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Abstract

This paper builds an econometric model of retail gas competition to explain the pricing decisions of retail outlets in terms of vertical management structures, input costs and the characteristics of the local market they operate within. The model is estimated using price data from retail outlets from the South-Eastern Queensland region in Australia, but the generic nature of the model means that the results will be of general interest. The results indicate that when the cost of crude oil and demographic variations across different localities are accounted for, branding (i.e. whether the retail outlet is affiliated with one of the major brand distributers - Shell, Caltex, Mobil or BP) has a statistically significant positive effect on prices at nearby retail outlets. Conversely, the presence of an independent (non-branded) retailer within a locality has the effect of lowering retail prices. Furthermore, the results of this research show that service stations participating in discount coupon schemes with the two major retail supermarket chains have the effect of largely off-setting the price increase derived from branding affiliation. While, branding effects are not fully cancelled out, the overall effect is that prices are still higher than if branding did not occur.

Keywords: Retail Gasoline Pricing, Vertical Restraints, Shop-a-Docket Discount Scheme, Spatial Econometrics, Australia.
JEL Classification: C21, L13

1 Introduction

This paper undertakes an empirical investigation of the determination of prices in retail gasoline markets, with a particular emphasis on the importance of spatial competition and vertical restraints. Spatial competition is taken here to mean the responsiveness of the individual retailer to neighboring outlets and also to the market space. A confounding factor in this modelling process is the role of vertical integration and restrictions in the retail gasoline market. It is well known, within the theoretical Industrial Organization literature that vertical integration and restrictions can circumvent the well known double-markup phenomenon and thereby bestow a cost advantage on firms vertically aligned with a wholesaler or refiner. Consequently the key question that needs to be addressed is how to accurately separate the impact of vertical restraints, which can lead to a relaxation in the degree of competition between firms and higher prices, from price mark-ups that are due to purely spatial effects.

The data set that used consists of retail price data for service stations located in the South-East Queensland region of Australia. This region consists of three distinct submarkets: Brisbane, and the Gold and Sunshine Coasts. The dataset comprises monthly observations on retail gasoline prices by outlet and time for a period of three years, 2006, 2007 and 2008. The time period is significant within Australia because it overlaps with the *"Inquiry into the price of unleaded petrol in Australia"* by the Australian Competition and Consumer Commission (ACCC), which was submitted on the 15 October 2007 to the Australian government. Hence the description of the Australian retail and wholesale market and its comparison with international markets contained within the report of this enquiry (ACCC 2007) is consistent with the market analysed in this study.

Service stations are broken into two distinct types: branded and independent. For the purpose of this study, any outlet owned by or vertically affiliated (i.e. a franchisee or leasee) with either Caltex, Mobil, BP or Shell (the companies which refine crude oil in Australia), is deemed to be a *branded* retailer. The *independent* retailers include operators ranging from the large independent chains (Liberty, United, Gull, 7-Eleven, Neumann Petroleum and Matilda) to small one to two-site operations. There are also independent operators that buy fuel from independent wholesalers and align themselves with that wholesalers' brand. In terms of vertical structure of this market, the majority of brand and independent retailers are either franchisees of or lease their outlet from the parent company (either Caltex, Mobil, BP, Shell or one of the large independent chains). Franchisees are independent retailers engaging in a two part pricing agreement with the parent company, while leaseholders are renting the outlet from the parent company.

In this market the interest is to test for two effects. The first is the effect on prices of being in competition with an "independent" retailer. One wishes to test whether or not prices are lower in these localities as compared to when retailers are solely aligned with one of the major brands. The second effect of interest concerns the impact that "Shop-a-Docket" discount coupons have on retail prices. Australia's two major supermarket retailers Woolworths (approximately 40%

market share) and Coles (approximately 35% market share) both operate discount schemes linked to branded petrol retails, namely, Caltex and Shell respectively. Consequently, a large number of Shell and Caltex service stations are Shell/Coles Express and Caltex/Woolworths service stations. In these retail outlets consumers possessing discount coupons attached to receipts from the Coles and Woolworths supermarket chains are eligible to receive a discount on fuel purchased. These schemes were introduced in 2005 and it is an open question as to the effect that "Shop-A-Docket" discount coupons might have on retail prices in Australia.

The results of this research indicate that branding in a spatially differentiated setting is associated with higher prices in general. Conversely, independent firms feature lower prices. It is found that if the branded retailer is a Shell/Coles Express or Caltex/Woolworths service station, and therefore a participant in the 'Shop-a-Docket" discount coupon scheme, their prices are lower than in non-participating brand outlets, but higher than would be the case if the firm were an independent outlet. The conclusion that one can draw from this study is that vertical structure of the market dictates price levels and that the behaviour of firms is entirely consistent with the predictions given from theoretical industrial organization which indicates that non-price competition in the form of branding and vertical restraints such as franchise fees and exclusive territory agreements among branded retailers lead to higher prices.

This paper is organised as follows. Section 2 provides a brief discussion of the contribution in this paper in the context of similar studies, conducted within the empirical industrial organisation literature, focusing on retail gasoline prices. Section 3 sets down the theoretical model upon which the econometric model developed in this paper is estimated. Section 4 outlines the the econometric framework along with the hypotheses to be tested empirically. Section 5 presents the dataset used and defines the variables in the econometric model. In Section 6, the results of estimation are presented and their implications discussed. In Section 7, the consequences of the results are examined in a policy setting. The final section will summarise and conclude.

2 Previous Research

In terms of similar research the paper of Hastings (2004) is of relevance to this study. Focusing on market power and vertical integration in the Southern Californian retail gasoline market, this study was based on a natural experiment regarding the acquisition of a large number of independent retail gasoline outlets in the Los Angeles and San Diego area. The Hastings model demonstrates not only that vertical integration is associated with higher prices at the retail outlet, but also that vertical integration is tied to product differentiation in terms of quality. This is consistent with Beard et al (2001) which suggests that wholesalers have an incentive to provide degraded inputs to non-aligned firms. In so doing, non-price competition is introduced into a market that would have otherwise featured a homogenous good.

However, the results of Hastings (2004), while important, do not address all the matters which

may affect pricing at the retail gasoline outlet. Specifically, accounting for factors such as the spatial interaction of retail outlets is confounded by the modelling approach adopted, in which a continuous variable is used to represent competition between vertically integrated and separated firms on the basis of a static one mile market boundary throughout the sample area. In a related study, the Federal Trade Commission (2007) found that vertical integration generally had either a small or insignificant effect on the pricing decision in the market examined by Hastings (2004). A very recent paper by Houde (2012) extends the methodology of Hastings (2004) developing a model of demand for spatially differentiated products and studying the impact of mergers with an application to gasoline markets. The findings are that gasoline sales are correlated with the distribution of work commuters more significantly than they are to the distribution of the local population. The study is based on two extensive surveys conducted in Québec City between 1991 and 2001, the first of gasoline stations and the second a transportation survey used to compute the distribution of commuting path in the market. Houde (2012) models the probability of purchasing at a given station given a commuting route. The demand at the station level is then obtained by aggregating individual choice probabilities. Houde (2012) derives a set of moment conditions and estimates the parameters of a structural model by GMM. The merger simulation conducted for the study find that small differences in the cross-section of stations can have large consequences on the estimated price change. His simulation model fails to predict a sizable price reaction from competing firms post merger, which the author speculate is linked with the distributional assumptions of consumer tastes which tends to underestimate the elasticity of substitution between close competitors.

Gugler and Clemenz (2006) and Pennerstorfer (2009) examine the problem of vertical integration using data for the retail gasoline markets of Austria. The approach used is similar to these studies, in that a method is proposed to estimate the effects of vertical integration while allowing for the effects of locational choice. The method proposed here extends the work of Gugler and Clemenz (2006) and Pennerstorfer (2009) by allowing for the effects of both input costs and the nature of the market space and provide further evidence of the effects of vertical integration. The results of Gugler and Clemenz (2006) describe the necessity of including the spatial element in the pricing decision. They conclude that retail chains may be able to artificially raise prices by co-ordinating locational choice across outlets such that they do not come into direct competition with one another.

Pennerstorfer (2009) obtains similar results, using a spatial Durbin model, modified to allow for the effects of the market space and the pricing decisions of rivals to differ between vertically integrated firms and their independent counterparts. The work of Pennerstorfer (2009) suggested that independent firms generally charge lower prices yet also have little effect on the pricing decision of the integrated outlet. Hence as will become clear, the findings in this paper are consistent with both Gugler and Clemenz (2006) and Pennerstorfer (2009). By comparison with these studies, the modelling approach used in this study is novel in the manner in which it treats interaction between

firms.

Previous investigations such as Hastings (2004), Gugler and Clemenz (2006), Pennerstorfer (2009) and Houde (2012) examined the issue of spatial interaction by making use of static market boundaries in order to define competition between outlets[1]. Rather than adopt this approach, the paper defines competition as occurring between nearest neighbours in the market space. This approach avoids any potential problems arising from the imposition of an artificial market boundary, such as the potential for mis-identification of interaction between firms due to differences between geographical boundaries and market boundaries. As a consequence, the effects of branding on retail gasoline pricing are estimated allowing for both the input costs of the firm and the manner in which the firm competes with rivals. This leads to qualitatively stronger results as will become apparent.

As previously stated, the main result from this research is that branding leads to higher prices at service stations. Specifically, it is found that branding is associated with a 0.8-1 cent increase per litre in the average monthly price of retail gasoline. A similar result has been shown in Hastings (2004), which describes the impact of a vertical merger, where a vertically integrated chain merged with a chain of vertically separated retailers. In this paper it was shown that a take over of an independent chain by a brand retailer led to higher retail prices in among service station outlets in San Diego and Los Angeles. Hence, the price change that was reported, could have been either a consequence of the change in the vertical structure of this market or a result of increased concentration as a consequence of the merger. By contrast results in this study show a difference in prices purely as a consequence of affiliation with a brand. This means that a consumers can expect to pay a lower price if they were to purchase fuel from an independent or non-branded retailer.

While this brand mark-up may at first seem insignificant, it accrues directly to the brand wholesaler - in this case Shell, Caltex, Mobil and BP. When viewed from this perspective, this insignificant mark-up accrues to a significant transfer of wealth due to the inelastic nature of demand and the staple quality of the good. This amount may be even larger, when accounting for the fact that many of these brand retailers are franchisees and as such will be subject to franchise fees that will transfer a larger portion of revenue to wholesalers. Furthermore, these results are entirely consistent with the theoretical literature on vertical restrains, in particular research by Rey and Stiglitz (1995, 1988) and Bonanno and Vickers (1988) that show prices will be substantially higher under franchise fee arrangements than under a price setting oligopoly.

[1] A static market boundary is defined here as a market boundary defined by a fixed distance for all firms, such as the boundaries of a suburb or distance by surface road. In Australia a 'suburb' refers to a geographical subdivision of the city.

3 The Theoretical Model

There are four business structures that prevail for retail sites in Australia: owner-operated, commission agent, franchise operated and the supermarket alliance arrangements. At owner-operated sites, the owner of the site determines the retail price. In the case of sites that are branded with one of the refiner-marketers, such owners may also have agreements with their supplier that include providing price support to the owner-operator. At commission agent sites, a site is managed on behalf of another organisation, typically a refiner- marketer or larger independent chain. At such sites, the retail price will be set by the owner and communicated to the commission agent on a regular basis. At franchise-operated sites, the operator rents a site or number of sites from a refiner-marketer and operates under a franchise agreement, under which fuel will generally be sourced from the owner. While the franchisee may be responsible for setting the retail price, the wholesale price is generally determined by the refiner-marketer and communicated to the franchisee and, in addition, the refiner-marketer may influence retail prices through providing price support. Price support is an important mechanism through which some refiner-marketers control prices set at retail at these sites.

For retail sites participating in supermarket alliance arrangements, the contractual agreements depend on whether the outlet is part of the Woolworth or Coles operated discount scheme. The majority of supermarket alliance operators are in a franchise arrangement with their participating refiner/marketer (Caltex for Woolworths and Shell for Coles). Woolworths routinely offers a four cents per litre discount on the price of fuel to customers who present a voucher which is obtained when a purchase of $30 or more is made at a Woolworths or Safeway supermarket, a Big W store or other Woolworths subsidiaries. From time to time, Woolworths offers a greater discount on gasoline to customers who have purchased a minimum value of goods from a particular retailer within the Woolworths Group. All gasoline sold at these outlets is owned by Woolworths and around 60 per cent of transactions of fuel involve a shopper docket. When setting gasoline prices, Woolworths' policy is to match the lowest price in the local area. Woolworths submitted to the ACCC that the price of fuel at any Woolworths' site is not dependent on the shopper docket scheme. However, Woolworths advised the ACCC that it does engage in retail price maintenance by identifying the minimum acceptable price (ACCC (2007) pp 181-182).

For Coles Express outlets a four cents per litre discount is offered on the price of gasoline to customers who have purchased a minimum value of $30 of goods or services from Coles' supermarkets or other companies in the Coles Group. Occasionally Coles Express offers special promotions above the standard four cents per litre discount. Coles Express funds one cent of the four cents per litre discount while the remaining three cents are funded by the business (such as Coles Supermarkets, K Mart or Officeworks) that elects to offer a shopper docket promotion. If the business elects to offer an additional discount above four cents per litre it funds the additional cost of the promotion. The management team of the business treats the shopper docket scheme as a promotional

option in the same category as a catalogue or TV advertising. Interestingly, Coles submitted to the ACCC that, at the commencement of the alliance, 60 per cent of alliance revenue came from fuel sales while 40 per cent came from sales in the convenience store located in the service station. Over time, revenue from convenience stores has grown so that it now represents about 50 per cent of the alliance's revenue. To illustrate the importance of convenience stores, Coles advised that it offers an additional two cents per litre discount associated with minimum purchases from its service stations convenience stores.

Bonanno and Vickers (1988) and Rey and Stiglitz (1988, 1995) have shown, for the two firm case, that under price competition when spatially differentiated, equilibrium retail prices will be substantially higher than marginal costs, under franchise fee agreements, provided a franchise fees can be used to extract retailers' surplus. The conditions required are price competition (i.e. strategic decisions are complementary) and that the goods sold by retailers are close substitutes (such as in the model presented here). The condition is required because it flattens the demand curve and reduces the effect of double marginalization - hence there is negligible difference between prices of vertically integrated and vertically separated retailers as retailers co-locate. Profits are highest when exclusive territories are combined with wholesalers charging franchise fees, the idea being that retail outlets of the same distributor free ride off one another, and as such should not locate near each other (as shown in Mathewson and Winter (1984)). This is the model that will be followed in this paper. The demand equation is derived from the following model of consumer preferences by an application of Roy's Identity:

$$U(Q_{1t},\ldots,Q_{Nt}) = \mathbb{A}_{it}\sum_{i=1}^{N} Q_{it} - \frac{n_i}{2(1+\gamma)}\left[\sum_{i=1}^{N} Q_{it}^2 + \frac{\gamma}{n_i}\sum_{j\neq i}^{N} w_{ij}Q_{it}Q_{jt}\right] \tag{1}$$

where Q_{it} denotes the quantity demanded of gasoline; $\mathbb{A}_{it}$ captures demand shifters such as consumers' willingness to pay, branding and use of dockets; γ measures the degree of product differentiation; and n_i is the number of firms competing against firm i within its neighbourhood. In the above utility model and the derived demand equation the degree of spatial dependence between outlets is captured using spatial weights, ω_{ij}, which relate outlet i to its spatial neighbours j where $j = 1, 2, \cdots, N$. The weights are defined as

$$\omega_{ij} = \begin{cases} 1 & \text{if } i\text{and } j\text{are neighbours} \\ 0 & \text{otherwise.} \end{cases}$$

The normalizing constant $n_i = \sum_{j=1}^{N} w_{ij}$ gives the number of firms competing against firm i within their neighborhood, and $n_i << N$.

The demand function for each outlet at time t will be given by:

$$Q_{i,t} = f(P_{it}, P_{-it}, \mathbb{A}_{it}, n_i) \tag{2}$$

where P_{it} is the price of gasoline at outlet i and time period t, P_{-it} is the price of gasoline at neighbouring outlets, $\mathbb{A}_{it}$ is a vector of variables that includes indicators of whether outlet i is a Caltex, Mobil, BP or Shell (*Branding*) and a Shell/Coles Express or Caltex/Woolworth station (*Docket*), a vector of explanatory variables capturing the willingness to pay of the consumers in the neighbourhood of i at time t, and a vector of explanatory variables measuring the car dependence of consumers and other characteristics of the market space in the neighbourhood of firm i at time t (the specific variables included are discussed in detail in Section 4). And, $f()$ is linear given (1).

The demand and utility equations model two stylised facts that are observed in the retail gasoline market. The first stylised fact is the persistence of branding for what is essentially a homogenous good. Within Australia, competition between service stations is based on the pricing of premium unleaded gasoline, which is what the majority of vehicle owners purchase. Although there are differences in the mix of this fuel provided by the major refiners, there would seem to be little definable difference between these products for the average consumer. Yet despite this, branding persists even to the extent that there is a proliferation of minor branded outlets. The second fact is the persistence of co-location of rival service stations. Seen from the perspective of this demand equation, the branding/location effects associated with each of the retailing outlets are sunk costs paid by the wholesaler, from which retailer draws proportional benefits. Co-location affords retailers the ability to free ride off the collective marketing efforts of other service stations located nearby regardless of their brand affiliation.

It is assume that each firm's marginal cost function is a linear function $C_{it} = \phi^T c_i$ of a vector of cost factors c_i, which include items such as wages, whole prices on other items sold on the premises, the whole price paid on fuel and rental charges on facilities. In addition the firm pays a franchise fee F_i to the refiner/distributor with which it is aligned. Taking the pricing decisions of the other outlet as given, the pricing decision of the ith retail outlet at time t looks like this:

$$\max_{p_{i,t}} \left(P_{it} - \phi^T c_i\right) Q_{i,t} - F_i \quad i = 1, \ldots, n_i. \tag{3}$$

The first order maximizing condition leads to the following reaction function for firm i at time t:

$$P_{it} = g(C_{it}, P_{-it}, \mathbb{A}_{it}) \quad i = 1, \ldots, n_i. \tag{4}$$

Note that symmetry is not imposed. The symmetry assumption is equivalent to assuming that all retailers within an area are identical, which implies that they must have identical vertical structures, which is not consistent with the market structure in Australia where the majority of service station operators are franchisees either of a chain supplied by a major refiner or of one of the minor distributors (ACCC, 2007).

4 The Econometric Model

Based on the previous theoretical discussion, an econometric model is formulated in order to assess the effects of branding and shop-a-docket and test a series of hypotheses on the effects of the market space on retail gasoline pricing. These will include the effect of demographic factors and willingness to pay.

The data contains firms that are either branded or independent (i.e. either owned by or contractually affiliated with the refiner) or independent outlets. They are price takers in the input market (price of crude oil), an assumption justified by the fact that many of the large distribution chains claim that the price they face is a reflection of the world's oil price (spot price). On the demand side the firm faces a set of local demographic characteristics as well as spatial interactions with competing outlets.

Due to the quadratic utility function, the price reaction function in (4) is linear (see Sing and Vives (1984)). A consistent econometric model is a Spatial Durbin Model (SDM) which takes the form:

$$\begin{aligned} P_{it} &= \beta_0^* + \sum_{k=1}^{2} \beta_k^* \mathbb{B}_{it} + \beta_3^* C_{it} + \rho \sum_{j=1}^{N} \omega_{ij} P_{jt} + \sum_{k=1}^{M} \theta_k^* \mathbb{W}_{ikt} + \sum_{k=1}^{R} \vartheta_k^* \mathbb{D}_{ikt} \\ &\quad + \sum_{k=1}^{2} \sum_{j=1}^{N} \alpha_k \omega_{ij} \mathbb{B}_{jkt} + \sum_{k=1}^{M} \sum_{j=1}^{N} \phi_k \omega_{ij} \mathbb{W}_{jkt} + \sum_{k=1}^{R} \sum_{j=1}^{N} \varphi_k \omega_{ij} \mathbb{D}_{jkt} + u_{it}, \end{aligned} \tag{5}$$

where P_{it} is the price of gasoline at outlet i and time period t. Gasoline prices are measured in one two ways, either as the average monthly price of unleaded gasoline or as the mark-up price on global average monthly price. $\mathbb{B}_{it}$ is a vector of two control variables indicating whether outlet i is a Caltex, Mobil, BP or Shell (*Branding*) and a Shell/Coles Express or Caltex/Woolworth station (*Docket*). C_{it} is the input cost faced by firm i in time period t. $\mathbb{W}_{it}$ is a $(M \times 1)$ vector of explanatory variables measuring the willingness to pay of the consumers in the neighbourhood of i at time t. $\mathbb{D}_{it}$ is an $(R \times 1)$ vector of explanatory variables measuring the car dependence of consumers in the neighbourhood of firm i at time t. The specific variables in $\mathbb{W}$ and $\mathbb{D}$ are detailed in the next section, and $u_{it} \sim N(0, \sigma_u^2)$. The parameter ρ governs the strength of the dependence of outlet price i to the price of its neighbours. The specification in equation (5) imposes the restriction that the effects of each of these demand side variables on the price of firm i is the same for all nearest neighbours. Equation (5) can be thought of as the reaction function for the ith firm, where ρ is the slope of firm i's reaction function and therefore it provides an insight into the interactions of firms in the sample. The parameters $\beta^* = \{\beta_1^*, \beta_2^*\}$, $\theta^* = \{\theta_1^*, \cdots, \theta_M^*\}$ and $\vartheta^* = \{\vartheta_1^*, \cdots, \vartheta_R^*\}$ are the instant effects on price in outlet i of the branded effect, willingness to pay and car dependence, respectively, of consumers in area i without accounting for the spatial effects. The parameters

$\alpha = \{\alpha_1, \alpha_2\}$, $\phi = \{\phi_1, \cdots, \phi_M\}$ and $\varphi = \{\varphi_1, \cdots, \varphi_R\}$, are the instant strategic effects on price in outlet i of branded effect, the willingness to pay and car dependence, respectively, of consumers in the neighbouring areas j. Note that imposing the restrictions $\alpha = \phi = \varphi = 0$ has the effect of reducing the spatial Durbin model to a simple spatial autoregressive (SAR) model.

To be informative about spatial competition, however, the econometric model must capture the interaction between locational choice and pricing. To capture spatial interactions between competitive outlets it is necessary to set up spatial weights, ω_{ij}, which relate outlet i to its spatial neighbours j where $j = 1, 2, \cdots, N$. These spatial weights are generated using a Delaunay decomposition as described in LeSage and Pace (2009) and the matrix of spatial weights is normalised so that for each i $\sum_{j=1}^{N} w_{ij} = 1$.

The direct approach to estimating the effects of spatial competition are obtained by estimation of a SDM. However, the marginal effect of explanatory variables, C_t, $\mathbb{B}_t$, $\mathbb{W}_t$ and $\mathbb{D}_t$, (i.e. $\partial P_i/\partial x_k$ where x is the kth regressor in the SAR or SDM model), is a function of ρ and the corresponding parameters from β^*, θ^*, ϑ^*, α, ϕ, and φ. These marginal effects are reported using their definition of *average (over space) direct effect* from LeSage and Pace (2009), which are defined as follows:

$$\frac{\partial P}{\partial x_k} = N^{-1} trace(S_k(W))$$

where,

x is a regressor, C, or in vectors $\mathbb{B}$, $\mathbb{W}$ or $\mathbb{D}$

$\partial P_i/\partial x_{jk} = S_k(W)_{ij}$ is an element of $S_k(W)$

$S_k(W) = (I_N - \rho W)^{-1}(I_N \beta_k^* + W\alpha_k)$ for the kth variable in $\mathbb{B}$, and others are defined similarly.

These are the effects of a one unit change in the given independent variable on the dependent variable accounting for the spatial interaction amongst neighbours. They are the comparable marginal effects to those obtained when the model has no spatial lag. The use of a reaction function to estimate the effects of branding is particularly important in the retail gasoline context, as it is suggested throughout the theoretical literature that the effects of branding may revolve around its effects on those outside the branding structure as much as on those inside it (Beard et al, 2001). It is necessary, therefore, to ascertain the effect of interaction between firms in a very explicit sense for any effect of branding to be coherent.

A less direct approach to the question of spatial correlation is to propose a functional form for a spatially correlated disturbance term. In this approach both the reaction function of firm i with respect to the prices of neighbours j and the effect of demand conditions in area j on the price of firm i are omitted from the specification in favour of a spatially correlated structure. The spatial

errors model (SEM) is given by

$$P_{it} = \beta_0 + \sum_{k=1}^{2} \beta_k \mathbb{B}_{it} + \beta_3 C_{it} + \sum_{k=1}^{M} \theta_k \mathbb{W}_{ikt} + \sum_{k=1}^{R} \vartheta_k \mathbb{D}_{ikt} + \epsilon_{it}, \quad (6)$$

$$\epsilon_{it} = \lambda \sum_{j=1}^{N} w_{ij} \epsilon_{jt} + u_{it}\,, \quad (7)$$

where $u_{it} \sim N(0, \sigma_u^2)$. In this model, the parameter λ reflects the spatial correlation between the prices of rivals but will also reflect the correlation due to omitted variables as well.

In addition, the SEM specification allows for several other insights into the nature of competition between firms. By estimating a spatial interaction in the unobserved error, the degree to which unobserved shocks at one retail gasoline outlet affect the price setting of another is assessed. A higher value for the correlation coefficient in this instance would therefore be indicative of greater homogeneity between firms. This in turn gives greater insight into the setting within which branding has taken place, as homogeneity among firms under branding may lead more towards an exercise of market power than toward gains in efficiency.

The primary hypothesis of interest is whether or not the parameter controlling spatial competition, namely ρ in the case of the SDM and SAR models and λ in the SEM model, is statistically significant. There are also a number of secondary hypotheses of interest that are summarised in Table 1. The specific variables included in the econometric model and hypotheses testing are defined in the next section.

Table 1: Hypotheses to be Tested

Coefficients Restricted in (6)	Hypothesis Tested
$\beta_1 = \beta_2 = \beta_3 = 0$	Cost Function Specification
$\theta = 0$ ($\theta^* = 0$ and $\phi^* = 0$)	Effect of Willingness to Pay on the Price of Retail gasoline
$\vartheta = 0$ ($\vartheta^* = 0$ and $\varphi^* = 0$)	Effect of Car Dependence on the Price of Retail gasoline

5 Data

The sample area of South Eastern Queensland consists of three distinct submarkets, namely the city of Brisbane and the urban agglomerations of the Gold Coast and Sunshine Coast. The data and sources are described fully in Appendix A.

The dataset comprises monthly observations on gasoline prices by outlet and time for a period of three years, 2006, 2007 and 2008. The outlets in the sample area are distributed as shown in Figure 1. The figure shows both the location of each retail gasoline outlet and its average price throughout the sample period. The grey average price scale shown on the right of the map provides initial evidence that there is no significant difference in pricing between the three sub-regions of the

sample space. As each observation of the retail pricing decision is a monthly average, the effects of the intra-weekly price cycle do not occur in the model estimated here.

Two alternative dependent variables are considered in the study. The first is the average price of gasoline at outlet i and month t. The second is the mark-up price on the monthly market average. The mark-up price is defined as

$$P_{it}^{m} = P_{it} - \frac{1}{N}\sum_{j=1}^{N} P_{jt} \tag{8}$$

where P_{it} is the average monthly price for outlet i; $\frac{1}{N}\sum_{j=1}^{N} P_{jt}$ is the average monthly price over the market. This variable reflects the outlet's markup above the market. The use of two different dependent variables is designed to evaluate the effects of branding on competition between firms. The model of average price measures the effect of branding on the outlet's pricing decision, while the mark-up model provides the effect on pricing deviations in the market examined.

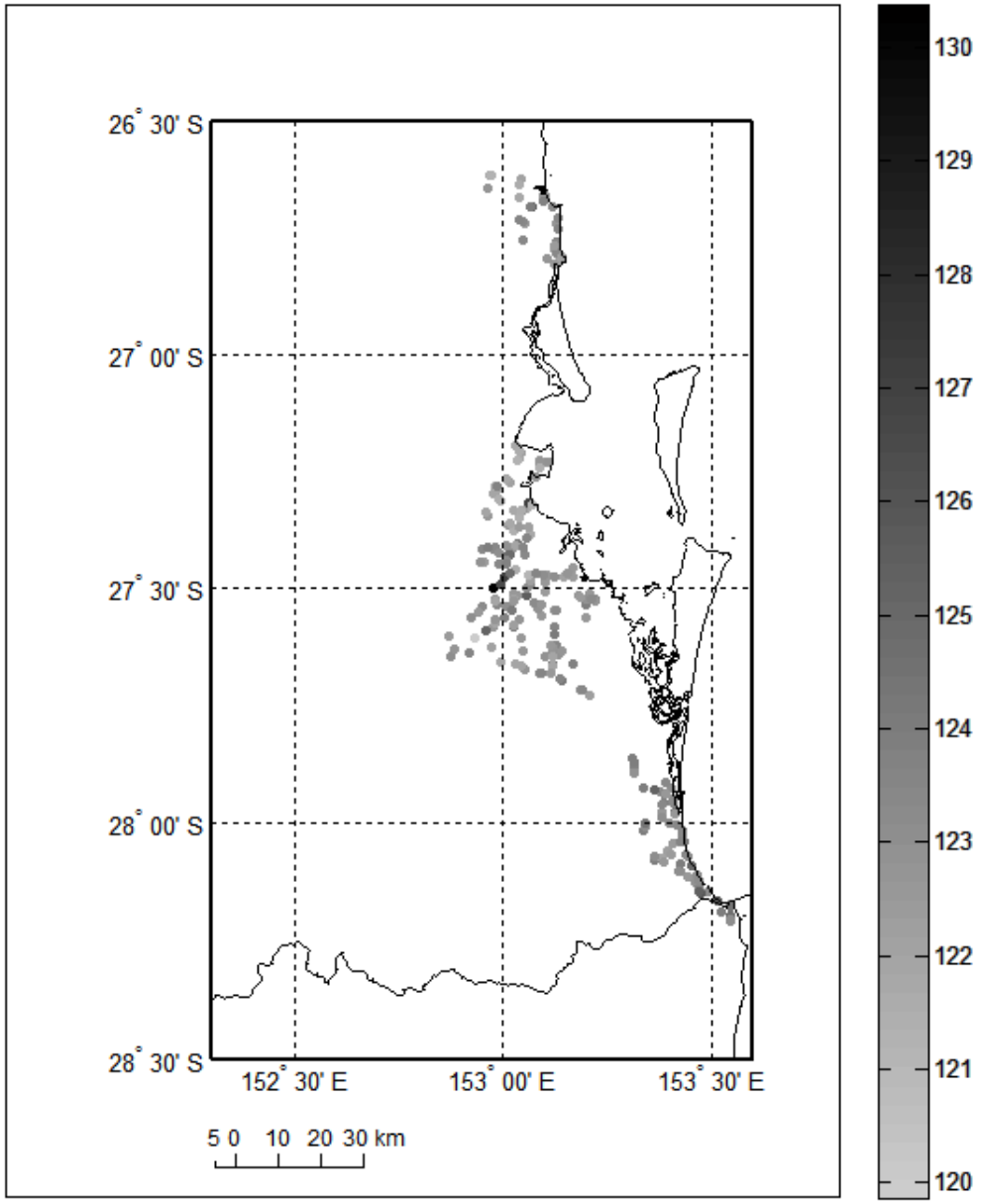

Figure 1: Dispersion of Retail gasoline Outlets Throughout South-East Queensland

Matched to each price observation for each outlet is the latitude and longitude coordinates of the outlet. The geographical coordinates of each outlet are necessary for several reasons. First, the knowledge of each outlet's location made it possible to identify the nearest neighbours of each firm, thus enabling the use of spatially-weighted estimation. Second, the locational information was used to align the dataset of pricing observations with a second dataset containing census information for each suburb in the market space. By matching each observation to census data for

its location in the market space the effect of the market space on the pricing decision, both at the local firm and its competitors can be assessed.

To describe the pricing decision of the firm in terms of its costs, data available from the US Energy Information Administration which gives the weekly spot price for Tapis crude oil are used. This choice is based on the report by ACCC (2007). Crude oil is the major input cost into gasoline refining, around 60 per cent of crude oil used in Australian refineries is imported, and the crude oil market in Australia is Tapis crude oil (a light, sweet crude produced in Malaysia). The Platts Tapis price quote is the representative regional crude oil price marker and is based on the average of prices for cargoes loading 15 to 45 days in the future. The observation for the first week of each month for the period 2006-2008 was included with a one-month lag to reflect the delays involved in re-negotiating supply contracts.

By using the branding information for each outlet, a dummy variable, which reflects the presence or absence of branding management structures at each outlet in the sample, is constructed (BRANDING). For the purpose of this study, any outlet owned by either Caltex, Mobil, BP or Shell (the companies which refine crude oil in Australia) is deemed to be branding. In addition a dummy variable (DOCKET) captures those outlets that are part of the shop-a-docket scheme with the two major supermarket chains (Coles and Woolworth). The dummy takes a value of 1 if the outlet is a Shell/Coles Express or a Caltex/Woolworth station.

The demographic controls in the econometric model (5) are willingness to pay by consumers, $\mathbb{W}_{it}$, and dependence on cars, $\mathbb{D}_{it}$. The percentage of the aboriginal population, ABORIGNAL, the working age population, AGE, Australian born population, AUS, and unemployed, UNEMP, are measures of the willingness to pay. This is based on the assumption that willingness to pay is affected by the employment prospects and socio-economic status of the consumer. The variables included in the measurement of car dependence on the price of gasoline, generally reflect the fact that as the market space becomes more densely populated, other transport alternatives are likely to become available, thus lessening the dependence on car-based transport. Therefore, the estimated resident population, ERP, average number of persons per dwelling, PPD, and the number of households with two or more cars, CARS, are included.

Formal tests for the null of no differences in the mean average price as well as the variance across the sub-markets were conducted using standard Z and F tests. The null of no statistical differences in the mean prices cannot be rejected although the variances are statistically different[2]. This provides a basis for the mark-up variable used in estimation (defined in (8)) and also provides some evidence regarding the nature of price-setting in the sample area. This result also indicates that transport costs are not a significant input into the retailer's pricing decision.

The descriptive statistics for the entire sample are shown in Table 2. From these statistics, several conclusions can be drawn. First, the mean of the *Branding* variable indicates that more than half of the outlets in the sample are owned by the wholesaler. The prices for the sample

[2]These results are not reported but are available from the authors on request

split into branded and independent stations are also shown. On average, branding is correlated with higher prices in the sample. The effect is however relatively small: approximately 0.7 cents per litre. This provides an expectation for the branding variable in the model, namely that there should be a positive and small effect.

Table 2: Summary Statistics of the Dataset

Variable	Minimum	Maximum	Mean	Std. Deviation
Average Price	94.50	161.20	123.05	13.31
Average Price (2006)	98.30	136.60	117.01	8.05
Average Price (2007)	101.90	137.90	117.54	6.64
Average Price (2008)	94.50	161.20	134.61	14.90
Average Price (Independent)	94.90	158.30	122.80	13.29
Average Price (Branded)	94.50	161.20	123.54	13.34
Caltex, Mobil, BP or Shell (BRANDING)	0.00	1.00	0.64	0.48
Shop-A-Docket (DOCKET)	0.00	1.00	0.31	0.46
Tapis	57.47	148.60	85.01	23.03
Percentage of the Population Identifying as Aboriginal and/or Torres Strait Islander (ABORIGINAL)	0.00	0.11	0.02	0.01
Percentage of the Population that is of Working Age (AGE)	0.53	0.87	0.64	0.05
Percentage of the Population Born in Australia (AUS)	0.39	0.83	0.71	0.08
Percentage of the Population who are Unemployed, or not in the Labour Force (UNEMP)	0.10	0.81	0.28	0.08
Estimated Resident Population (ERP)	29.00	25203.00	9092.29	5227.91
Percentage of Households Owning 2 or More Motor Cars (CARS)	0.11	0.84	0.45	0.14
Average Number of Persons Per Dwelling (PPD)	0.77	8.75	2.38	0.61

In addition to this information for the pooled sample, descriptive statistics for the retail price of gasoline for the sub-markets and each year in the sample are provided in Table 3. The average price of retail gasoline varies with time and both the mean and standard error in gasoline prices increased significantly in 2008. Several plausible explanations may exist for this. The simplest of these suggests that the sample covers the period leading up to and including the disruption in global financial markets of 2008.

The effect of this on retail gasoline prices should be noticeable through changes in the price of Tapis crude oil. Figure 2 shows that the relationship between the retail price of gasoline and Tapis crude oil appears to be stable over the sample period. This justifies the use of the price of Tapis crude oil as a proxy for the input costs of the retail firm. It is also noticeable that the margin between the retail price of gasoline and the price of Tapis crude oil narrowed as the price of

Table 3: Average Retail Gasoline Price for the Regions of South-East Queensland by Year

	Year		
Region	2006	2007	2008
Gold Coast	117.04	118.10	135.44
Brisbane	116.96	117.33	134.32
Sunshine Coast	116.96	117.02	134.30

Tapis crude oil increased. This may imply that wholesale costs are not completely passed onto the consumer. One potential reason for this may be that local market constrains the exercise of market power on the part of the wholesaler, limiting their ability to pass on cost increases to consumers. This will be examined more thoroughly in the next section.

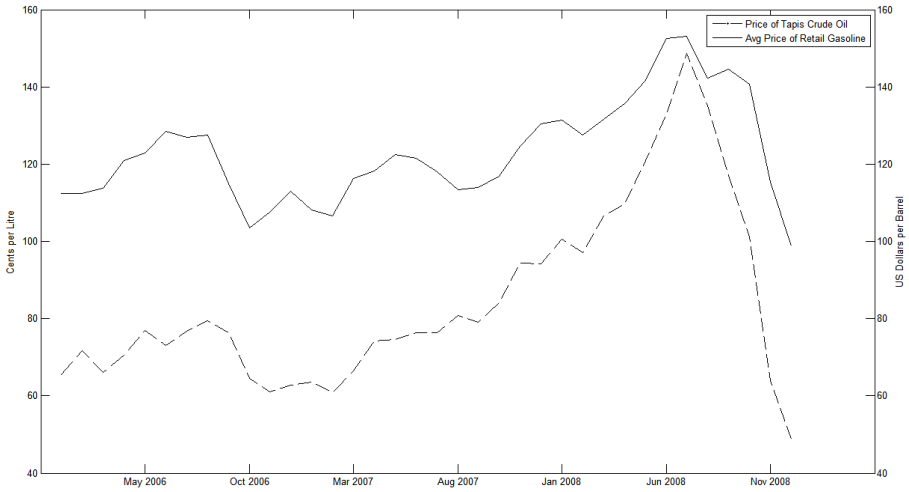

Figure 2: Correlation Between the Market-wide Average Price of Retail Gasoline and the Price of Tapis Crude Oil

6 Estimation and Results

In order to establish the effect of the market space on retail gasoline pricing and test the hypotheses stated in Section 4, four models are estimated. These are: the baseline model without any spatial interactions; the spatial Durbin model in equation (5); the simple spatial autoregressive model, which is a restricted version of the the spatial Durbin model; and the spatial error model in equation (6). All estimation was conducted using Matlab and functions from the Spatial Econometrics Toolbox LeSage and Pace (2009) which were modified as required for the model specification.

To allow for the possibility of seasonality as well as account for the overall trend over the three years, a number of deterministic components are added to the model. These are monthly dummy

variables and interacted with dummy variables for the years 2007 and 2008. Enough of these deterministic terms were statistically significant to indicate that the model would be significantly misspecified without their inclusion.

Table 4 reports the results for the estimation when the average monthly price of unleaded gasoline is the dependent variable and Table 5 reports the results when using mark-up price as the dependent variable. The variable reflects the outlet's mark-up above the market average as per equation (8).

Table 4: SAR, SEM and SDM Estimation Results for the Average Monthly Price of Retail gasoline

	Model Specification				
Variable	No Spatial Effects	SEM	SDM Effects		
			Instantaneous	Strategic	Average Marginal
Branding	0.790***	1.015***	0.700***	-0.483***	0.802
	(0.131)	(0.052)	(0.038)	(0.098)	
Docket	-0.681***	-0.561***	-0.551***	0.598***	-0.502
	(0.133)	(0.034)	(0.040)	(0.116)	
Tapis	0.623***	0.627***	0.036***	NA	0.055
	(0.005)	(0.026)	(0.001)	NA	
Aboriginal %	-5.338	12.017***	9.989***	-28.982***	-1.373
	(5.671)	(1.953)	(1.980)	(3.511)	
Age %	2.717	0.963	0.973*	-0.040	1.483
	(1.509)	(0.652)	(0.517)	(0.983)	
Aus %	0.085	1.151***	1.294***	-0.954*	1.449
	(0.834)	(0.379)	(0.352)	(0.504)	
Unemp %	0.416	-0.744	-0.821*	2.220***	0.019
	(1.077)	(0.535)	(0.499)	(0.678)	
ERP (in thousands)	7E-03	6E-03	4E-03	2E-03	8E-03
	(1E-02)	(4E-03)	(4E-03)	(7E-03)	
Cars %	0.553	2.065	1.737***	-3.925***	0.409
	(0.929)	(0.384)	(0.363)	(0.572)	
PPD	-0.528***	-0.677***	-0.570***	1.178***	-0.198
	(0.171)	(0.067)	(0.063)	(0.110)	
Spatial Parameter	0	0.941***	0.943***		
R^2	0.860	0.989	0.859		
Log Likelihood	N\A	-13733.714	-13693.271		
LM-SEM	12334.66				
	p-val=0.00				
LM-SAR	13578.90				
	p-val=0.00				
LR H_o: SAR; H_1: SDM$^{(b)}$	248.64				
	p-val=0.00				

$^{(a)}$ See equation **??**

$^{(b)}$ SAR is nested in SDM, The restriction is rejected and thus SAR estimates are not shown

The model without spatial effects is estimated by least squares and its residuals are used to test for no spatial effects against the alternatives of spatial errors (LM-SEM) and spatial lag (LM-SAR) effects. The null is rejected in both cases. The likelihood ratio for the null that there are no strategic effects in the model and therefore a SAR model is a valid specification is rejected in favour of the SDM.

The estimate of the spatial correlation parameter in the SEM model indicates that neighbouring

firms tend to experience unobserved shocks in a very similar fashion, supporting the notion that firms in this market tend to be homogenous. The estimated coefficient of the BRANDING variable is significant and positive in all specifications. It can therefore be drawn from these results that not only does BRANDING appear to lead to significant increases in the average monthly price of retail gasoline, but also that the nature of the firms in the market would predispose them to collusive activity. Further, the degree to which branding leads to higher prices in this market does appear to be significantly influenced by the nature of the market space. The effect of the Shop-A-Docket scheme is interesting and in line with Gans and King (2004) conclusion that rival gasoline retailers, rather than supermarkets, had the most to lose. This is also in line with the submissions made to the ACCC (2007, p.187) by BP, Mobil and the leading independent chains, all of whom stated that the Shop-a-Docket scheme impacted their volume of sales. This would be an explanation for the effect that the docket schemes had on prices, as the easiest way to increase sales volume in nearby outlets would be the lower prices. While the marginal effect of branding results in a significant increase of between 0.8 to 1 cents, the docket scheme produces an offset of 0.5 to 0.6 cents depending on the specification used. It is also interesting to note that the average marginal effects come from a combination of significant strategic effects captured in the SDM specification by the interaction of demographic characteristics of the market space with the regressors. The time effects (not shown) are significant for some months of the year indicating there might be some systematic seasonality in the prices. Interestingly 2008 does not appear to be statistically different from 2006 although the average price was higher.

The re-estimation of the above models using the average monthly mark-up as the dependent variable, Table 5, shows relatively similar results with the exception of the time fixed effects. This would indicate that the decision to mark prices up is time-invariant. Further, the spatial correlation coefficient in each of the spatially augmented models estimated here is dramatically lower when estimated using the mark-up variable. This indicates that the decision to mark prices up above the market average is driven less by the decisions of rivals than the nature of the market space. In turn, this suggests that locational choice does affect pricing. The shop-a-docket scheme shows no significant strategic effects, although the overall effect on the mark-up is still significant and negative. The strategic effects are highly significant for most variables.

The statistical insignificance of the time fixed effects and the TAPIS variable in the model for mark-up are consistent with the hypothesis that the decision to mark up is dependent on the characteristics of the market space rather than the need to pass on costs to the consumer. This result is stronger when considering that the estimate of the spatial correlation coefficients are much lower than those in the previous model. Thus, while the decision to mark up is to some extent dependent on the actions of neighbouring firms, the retail gasoline outlets in this market tend to mark prices up more in response to their own cost and demand pressures. Branding is to some extent isolated from the effects of competition between firms.

Using the estimates from the models in Table 4 the hypotheses stated in Table 3 are tested. The

Table 5: SAR, SEM and SDM Estimation Results for the Mark-up on the Global Average Monthly Price

Variable	Model Specification				
	No Spatial Effects	SEM	SDM Effects		
			Instantaneous	Strategic	Average Marginal
Branding	0.791***	0.704***	0.780***	0.268***	0.832
	(0.040)	(0.035)	(0.037)	(0.098)	
Docket	-0.681***	-0.594***	-0.647***	-0.156	-0.670
	(0.041)	(0.036)	(0.039)	(0.116)	
Tapis	0.000	2E-04	0.000	NA	0.000
	(0.002)	(0.003)	(0.001)	NA	
Aboriginal %	-5.338***	3.838**	7.584***	-39.740***	4.389
	(1.741)	(1.797)	(1.944)	(3.459)	
Age %	2.717***	2.156***	1.277**	1.848*	1.484
	(0.463)	(0.468)	(0.507)	(0.975)	
Aus %	0.085	0.715**	1.018***	-0.992**	0.968
	(0.256)	(0.288)	(0.345)	(0.495)	
Unemp %	0.416	-0.093	-0.608	3.139***	-0.356
	(0.331)	(0.389)	(0.490)	(0.668)	
ERP (in thousands)	-7E-03**	3E-03	2E-03	-2E-02***	0.000
	(3E-03)	(3E-03)	(4E-03)	(7E-03)	
Cars %	0.553*	1.418***	1.572***	-4.038***	1.276
	(0.285)	(0.311)	(0.357)	(0.568)	
PPD	-0.528***	-0.648***	-0.512***	1.041***	-0.440
	(0.053)	(0.055)	(0.061)	(0.109)	
Spatial Parameter	0	0.462***	0.421***		
R2	0.096	0.230	0.144		
Log Likelihood	N\A	-12588.637	-12436.978		
LM-SEM	12334.66				
	p-val=0.00				
LM-SAR	13578.90				
	p-val=0.00				
LR H_o: SAR; H_1: SDM[(b)]	284.37				
	p-value=0.00				

[(a)] See equation 5

[(b)] SAR is nested in SDM, The restriction is rejected and thus SAR estimates are not shown

Table 6: Significance Tests for Profit Decision and Market Space Hypotheses in Spatially Augmented Models

Hypothesis	No Spatial Effects	Critical Value	SEM	Critical Value	SDM	Critical Value
Cost Function Specification	4944.66	2.61	739.84	7.82	791.46	11.07
Willingness to Pay	8.32	2.61	130.72	7.82	177.50	12.59
Car Dependence	3.12	2.37	42.358	9.49	135.89	15.51

results of these tests are given in Table 6. In all cases, the proxy for the costs of the firm, measured by variables of TAPIS and BRANDING and DOCKET are significant. Demographic characteristics do play a role in the determination of the average monthly price of gasoline regardless of model specification. In the non-spatial effects framework the willingness to pay of the consumer is not statistically significant in determining average retail price; however, once spatial interactions of firms are taken into account the effect is indeed significant.

A number of robust conclusions emerge from the results reported in Tables 4 and 5. Foremost among these is that branding in a spatially differentiated setting is associated with higher prices. When interaction is assumed to be through spatial interaction in both the price and exogenous demand drivers (SDM), the effect is approximately 0.8 cent in magnitude. When the spatial correlation is modelled in the unobserved error (SEM), the effect of branding is an increase in the monthly retail price of approximately half a cent as shown in Table 4.

The spatial interaction represented by the SDM is of interest in this regard because it includes not only spatially dependent variables (price data for competing retail outlets at other locations), but also demographic information for each suburb in the market area. By matching outlets to their suburbs, the modelling in this study is able to control for the effect of local market differences on the pricing decision of firms located in that suburb. Hence the reaction functions estimated as an SDM model capture the Hotelling and co-location effects discussed in Sections 2 and 3.

The results of the SDM model indicate that pricing of service stations is sensitive to the demographic of consumers located in the vicinity of it and rival outlets. This would suggest that prices are higher due to some form of tacit collusion. Anecdotal evidence of the dominant practice of billboard pricing would support this conclusion, as the ability to signal strategic decisions is a necessary condition for the existence of such behavior. The SEM reaction function is important in identifying whether this behavior occurs. The SEM reaction function shows the effect of spatial correlation in the differences between prices. Athey et al. (2004) show, through a theoretical model, that price rigidity (as identified by low price variance) is closely associated collusion in a repeated game. The strongly correlated errors, as would be typified under Bertrand pricing and low variance, suggests the presence of tacit collusion as argued in Athey et al. (2004).

7 Conclusion

In this paper an econometric model of retail gas competition is built that purports to explain the pricing decision of the retail outlet in terms of managerial structures, the input costs of the retail firm and the characteristics of the market it operates within. The results obtained indicates that the effect of branding on the average monthly price of retail unleaded gasoline is positive and approximately 0.8 - 1 cent in size depending on the model specification. The model is estimated using data relating to the retail gasoline markets of South-East Queensland but the generic nature of the model means that the results will be of general interest.

The results indicate that both local effects, such as the demographic characteristics of each locality where service stations are situated, and global effects, namely input costs represented by the price of crude oil, are important determining factors of retail price differences between retail outlets. It is shown that when the costs of the retail firm and the nature of the market space (as characterized by variations in demographics between localities) are accounted for, branding leads to significantly higher prices. This is interesting given that the majority of the firms in this market (whether independent or branded) are engaged franchising arrangements. As indicated earlier, the majority of independent operators are franchisee or leasees of non-branded chains (such as Matilda or Neumann). Furthermore, outlets engaged in the Shop-A-Docket discount scheme pay a franchise fee to the participating supermarket chain.

This would indicate that contractual arrangement are a dominant factor in determining the differences in prices between outlets once local demographic characteristics and crude oil prices have been accounted for. Speaking more broadly, the results reject the Chicago School arguments put forth in the anti-trust literature which suggest that vertical restraints are not a mechanism by which firms can exercise market power. As such, an anti-trust action on the part of local regulatory authorities must require an investigation of the terms of the contractual relationships between retailers and wholesalers.

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A Data Descriptions

The description and source of all the variables used in the modelling follows.

- Average monthly retail gasoline prices for 243 firms over 36 months from Jan 2006 to Dec 2008.
  - Notation: P_{it}
  - Source: `motormouth.com.au`
- Mark-up retail gasoline prices for 243 firms over 36 months from Jan 2006 to Dec 2008.
  - Notation: $P_{it} - \frac{1}{N}\sum_{i=1}^{N} P_{it}$
  - Source: Generated.
- Latitude and Longitude coordinates of each retail outlet.
  - Source: `motormouth.com.au`
- Branding Information.
  - Notation: Caltex, Mobil, BP, Shell or other
  - Source: `motormouth.com.au`
- Branding.
  - Notation: BRANDING
    - =1 if a retail outlet is affiliated with a refiner, =0 otherwise
  - Source: Generated
- Docket.
  - Notation: DOCKET
    - =1 if a retail outlet is a Shell/Coles or Caltex/Woolworth, = 0 otherwise
- Price of Tapis crude oil for the first week of each month (36 observations). Proxy for firms' costs.
  - Notation: TAPIS
  - Source: US Energy Information Administration.
  - Modification: Data are lagged by one month.