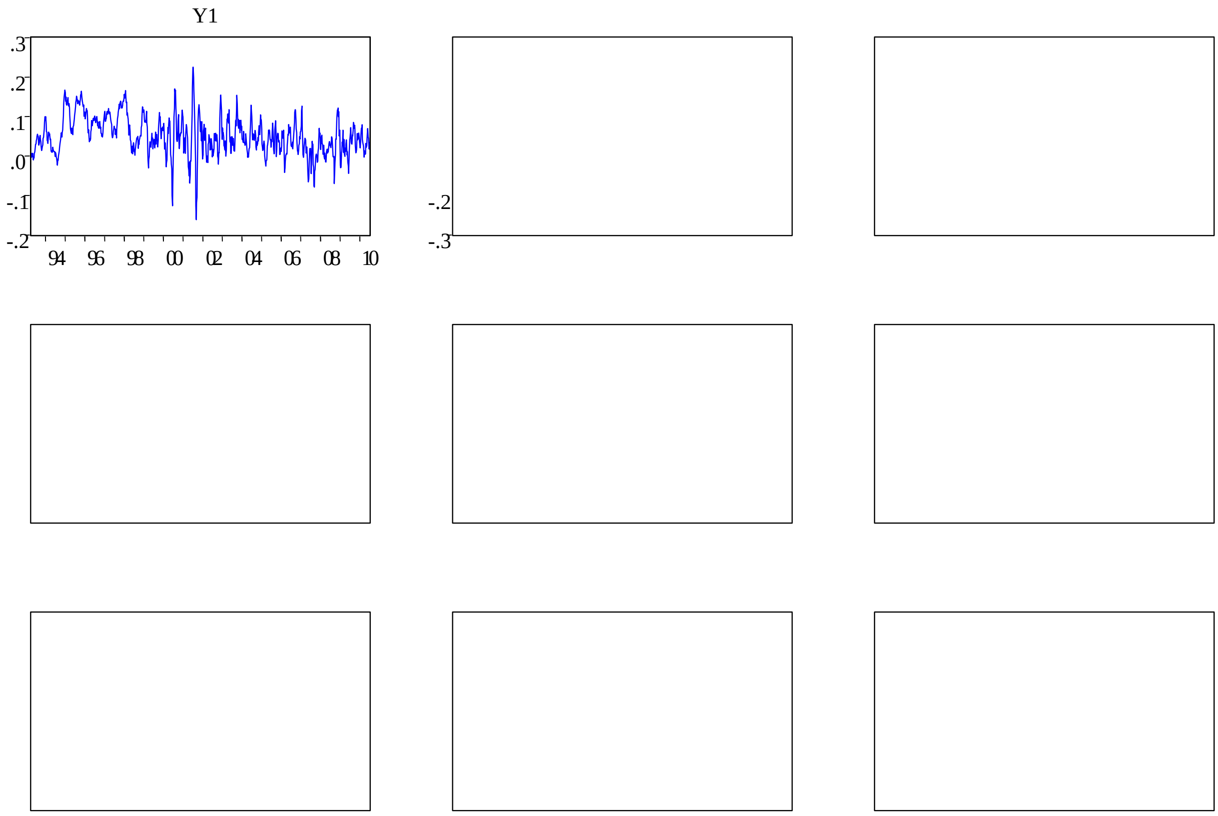
Uri N., D.J., Howell and J.R. Rifkin (1985) On defining geographic markets, Applied Economics, Vol. 17, pp. 959-977.

Figure 1- Gasoline Taxes across the US[5]

Note: Representing plots of log differential in prices of gasoline in CA, EC, GC, LA, MW, NE, RM, WC; $\mathbf{Y_1}$= log (P_{CA})- log (P_{EC}

Figure 3- [6]

Figure 4- Plot of gasoline log price differential in different regions of US based on the regional gasoline infrastructure



[6] The above diagram was obtained with permission of the National Association of Convenience Stores, from the 2012 NACS Retail Fuels Report.

Table 1- Summary of ADF tests, DF-GLS tests and KPSS tests on the log differential of gasoline prices - with intercept and no trend.