Conjectural Reactions and Deregulation in the Japanese Oil Industry

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EXTENDED ABSTRACT

The purpose of this paper is to investigate how firms in the Japanese oil industry expect their rivals to react when the firm changes its output level.

This paper focuses on an act of deregulation, the abolition of production quotas for two oil products, diesel oil and kerosene, in March 1992. Following this deregulation, oil companies could freely supply oil products. A key questions arising from this deregulation is how did the regulated industry behave in the face of this "release" from the prior production constraints.

There have been several recent studies of the Japanese oil industry, but they have all focused on the impact of the abolition of the *Tokusekiho*, the Provisional Law relating to the Importation of Specified Petroleum Products, that restricted the importation of specified petroleum products to limited number of companies. The *Tokusekiho*, was abolished at the end of March 1996. However, despite this liberalization, total imports of specified petroleum products, gasoline, diesel oil and kerosene, have been very small relative to the total production of these products in Japan. This paper casts doubt on the positive evaluation of the abolition of *Tokusekiho* that the media has often suggested.

This paper analyzes two oil products, diesel oil and kerosene. All recent studies of the Japanese oil industry have analyzed the behavior of firms and the retail price of just gasoline product despite the fact that the liberalization covered three oil products. An evaluation of the differences in the magnitudes of competition for oil products other than gasoline is necessary in order to fully analyze the effect of deregulation.

Figure 1 depicts the structure of the estimation process in this paper. On the supply side, this paper assumes that the situation in the Japanese oil industry was the beginning of quantity setting competition. Using the conjectural variation approach (CVA), the paper investigates how one firm expects its rival firms in the oil industry to react when the firm changes its output level. On the demand side, a log-linear demand function is estimated. Each firm's first order condition derived from profit maximization contains the price elasticity of demand. Therefore, in order to achieve more efficient estimation, joint estimation of the supply and demand sides is conducted by using the General Method of Moments (GMM) estimator. Furthermore, the impact of the abolition of the temporary protection law, *Tokusekiho*, and two mergers of gasoline firms is also investigated.

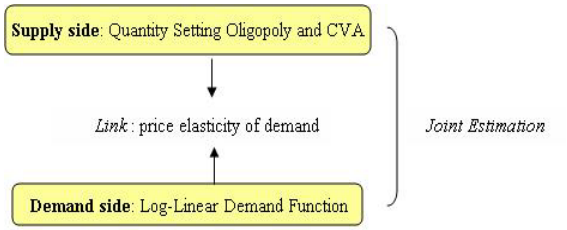

Figure 1. Structure of Estimation Process

In stark contrast to the results obtained by Goto and McKenzie (2005) for gasoline, the results here show that firms in the Japanese oil industry almost never expect their rivals to react when the firm changes its output level.

One possible reason for this outcome is that commercial customers such as bus companies and truck carrying companies, form a significant part of the demand of diesel oil. These customers may not switch between suppliers so readily. As a result, firms do not need to worry about their rival's behavior.

A large part of the demand of kerosene is used by households for home heating plant. There has been a national policy to maintain a stable price of kerosene Therefore, the market may be non-competitive, and the degree of interaction among firms may be small.

1. INTRODUCTION

Japan is an oil-poor country. In order to maintain a stable supply of oil products, the government has controlled the Japanese oil industry in various ways since the end of the Second World War. However, recently pressure to open Japanese markets has encouraged the government to partially deregulate the oil industry.

This paper focuses on the impact of an act of deregulation, the abolition of production quotas for diesel oil and kerosene in March 1992. Following this deregulation, oil companies could freely supply oil products. A key question arising from this deregulation is how did the regulated industry behave in the face of this "release" from the production constraints

This research assumes the situation that occurred in the Japanese oil industry ws the beginning of the quantity setting competition. Using the conjectural variation approach (CVA), this paper investigates how a firm expects its rival firms in the oil industry to react when the firm changes the level of its output.

In contrast to the results for gasoline reported in Goto and McKenzie (2005), it is found that in relation to diesel oil and kerosene that firms in the Japanese oil industry almost never expect their rivals to react when the firm changes its output levels.

Commercial customers, such as bus companies and transport companies using trucks, constitute a large part of the demand for diesel oil. These customers may not switch suppliers so readily. As a result, firms may not worry about their rival's behaviour so much.

For the most part kerosene is used for households for purposes such as home heating plant. A national policy has sought to maintain a stable price of kerosene. As a result, the market may be non-competitive, and the degree of interaction among firms may be small.

There have been several recent studies of Japanese oil industry, but they have all focused on just gasoline and the impact of the abolition of the *Tokusekiho*, the Provisional Law relating to the Importation of Specified Petroleum Products, gasoline, diesel oil and kerosene. This law restricted the importation of specified petroleum products to limited number of companies, but was abolished at the end of March 1996. However, despite this liberalization, the total imports of specified petroleum products have been very small relative to the total production of these products in Japan. This paper casts doubt on the positive evaluation of the abolition of *Tokusekiho* that has often been suggested in the media.

Earlier analyses of the Japanese oil industry include: an application of cartel theory to explain empirically the sharp decline in the retail price of gasoline (Nagaoka and Kimura [1999]); and an application of infinitely repeated game theory that leads to forward looking behavior by gasoline stations and identifies the future volatility of the retail price of gasoline as an important factor explaining current price (Goto and McKenzie [2002]). Whether the Tokusekiho, a law providing temporary protection, worked effectively depends on whether the oil industry viewed its temporariness as being credible. Based on estimates of each firm's cost function, Goto's [2005] investigation suggests that the temporary protection policy lacked credibility.

The CVA has been used as one way to identify market structure (see Reiss and Wolak [2005]). Some papers have tried to identify the conjectural variation parameter for each firm in the industry using a proxy variable for marginal costs (for example, Appelbaum [1982] and Spiller and Favaro [1984]), but in most cases firm level data has not been available. Bresnahan [1982] developed a method to estimate the conjectural variation parameter using industry level without information on marginal costs. Genoseve and Mullin [1998] and Wolfram [1999] compared the estimates of parameters obtained using Bresnahan's [1982] method to estimates of the parameter obtained using the direct marginal cost, and evaluated the effect of a cartel in the sugar industry and the effect of deregulation in the British electricity spot market, respectively. These papers find very little difference in the estimates of the conjectural parameters based on the two measures of marginal costs.

This paper is organized as follows. A model of the firm's behavior using the CVA is presented in section 2. Section 3 details the estimation strategy, while section 4 describes the data used. Estimated results are presented in section 5. A brief conclusion is presented in section 6.

2. STRUCTURAL MODEL

In this section, a structural model that permits the estimation of a conjectural elasticity parameter is discussed. This paper assumes that diesel oil and kerosene are each homogeneous goods, with a perceived demand function that each firm

recognizes as being determined by consumer behavior and being given by

$$Q = Q(p, z, \varepsilon) \quad (1)$$

where Q, p, z and ε are, respectively, the total quantity demanded, the price of the oil product, other factors that influence the quantity of the oil product demanded, and a random error term.

Suppose there are n firms in the market, each producing a quantity of the oil product, $q_i, i = 1, \ldots, n$. In the absence of inventories, the total quantity supplied is $Q = \sum_{i=1}^{n} q_i$. It is assumed that each firm regards its output, q_i, as its strategic control variable. In addition, each firm cannot observe the behavior of consumers perfectly. Each firm is assumed to be risk neutral and to maximize its expected profits.

Each firm is assumed to choose q_i to maximize

$$E\pi_i = E\left[p(Q : z, \varepsilon)q_i - c_i(q_i, w)\right] \quad \forall i \quad (2)$$

where π_i denotes the profits of firm i, $p(Q : z, \varepsilon)$ is the inverse demand function of the oil products, $c_i(q_i, w)$ is the cost of producing q_i, w denotes the other factors that influence the cost of production, and E denotes the expectation operator.

The first order condition (FOC) for each firm is given by

$$\frac{\partial E\pi_i}{\partial q_i} = E\left[p + \frac{\partial Q}{\partial q_i}\frac{\partial p}{\partial Q}q_i - \frac{\partial c_i(q_i, w)}{\partial q_i}\right] = 0$$

$$\Rightarrow E\left[p + \left(1 + \sum_{j \neq i}\frac{\partial q_j}{\partial q_i}\right)\frac{\partial p}{\partial Q}q_i - \frac{\partial c_i(q_i, w)}{\partial q_i}\right] = 0 \ \forall i \quad (3)$$

In order to estimate how firm i expects other firms to behave in response to its behavior, it is crucial to make some assumptions about the conjectural elasticity parameter. Here, we adopt a simplified version of Spiller and Favaro's [1984] assumption, namely,

$$\frac{\partial q_j}{\partial q_i}\frac{q_i}{q_j} = \lambda_{ji} \quad i \neq j. \quad (4)$$

Given the lack of any explicit data on the marginal costs of individual producers, it is assumed that the marginal cost function takes the following form:

$$\frac{\partial c_i(q_i, w)}{\partial q_i} = \alpha_0 + \alpha_1 q_i + \alpha_2 g \quad \forall i, \quad (5)$$

where $\alpha_i, i = 0, 1, 2$ are unknown parameters to be estimated, and g is the price of imported crude oil. Substituting (4) and (5) into (3), and rearranging gives

$$E\left[1 + \frac{1}{\eta}\left(S_i + \sum_{j \neq i}\lambda_{ji}S_j\right) - \frac{\alpha_0 + \alpha_1 q_i + \alpha_2 g}{p}\right] = 0 \ \forall i \quad (6)$$

where $S_i = \frac{q_i}{Q}$ and $\eta = \frac{\partial Q}{\partial p}\frac{p}{Q}$ are, respectively, the market share of firm i, and the price elasticity of demand.

3. ESTIMATION STRATEGY

In order to obtain estimates of the parameters in the FOC efficiently, joint estimation of the demand function and each firm's FOC are conducted using the Generalized Method of Moments (GMM) estimator .

3.1. ESTIMATION OF THE DEMAND FUNCTION

The following functional form for the logarithm of demand is assumed:

$$\log Q_t = \beta_0 + \eta \log p_t + \beta_1 \log Y_t + \beta_2 D_{1t} + \beta_3 D_{2t} + \beta_4 D_{3t} + \beta \log z_{t-1} + \varepsilon_t \quad (7)$$

where Y_t, D_{it}, z_{t-1} and ε_t are, respectively, GDP, a quarterly dummy variable for the i'th quarter, a vector containing the lagged values of Q_t, p_t and, Y_t and an error.

3.2. FOC FOR EACH FIRM

Equation (6) contains a large number of unknown parameters, (n-1) λ parameters and three α parameters. In order to simplify the estimation of (6), this paper follows Spiller and Favaro [1984] by dividing firms into two groups, firms in the Dominant Firm Group (DFG) (denoted by a subscript D) and firms in the Fringe Firm Group (FFG) (denoted by a subscript F). Cluster analysis based on the volume of sales by each firm is used to divide the firms into two groups. Nippon, Idemitsu, Cosmos, Show Shell, Jomo are identified as belonging to the DFG, while all other firms are treated as belonging to the FFG. As a result,

instead of assuming (4), it is assumed that in response to changes in its own output the i'th firm expects the reaction of its competitors to depend on which group they belong to, that is,

$$\frac{\partial q_k}{\partial q_i}\frac{q_i}{q_k} = \lambda_{ki} \quad k = D, F \tag{8}$$

where k denotes the total output of all firms in group k (excluding firm i if it is a member of this group).

Then, the FOC of the i'th firm depends on whether it is a member of the DFG or the FFG. When the i'th firm is a member of DFG, its FOC is:

$$E\left[1+\frac{1}{\eta}\left(S_i+\lambda_{Di}\left(S_D-S_i\right)+\lambda_{Fi}S_F\right)-\frac{\alpha_0+\alpha_1 q_i+\alpha_2 g}{p}\right]=0 \;\forall i \tag{9}$$

where $S_D = \sum_{i\in D} S_i$ and $S_F = \sum_{i\in F} S_i = 1 - S_D$, are the market shares of the DFG and FFG, respectively. When the i'th firm is a member of the FFG, its FOC is:

$$E\left[1+\frac{1}{\eta}\left(S_i+\lambda_{Fi}\left(S_F-S_i\right)+\lambda_{Di}S_D\right)-\frac{\alpha_0+\alpha_1 q_i+\alpha_2 g}{p}\right]=0 \;\forall i \tag{10}$$

In addition, the abolition of the *Tokusekiho* in March 1996 and two mergers of firms may have impacted on the way that firms expect their rivals to react when the firms change their output. To take account of this possibility, the following specification is adopted:

$$\frac{\partial q_k}{\partial q_i}\frac{q_i}{q_k} = \lambda_{ki} + \lambda_{kil}D_l \quad k = D, F \tag{11}$$

where D_l is a zero-one dummy variable defined for the following three events one for the abolition of the *Tokusekiho*, and one for each of the two mergers.

4. DATA

In order to estimate the FOC and demand function, quarterly data from the first quarter of 1992 to the third quarter of 2003 on the sales of the sixteen oil companies in Japan, Nippon Oil Corporation (Nippon), Mitsubishi Oil Company (Mitsubishi), Japan Energy Corporation (Jomo), Showa Shell Sekiyu (Shell), Idemitsu, Cosmos, Mobil, Esso, Exxon-Mobil, Tonen General Sekiyu, Kyushu Sekiyu, Kgynus Sekiyu, Taiyo Sekiyu, Teikoku, Seibu Sekiyu, and Mitsui Oil and Gas have been used. Between 1992 and 2003, two mergers occurred. In April 1999, Nippon was formed as a result of a merger of Nippon and Mitsubishi. In April 2002, Exxon-Mobil was formed as the result of a merger of Mobil, Esso and Tonen General Oil. Following these mergers, there are now only twelve companies in Japan.

Data on the quarterly volume of sales of diesel oil and kerosene for each company were obtained from the Quarterly Oil Communication (*Sekitsu*) published by Sekiyu Tsushinsha. Data on retail prices published by the Japan Energy Economic Research Institute's Oil Information Center were obtained from the Nikkei NEEDS Macro database. Data on crude oil prices, GDP and the GDP deflator were also obtained from the Nikkei NEEDS Macro database. Quarterly data is obtained as a simple average of the monthly data.

5. ESTIMATION RESULTS

The estimation results for diesel oil and kerosene are presented in Tables 1 and 2, respectively. Each firm's FOC in the DFG is estimated, but only Exxon-Mobil as a representative of the FFG is estimated since the sales volume of gasoline of other firms in the FFG is rather small relative to total sales. Variables that are not the significant level have been dropped. The signs of all estimated coefficients of the retail price of gasoline and the income proxy, GDP, satisfy the properties expected for a demand function, and they are statistically significant. Most of the estimated coefficients of the perceived price elasticity of gasoline demand estimated differ across firms and are consistent with demand being inelastic.

5.1 INTERPRETATION OF EACH FIRM'S CONJECTURAL ELASTICITY PARAMETER

Most estimates of λ_D and λ_F are not statistically significant for firms in either DFG or the FFG, that is, firm i assumes that when it increases its own output by one per cent, the output response of other firms is zero. It would appear that all firms ignore the behavior of their rivals.

The effect of deregulation brought about by the abolition of the Tokusekiho is measured by the estimated coefficients of the 96 dummy variables. Although not reported in Tables 1 or 2, all the estimated coefficients of the dummy variables are not statistically significant. As a result, for diesel oil and kerosene the abolition of *Tokusekiho* has

not had any impact on the way firms form conjectures about their rival's behavior.

Finally, two large mergers are evaluated using dummy variables. For the merger of Nisseki and Mitsubishi in April 1999, the estimated results suggest that for diesel oil, only Nippon expects an "adaptive" response by other members of the DFG to the same action as if they seek to maintain the retail price and stabilize their profits. For the merger of Mobil, Esso and Tonen General Oil in April 2002, most dummy variables are not statistically significant. This merger also appears not to have affected most firms regardless of whether they were a member of DFG or FFG.

6. CONCLUSION

This paper has examined how firms in the gasoline industry make conjectures about their opponents' behavior in the presence of deregulation and two mergers. It would appear that in the diesel oil market and kerosene markets, firms i industry almost never expect their rivals to react when the firm changes its output decisions. This result is quite different to the results for the gasoline market reported by Goto and McKenzie (2005).

One possible reason for this finding is that a significant portion of the demand for diesel oil comes from commercial customers, such as bus companies and freighting companies using trucks. These customers may not switch suppliers so readily. As a result, each firm may not worry about the behavior of other firms. The demand for kerosene mainly comes from households who use it for home heating. A national policy that has sought to maintain a stable price for kerosene may have led the market to be non-competitive, and the degree of interaction among firms to be small.

7. ACKNOWLEDGMENTS

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Table 1 : Estimated Diesel Oil Demand Function and First Order Conditions by Firm

	Dominant Firms					Fringe Firm
	Nippon[1]	Idemitsu	Cosmos	Showa Shell	Jomo	Exxon-Mobil[2]
logp	-0.059	-8.741	-0.132	-7.543	-0.120	-8.355
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
logY	1.467	2.702	0.616	2.536	1.312	2.536
	(0.000)	(0.000)	(0.009)	(0.000)	(0.000)	(0.000)
D1	0.251	0.574	0.079	0.525	0.227	0.528
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
D2	0.220	0.244	0.166	0.240	0.205	0.212
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
D3	0.219	0.384	0.131	0.358	0.204	0.351
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
logp(-1)	*	7.435	*	6.456	-0.897	7.032
		(0.000)		(0.000)	(0.000)	(0.003)
logY(-1)	-0.992	-2.972	*	-2.766	-0.897	-2.920
	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
logD(-1)	*	*	0.095	*	*	*
			(0.002)			
λ(Dominant)	-0.195	*	*	*	*	11.428
	(0.000)					(0.002)
λ(Fringe)	*	*	*	*	*	*
λ(Dominant)DMerger1[1]	-0.129	*	*	*	*	*
	(0.000)					
λ(Fringe)DMerger1[1]	*	*	*	*	*	*
λ(Dominant)DMerger2[2]	*	2.315	*	*	-0.011	
		(0.000)			(0.000)	
λ(Fringe)DMerger2[2]	*	*	*	*	*	-7.797
						(0.001)
α0	0.015	-0.004	0.013	0.114	0.023	0.013
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α1	-0.056	0.994	-0.003	0.330	0.005	0.013
	(0.000)	(0.000)	(0.301)	(0.000)	(0.026)	(0.000)
α2	0.059	-0.003	0.012	0.350	0.026	0.004
	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)
J-Statistics	0.235	0.254	0.253	0.259	0.240	0.234

1: Nippon Oil Corporation was formed as the resut of a merger of Nisseki and Mitsubishi Oil in April 1999.
2: Exxon-Mobil was formed as the result of a merger of Mobil, Esso and Tonen General Oil in April 2002.

Notes: Figures in parentheses are p-values.

Table 2 : Estimated Kerosene Demand Function and First Order Conditions by Firm

	Dominant Firms					Fringe Firm
	Nippon[1]	Idemitsu	Cosmos	Showa Shell	Jomo	Exxon-Mobil[2]
logp	-0.208 (0.000)	-0.150 (0.000)	-0.136 (0.000)	-0.122 (0.000)	-0.421 (0.000)	-0.080 (0.000)
logY	0.794 (0.001)	0.875 (0.000)	0.933 (0.000)	1.043 (0.000)	0.829 (0.000)	0.875 (0.000)
D1	-0.880 (0.000)	-0.898 (0.000)	-0.896 (0.000)	-0.889 (0.000)	-0.856 (0.000)	-0.886 (0.000)
D2	-1.130 (0.000)	-1.051 (0.000)	-1.046 (0.000)	-1.030 (0.000)	-1.126 (0.000)	-1.058 (0.000)
D3	-0.210 (0.000)	-0.114 (0.004)	-0.107 (0.012)	-0.099 (0.024)	-0.204 (0.000)	-0.123 (0.000)
logp(-1)	*	*	*	*	*	-0.289 (0.047)
logY(-1)	-0.916 (0.000)	-0.893 (0.000)	-0.948 (0.009)	-0.887 (0.000)	-1.110 (0.000)	-1.101 (0.000)
logD(-1)	*	0.098 (0.004)	0.105 (0.002)	0.102 (0.005)	*	0.090 (0.013)
λ(Dominant)	*	*	*	*	0.520 (0.000)	*
λ(Fringe)	*	*	*	*	*	*
λ(Dominant)DMerger1[1]	*	*	*	*	*	*
λ(Fringe)DMerger1[1]	*	*	*	*	*	*
λ(Dominant)DMerger2[2]	*	0.034 (0.000)	*	-0.050 (0.000)	*	*
λ(Fringe)DMerger2[2]	*	*	*	*	* *	*
α0	0.003 (0.566)	-0.001 (0.014)	-0.004 (0.000)	-0.009 (0.116)	-0.002 (0.000)	0.0145 (0.011)
α1	0.001 (0.845)	-0.019 (0.000)	-0.017 (0.000)	0.0218 (0.000)	-0.015 (0.000)	-0.176 (0.000)
α2	0.012 (0.005)	-0.0007 (0.043)	-0.004 (0.000)	-0.013 (0.03)	-0.0003 (0.412)	0.018 (0.000)
J-Statistics	0.259	0.246	0.236	0.243	0.247	0.264

1: Nippon Oil Corporation was formed as the resut of a merger of Nisseki and Mitsubishi Oil in April 1999.
2: Exxon-Mobil was formed as the result of a merger of Mobil, Esso and Tonen General Oil in April 2002.

Notes: Figures in parentheses are p-values.