Price Collusion and Deregulation in the Japanese Retail Gasoline Market

Ujo Goto, Osaka School of International Public Policy, Osaka University
Colin McKenzie, Osaka School of International Public Policy, Osaka University

Abstract: This paper estimates models for the retail price of gasoline in Tokyo and Osaka based on recent game theory models emphasizing the importance of forward-looking behaviour by firms. Using monthly data for the 1990s, this paper presents evidence consistent with the theory that future changes in the economic environment firms face do have an impact on the current retail price of gasoline. Some evidence is also presented that suggests the behaviour of retail prices has changed over the time period being examined.

1. INTRODUCTION

The purpose of this paper is to estimate models for the retail price of gasoline in Tokyo and Osaka. These price models are based on recent insights from the game theory literature that predict expected future changes in the economic environment firms face (for example, demand or cost conditions) will affect their current price setting if the firms engage in competition in a repeated game context (see, for example, Rotemberg and Saloner [1986] and Haltiwinger and Harrington [1991]). A second purpose of the paper is to examine the impact of deregulation of the oil industry on the behaviour of retail prices in Tokyo and Osaka. Differing responses to current and future economic conditions by firms in Tokyo and Osaka provide one explanation for the differing behaviour of gasoline prices in the two prefectures.

The paper is organized as follows. In section 2, a brief survey of recent studies relating to the Japanese and the North American oil industries are presented. A simplified version of Rotemberg and Saloner's [1986] model is presented in section 3 to suggest what variables influence a gas station's price setting behavior, and also the direction of that influence. Section 4 details the models to be estimated, while section 5 describes the data used. Estimated results are presented in section 6.

2. RECENT RESEARCH ON THE OIL INDUSTRY

At the end of March 1996, the provisional law relating to the importation of specified petroleum products (Tokutei sekiyu seihin yunyu zantei sochiho, called Tokusekiho) that restricted imports of specified petroleum products (gasoline, kerosene, light oil) to a certain number of companies was abolished. As a result, the importation of specified petroleum products was liberalized. In June 1994, it became clear that the Tokusekiho would be abolished at the end of March 1996. Despite this liberalization, total imports of specified petroleum products relative to total production in Japan have been very small, and the number of new importers of these products has remained rather small. At around the same time that the decision to abolish the Tokusekiho was made, the retail price of gasoline began to fall. As a result, the media has often suggested the abolition of the Tokusekiho was a successful case of deregulation.

There have been several recent studies of the Japanese oil industry. Prior to the actual abolition of the Tokusekiho, Chida [1996] provides some simulation results that suggest that the retail price of gasoline will fall as a result of the Tokusekiho's abolition. Ohnishi et al.'s [1997] graphical analysis of the national retail price of gasoline suggests that the abolition significantly reduced the retail price of gasoline. Goto's

[1999a] analysis of the impact of the protection provided by Tokusekiho suggests that it was associated with an upward shift in the cost function of several of the major Japanese oil refiners. Goto [1999b] applies cointegration analysis to the relationship between the wholesale and retail prices of gasoline, and attempts to verify whether the relationship has been affected by the abolition of the Tokusekiho. None of these papers attempt to apply recent developments in the game theory literature to the retail or wholesale gasoline market in Japan.

In contrast, using detailed firm level data, Slade [1987, 1992] suggests that gas stations in Vancouver have set a collusive price rather than a Nash equilibrium price. Borenstein and Shepard [1996] using city level gasoline data for the United States apply the ideas of Rotemberg and Saloner [1986] and Haltiwinger and Harrington [1991] that, in a repeated game context, future changes in the economic environment (for example, demand and cost factors) will affect current collusive prices. Their evidence indicates that expected future demand and cost changes do influence current gasoline prices, suggesting that gas stations are behaving in a manner consistent with a repeated game.

3. ROTEMBERG-SALONER MODEL

Here, we present a simplified version of Rotemberg and Saloner's [1986] model to suggest what variables influence a gas station's price setting and also the direction of that influence.

The structure of the retail gasoline market is assumed to be as follows. There are n identical gas stations that are assumed to supply identical gasoline. Bertrand Competition is assumed so that the gas stands simultaneously choose their selling price. This competition is assumed to be repeated infinitely. The marginal cost of gasoline to the gas stand at time t is assumed to be c_t. At time t, the market demand function for gasoline is

$$Q_t = Q_t(p_t, z_t), \qquad (1)$$

where Q_t, p_t, z_t are, respectively, the volume demanded, the price and the state. The state measures the size of demand shocks, and is assumed to be distributed according to an iid distribution. As a result, gas stations face strong demand in a boom and weak demand in a recession. In each period, the state of demand is realised before the gas stands make their price decisions.

The collusive price is denoted by p_t^m. When this is the price each gas station sets, it is assumed that total demand is divided equally among the gas stations. In this case, the collusive price is a function of the current state of the economy, $p_t^m(z_t)$.

Given Bertrand competition, if $p_{jt}(z_t)$ denotes the price posted by stand j at time t given the observed state z_t, then the following trigger strategy for firm i at time t, $S_{it}(z_t, c_t)$, will support the adopted collusive price as a sub-game perfect equilibrium.

$$S_{it}(z_t, c_t) = \begin{cases} p_t^m(z_t) & \text{if } p_{j\tau}(z_\tau) = p_\tau^m(z_\tau) \\ & \forall \tau \in \{1, \ldots, t-1\} \forall j \in \{1, \ldots, n\} \\ c_t & \text{otherwise} \\ & \forall t \in \{2, 3, \ldots\} \end{cases} \qquad (2)$$

The necessary and sufficient condition to support the collusive price given the trigger strategy is as follows:

$$\sum_{\tau=t+1}^{\infty} \delta^{\tau-t} E\left[\frac{1}{n} Q_\tau(p_\tau^m, z_\tau)(p_\tau^m - c_\tau)\right] \geq \frac{(n-1)}{n} Q_t(p_t^m, z_t)(p_t^m - c_t), \qquad (3)$$

where δ and E are, respectively, the discount rate and the expectation operator. The term before the inequality is the expected net present value of the loss of future profits that would occur if a firm was found to be cheating in the current period. The term after the inequality is the profit gain a firm could achieve by cheating in the current period and supplying the whole market by itself. If the latter term is greater than the former, firms are assumed to cheat. Depending on the value of δ, the necessary and sufficient condition means that the collusive price may have to be set lower than the monopoly price to sufficiently reduce the temptation for firms to cheat. Assuming that the current collusive price lies somewhere between the monopoly price and marginal cost, an examination of this condition suggests that if

a) the current state improves, the gain from cheating becomes larger, so that collusion becomes more difficult and the current collusive price needs to be reduced;
b) the future state is expected to improve, the penalty from cheating becomes larger, so that it is easier to maintain collusion and the current collusive price can be raised;
c) current costs rise, the gains from cheating fall, so that collusion becomes easier to maintain and the current collusive price can be raised; and
d) future costs are expected to rise, the penalty from cheating falls, so that collusion becomes more difficult to maintain and the current collusive price needs to be reduced.

For sufficiently large values of δ, the collusive price will be the monopoly price, and this will be unaffected by changes in future economic conditions. For sufficiently small values of δ, collusion is not possible and the retail price will be set at marginal cost.

4. MODEL

The model in section 3 indicates that when gas stations are facing a state of mutual dependence, and behave cooperatively, the collusive price may result from firms forecasting their future economic environment and choosing their behaviour accordingly. To take account of this, the following price equation was estimated

$$P_{it} = a_{0i} + a_{1i}Q_{it} + a_{2i}W_t + a_{3i}EQ_{it+1} + a_{4i}EW_{t+1} + e_{it}, \quad (4)$$

where P_{it} is the retail price of gasoline for the ith prefecture at time t, Q_{it} is the quantity of gasoline sold in the ith prefecture at time t, W_t is the national wholesale price of gasoline, E is the expectation operator, and e_{it} is a disturbance. The discussion of Rotemberg and Saloner's [1986] model in the previous section suggests the coefficients in (1) should have the following signs $a_{1i}<0$, $a_{2i}>0$, $a_{3i}>0$, and $a_{4i}<0$.

In order to estimate the price equations, it is necessary to calculate the expected values of future demand and wholesale prices in some way. Here, we follow Borenstein and Shepard's [1996] approach of fitting equations for Q and W, and then using the computed predicted values from these equations as estimates of the expected values. The estimated equations are of the following form:

$$Q_{it} = b_{0i} + b_{1i}Q_{it-1} + b_{2i}P_{it-1} + \sum_{j=1}^{11} \theta_{ji}S_{tj} + b_{3i}t + b_{4i}t^2 + \text{error}, \quad (5)$$

$$W_t = c_0 + c_1 W_{t-1} + c_2 W_{t-2} + \text{error}, \quad (6)$$

where S_{tj} is a seasonal dummy for the jth month. To save space, estimates of equations (5) and (6) are not presented.

5. DATA

The monthly data used in this paper run from October 1990 to June 1998. Data on retail gasoline prices at a prefectural level were obtained from the Monthly Survey of the Market Situation of Oil Products (Sekiyu seihin shijo getsuji chosa) produced by the Japan Energy Economic Research Institute's Oil Information Centre (Nihon Enerugi keizai kenkyusho Sekiyu joho senta). This data is obtained from surveys of the price of regular gasoline sold at gasoline stations. The surveys are carried out on the tenth day of each month.

Data on wholesale gasoline prices were obtained from the Nikkei NEEDS database using the price paid by traders who purchase gasoline from refineries and distribute it to gas stations. Data on gasoline prices at the wholesale level are not available at a prefectural level so the wholesale price is treated as being the same across Japan.

The invoice price of gas sold to gas stations is obtained from the monthly magazine Gasorin Sutando, and is the average of price charged by eleven of the twelve refining companies. The difference between the invoice price and the wholesale price is used to estimate the size of rebates paid by refining companies to gas stations.

Data on retail sales of gasoline at a prefectural level, the price of crude oil, and the number of gasoline-powered vehicles registered in Japan were also obtained from the Nikkei NEEDS data base. Although retail price and sales data is available for all 47 prefectures in Japan, the analysis in this paper is limited to the prefectures of Tokyo and Osaka. An examination of the retail prices in these two prefectures suggests that there are some substantial differences in the behaviour of retail prices in Tokyo and Osaka after mid-1994.

6. RESULTS

Estimates of equation (4) for Tokyo and Osaka are presented in Tables 1 and 2, respectively. For both prefectures, retail price equations are estimated using three samples: all the data (1990:11-1998:5); the first half of the data (1990:11-1994:5); and the second half of the data (1994:6-1998:5). The time at which the sample is divided into roughly two halves, 1994:6, is when the abolition of the Tokusekiho was formally decided. Estimates using ordinary least squares and instrumental variables are presented; the latter takes account of the possibility that all the explanatory variables in (4) may be correlated with the equation's error. The instruments used varied across the time periods and prefectures being considered, but they were drawn from seasonal dummies, time trend (and its square), lagged demand, lagged wholesale price, current and lagged rebate, current and lagged price of imported gasoline, and current and lagged number of registered gasoline-powered vehicles.

There are two reasons for computing the t-statistics in all cases using Newey-West's correction. First, the diagnostic tests in most cases provide evidence of strong serial correlation in the error. Secondly, computing the fitted values of expected future quantities and retail prices causes a generated regressor problem (see Pagan [1984, 1986] and McKenzie and McAleer [1987]) that, in general, induces serial correlation and heteroscedasticity in the equation's error. Limitations on the availability of relevant data on a monthly basis severely restricted our attempts to investigate the possibility that it was misspecification of the equation that was causing the significant diagnostic test results.

For Tokyo, the signs of the estimated coefficients for current and expected future wholesale prices are consistent with the predictions of the Rotemberg and Saloner [1986] model presented in section 3. However, the signs of the estimated coefficients for current and expected future quantities are the opposite of those predicted by the model. For all the sample periods, at least one of the expected future variables is statistically significant. This finding is consistent with game theoretic models that suggest future changes in the economic environment will affect current price setting by firms if the firms are engaged in competition in a repeated game context.

For Osaka, the signs of the estimated coefficients for current and expected future wholesale prices are also consistent with the predictions of the Rotemberg and Saloner [1986] model when the whole sample and the first half of the data are used. Both these signs are however reversed for the second half of the data suggesting a structural change around the time the abolition of the Tokusekiho was decided. As with Tokyo, the signs of the estimated coefficients for current and expected future quantities are the opposite of those predicted by the theoretical model. For all the sample periods, at least one of the expected future variables is statistically significant.

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Table 1: Estimated Retail Price Equations for Tokyo

Estimator	1990:11-1998:5 OLS-NW	1990:11-1998:5 IV-NW	1990:11-1994:5 OLS-NW	1990:11-1994:5 IV-NW	1994:6-1998:5 OLS-NW	1994:6-1998:5 IV-NW	1994:6-1998:5 OLS-NW	1994:6-1998:5 IV-NW
Q_{it}	0.241	0.299	0.121	0.216	0.197	0.99	0.206	0.239
	(5.63)	(2.30)	(1.19)	(2.45)	(4.17)	(2.73)	(4.40)	(6.26)
W_t	2.438	2.046	3.077	3.309	2.109	2.046	1.183	1.215
	(4.09)	(8.28)	(5.41)	(4.03)	(1.60)	(2.51)	(12.48)	(13.86)
Q^e_{it+1}	-0.378	-0.405	-0.150	-0.252	-0.318	-0.405	-0.329	-0.356
	(15.09)	(4.61)	(1.15)	(2.20)	(5.00)	(5.44)	(5.09)	(10.27)
W^e_{t+1}	-1.431	-0.974	-2.301	-2.574	-0.945	-0.974		
	(2.22)	(3.74)	(3.84)	(2.97)	(0.71)	(1.10)		
s	1.506	1.564	1.008	1.031	1.550	1.566	1.560	1.576
R^2	0.982	0.991	0.938	0.915	0.956	0.973	0.954	0.971
SC	61.94*	48.29*	25.50*	23.60*	33.35*	28.78*	29.37*	26.41*
FF	14.18*	15.72*	10.98*	11.48*	0.31	0.33	0.87	0.81
H	0.01	0.53	0.68	0.01	7.13*	4.34*	5.75*	2.85
ST	na	23.06	na	28.29	na	20.86	na	21.93

Notes: OLS-NW and IV-NW denote estimation using ordinary least squares (OLS) and instrumental variables (IV), respectively, with the t-statistics adjusted using the Newey-West (NW) correction. Figures in parentheses are absolute values of the t-statistics. s and R^2 denote the standard error of the regression and the coefficient of determination (for models estimated by instrumental variables this is the generalized R^2 measure proposed by Pesaran and Smith [1994]). SC, FF and H denote tests for 12^{th} order serial correlation, functional form misspecification and heteroscedasticity, and are distributed as χ^2 variates with 12, 1 and 1 degrees of freedom under their respective null hypotheses. ST is Sargan's general misspecification test for models estimated by instrumental variables. For these diagnostic tests, a '*' indicates significance at the 5% level. An entry of na, indicates that the ST are inapplicable for models estimated by OLS. Estimates of the constant are not presented.

Table 2: Estimated Retail Price Equations for Osaka

	1990:11-1998:5		1990:11-1994:5		1994:6-1998:5		1994:6-1998:5	
	OLS-NW	IV-NW	OLS-NW	IV-NW	OLS-NW	IV-NW	OLS-NW	IV-NW
Q_{it}	0.490	1.51	0.262	0.416	0.522	0.266		
	(6.25)	(11.19)	(4.07)	(4.80)	(3.52)	(1.21)		
W_t	1.408	4.156	2.863	3.033	-1.912	-4.33	-1.389	-5.073
	(1.24)	(3.18)	(7.00)	(5.52)	(3.20)	(2.85)	(2.17)	(3.61)
Q^e_{it+1}	-1.277	-2.436	-0.619	-0.842	-2.63	-2.530	-1.684	-2.237
	(2.89)	(10.45)	(4.15)	(9.83)	(4.93)	(4.62)	(4.52)	(6.39)
W^e_{t+1}	-1.097	-4.081	-2.234	-2.507	1.899	4.418	1.800	5.302
	(1.05)	(2.53)	(5.02)	(4.05)	(3.00)	(2.67)	(2.44)	(3.70)
s	3.032	4.843	1.160	1.186	2.407	2.767	3.069	3.358
R^2	0.891	0.932	0.930	0.930	0.905	0.924	0.841	0.915
SC	78.03*	14.23	28.03*	8.62	39.26*	23.20*	23.77*	13.71
FF	16.25*	3.89*	26.00	17.10*	31.82*	18.54*	18.84*	9.14*
H	14.60*	7.47*	0.42	0.01	13.18*	2.32	1.54	0.05
ST	na	18.48	na	25.16	na	24.78	na	18.87

Notes: As for Table 1.

8. REFERENCES

Borenstein, S. and A. Shepard, Dynamic pricing in retail gasoline markets, *RAND Journal of Economics*, 27(3), 429-451, 1996.

Chida, R., Sekiyu seihin no yunyu jiyuka ni tsuite (On the import liberalization of oil products), *Nihon Keizai Research*, 31, 276-298, 1996.

Goto, U., Jigen hogo kikan to kigyou kodo – nihon no sekiyu sangyo no kesu (Temporary protection and firm behavior: the Japanese oil industry), *International Public Policy Studies*, 3(2), 241-254, 1999a.

Goto, U., Time series analysis on the Japanese gasoline price fluctuation, mimeo, 1999b.

Haltiwanger, J. and J. E. Harrington, The impact of cyclical demand movements on collusive behavior, *RAND Journal of Economics*, 22(1), 89-106, 1991.

McKenzie, C.R. and M. McAleer, On efficient estimation and correct inference in models with generated regressors: a general approach, *Japanese Economic Review*, 48(4), 368-389, 1997.

Onishi, K., T. Ueki, and S. Mizuguchi, Kisei kanwa no gasorin kakaku ni ataeru eikyo (The impact of deregulation on gasoline prices). *Osaka Economic Papers*, 47(1), 132-133, 1997.

Pagan, A.R., Econometric issues in the analysis of regressions with generated regressors, *International Economic Review*, 25, 221-247, 1984.

Pagan, A.R., Two stage and related estimators and their applications, *Review of Economic Studies*, 53, 517-538, 1986.

Pesaran, M.H. and R.J. Smith, A generalized $\bar{R}^2$ criterion for regression models estimated by the instrumental variable method, *Econometrica*, 62, 705-710, 1994.

Rotemberg, J. and G. Saloner, A supergame-theoretic model with price wars during booms, *American Economic Review*, 76(3), 390-407, 1986.

Slade, M., Interfirm Rivalry in a repeated game: an empirical test of tacit collusion, *Journal of Industrial Economics*, 35(4), 499-516, 1987.

Slade, M., Vancouver's gasoline-price wars: an empirical exercise in uncovering supergame strategies, *Review of Economic Studies*, 59(2), 257-276, 1992.