Disguised Protectionism? Environmental Policy in the Japanese Car Market*

Taiju Kitano†

National Graduate Institute for Policy Studies (GRIPS)

May 2012

Abstract

US government criticized Japanese environmental policies for the promotion of eco-friendly car(eco-cars) purchases, e.g. tax exemptions and subsidies, as disguised forms of domestic protection because none of US car models was certified as eco-cars unlike many Japanese car models. The purpose of this paper is to assess whether or not the Japanese environmental policies from 2005 to 2009 were the case of the disguised form of protection that was prohibited under the WTO rule. To achieve this goal, this paper implements counterfactual simulation based on the structural econometric model of multi-product oligopolistic competition to obtain what would happen if the Japanese government introduces an alternative eco-car certification rule that expands the target of the subsidy as suggested by the US government. Simulation results show that although the average fuel economy under the alternative rule is comparable to that under the actual, the alternative is costly in terms of improving fuel economy because it requires much larger amount of subsidy in order to achieve the same average fuel economy level as in the actual. Accordingly, the Japanese environmental policies were efficient in terms of improving the environmental quality and thus would not be the case of the disguised protectionism.

Keywords: Discrete choice model; Micro moments; Disguised protectionism; Environmental policy; Car market

JEL Classification: F18; L62; Q56

*Very preliminary. The author would like to appreciate Minoru Kitahara, Satoshi Myojo, Ryo Nakajima, Ryo Ogawa, Hiroshi Ohashi, participants at several seminars for their helpful comments. Financial support from the JSPS is gratefully acknowledged. All remaining errors are my own.

†7-22-1 Roppongi, Minato-ku, Tokyo 106-8677, JAPAN. E-mail: t-kitano@grips.ac.jp

1 Introduction

With increasing concern on the greenhouse gas emission in car use, a number of countries have introduced environmental policies that aim at diffusing low emission and fuel efficient automobiles (hereafter, eco-cars). In Japan, the government has employed several forms of environmental policies, such as tax incentives and a subsidy for eco-car purchases. In the history of the Japanese environmental policies, the set of policies introduced in 2009 that included a subsidy for purchasing eco-cars and scrapping old cars had a significant impact on the consumers' car replacement. As is shown in Table 1, an average car age for existing passenger cars decreased in 2010 for the first time since 1993.

Although this kind of environmental policies can be justified in terms of resolving negative externality of car use[1], trade experts often express concerns on the use of environmental policies as disguised forms of protection. Indeed, in the case of the Japanese policies, US manufacturers, GM, Ford and Chrysler, criticized the policies as "disguised protectionism" because none of their cars obtained the certification as eco-cars and thus the policies designed to provide benefits to Japanese manufacturers (*AFPBB News, Dec. 11, 2009*). They asked US Trade Representative (USTR) to protest against the Japanese government in this regard, and upon the request of US manufacturers, USTR requested Japanese government to expand the scope of the fuel economy standards. As a result, Japanese government altered the standards of the eco-car certification for imported cars in Jan. 2010. Then, 15 of US cars met the standards for obtaining the subsidy.

With respect to the disguised protectionism argument, trade theories show that a government has incentives to distort domestic policies for the purpose of improving the terms of trade (Copeland (1990); Ederington (2001); Ederington (2002)) and giving domestic firms competitive edge (Barrett (1994); Conrad (1993); Kennedy (1994)). Although the argument might not be true if the countries can use trade policies freely for the purpose of their own welfare, the incentives to distort domestic policies have become a real issue because under

[1] See Parry, Walls, and Harrington (2007) for the survey on the externality on car use.

the current World Trade Organization (WTO) system, member countries have limited ability to use their trade policies.

Corresponding to this concern, the WTO rules that member countries cannot set their domestic policies freely under the rule of National Treatment of the General Agreement on Tariffs and Trade(GATT). National Treatment requires the member countries to apply the same level of internal taxes and subsidies and other regulations to domestic-like foreign products, and prohibit to discriminate between domestic and foreign products. Therefore, the Japan's environmental policies might went against the National Treatment.

However, it is not impossible for the member countries to deviate the rule of the National Treatment. Under the GATT Article XX, the WTO members can apply measures that may affect competition between domestic and foreign firms if the measures do not explicitly discriminate the products on the basis of country of origin and, with respect to the environmental concern, are necessary to public health or environment.[2] Note that, the GATT XX does not mean that a government can set its policies freely even though the policies relates to public health or environment. It actually specify that the policies can not constitute means of "arbitrary or unjustifiable discrimination" and "disguised restriction on international trade". Therefore, although the Japanese environmental policies aim at improving the environmental quality on its surface, they might went against the WTO rule if the policies designed to promote domestic industries rather than to improve environmental quality.

The purpose of this paper is to assess whether or not Japanese environmental policies constitute "arbitrary or unjustifiable discrimination" and "disguised restriction on international trade". To achieve this goal, I analyze what would happen if the certification of the eco-cars are relaxed as US government suggested. In the analysis, I employ a discrete choice model to estimate car demands and specify a multiproduct oligopolistic competition model in order to recover an unobserved marginal cost for each product. In the demand model, I

[2]This discussion is based on the case of the US Corporate Average Fuel Economy (CAFE) standard that was challenged by European countries. See Esty (1994) and Vogel (1997) for the detail of this case.

allow the consumers' choice to depend on the state of the car ownership, the ages of cars that they own because the replacement subsidy introduced in 2009 can be applicable only when scrapping a car aged 13 and over.

The model used in this paper is relevant to the previous studies on automobile replacement. One of the prominent work is Adda and Cooper (2000) that develop a dynamic discrete choice model focusing on consumers' decisions replacing and keeping their existing cars. While Adda and Cooper (2000) do not incorporate car model choices in the dynamic decision, Schiraldi (2011) incorporates taste heterogeneity on car models, as in Berry, Levinsohn, and Pakes (1995), into a dynamic discrete choice framework. Contrary to these studies, the model used in this study is a static discrete choice like Berry, Levinsohn, and Pakes (1995), but it allows state dependence of consumers' car choice as in Schiraldi (2011): consumers' choice depends on their state of car ownership, i.e., the ages of cars that they own. In estimating the demand, I use a moment condition used in Berry, Levinsohn, and Pakes (1995) and incorporate micro moments based on the evolution of car age distribution to identify the effects of the car ages on consumer choices as in Petrin (2002).

Based on the estimates of demand and recovered marginal costs, I implement two counterfactual simulations. First, I assess the impacts of the set of environmental policies introduced from 2005 to 2009. The simulation results show that the environmental policies had a large impacts on the firms' profits. In particular, Honda and Toyota significantly earned from the environmental policies. The results also reveal that although the policy improved the average fuel economy of newly sold cars only a little from 2005 to 2008, the revised policy introduced in 2009 has a large impact on the average fuel economy. Second, this paper further investigates the alternative eco-car certification system suggested by USTR, focusing on the replacement subsidy introduced in 2009. The simulation results shows that although the effects on average fuel economy under the alternative eco-car certification system is comparable to that under the actual eco-car certification system, the alternative one is inefficient in terms of improving fuel economy because it requires much larger amount of subsidy in order to achieve the same fuel economy level. According to the findings, environmental policies can be justifiable to improve fuel economy effectively if the alternative certification suggested by US as a reference.

Several studies have been studies car markets based on structural econometric models and assessed environmental policies and trade policies independently. The former literature includes Goldberg (1998) for the effects of Corporate Average Fuel Economy (CAFE) standards in US; Adda and Cooper (2000) for the effects of replacement subsidy in France; Beresteanu and Li (2011) for the effects of tax incentives introduced in US on hybrid car demands; Schiraldi (2011) for the effects of replacement subsidy in Italy. The latter literature includes Berry, Levinsohn, and Pakes (1999) for the effects of Voluntary Export Restraints (VER) against Japanese car imports to US in the 1980s; Goldberg and Verboven (2001) for the effects of absolute and relative quotas in Europe; Clerides (2008) for the effects of the trade liberalization in used car markets in Cyprus automobile industries; Kitano (2011) for the effects of a safeguard introduced in the US motorcycle market. Compared to these studies, this paper investigates the link between trade and environment, and thus contributes to the trade and environment disputes that has been a focus of a discussion under the WTO, a la Tuna-Dolphin cases in US.[3]

In addition, this paper provides additional empirical evidence on the literature of the effects of environmental regulation on international trade. In particular, while previous studies usually focus on the impact of environmental regulations on trade flows based at cross industry level (Ederington and Minier (2003); Ederington, Levinson, and Minier (2005); Kel (2009)), this paper investigates the effects of the environmental policy on firms' sales and profits at an industry level.

The remainder of this paper is organized as follows. In Section 2, I describe the feature of Japanese car markets and the evolution of environmental policies on car purchase and holding from fiscal year 2005 to 2009. Section 3 introduces the structural model of demand

[3]See Irwin (2009), Esty (1994) and Vogel (1997) for the trade and environment cases in the WTO.

and supply. Section 4 introduces moment conditions used in GMM estimation with discussion on the identification of the structural parameters, and report the estimation results. Section 5 presents simulation results and reports the effects of environmental policies on Japanese firms. Section 6 concludes and outlines direction for future research.

2 Japanese car market and environmental policies

The Japanese car market, in which about 3 million passenger cars are sold annually, is the second largest market in the world next to the US. Toyota is the largest manufacturers that consists around 43% of market share, and Nissan and Honda are the second and third largest that consist 17% and 15%, respectively. After them, Daihatsu, Mitsubishi, Mazda, Suzuki, and Subaru follows. More than 90% of the sales is Japanese cars, and thus the import cars are still less prevalent. In particular, the sales of the US manufacturers are around 4000, so their share is tiny.

With increasing concern on the effects of car usage on the environment, Japanese government has established environmental policies in car market for the purpose of diffusing this kind of eco-cars. The policies employed took the form of tax reduction on the car use and purchase, and subsidy for purchasing eco-cars and scrapping old cars.

I here explain the environmental policies on passenger cars that was in effect from 2005 to 2009.[4]

2.1 Tax reduction

Car users in Japan have to pay various taxes at the stages of car purchase and ownership.[5] In the purchase stage, consumers have to pay 5% automobile acquisition tax for the 90% of

[4]The market structure and policy regarding Japanese car markets are well written in *The Motor Industry of Japan*, annual publication of Japanese Automotive Dealers Association (JAMA).

[5]In addition to these stages, consumers are subject to gasoline taxes at the usage stage. However, the gasoline tax is out of the scope of the environmental policies.

a car price[6] in addition to 5% consumption tax. In the ownership stage, consumers have to pay tonnage tax and automobile tax. The amount of the tonnage tax payments depends as car weights, 6300 JPY (ca. 80 USD)/500kg[7], while the automobile tax depends on the size of engine displacement; for example, the tax of cars with less than 1000 cc is 29500 JPY, and that of cars with 1000 – 1500cc is 34500 JPY. While consumers have to pay the acquisition taxes once at the time of car purchase, they have to pay the automobile and tonnage taxes every year.

Japanese government has provided tax incentive measures in order to diffuse eco-cars. From fiscal year 2005 to 2009, those who purchase cars that satisfies low Green House Gas (GHG) emissions, such as NOx and CO, and fuel economy certifications were reduced the taxes depending on the emissions and fuel economy. From 2005 to 2008, the tax system was slightly revised over time as is summarized in Table 2. The automobile tax was reduced by up to 50%, while the acquisition tax was reduced by up to 15000 JPY for gas car and by up to 44% of the acquisition tax payment for hybrid-vehicle.[8]

On April 1, 2009, the government expanded the scope of tax exemption for eco-cars. Under the new tax system, the tonnage tax became a target of the tax exemption. In addition, the amount of the tax reductions was increased; in particular, the taxes of hybrid vehicles were reduced by 100%, and that of the vehicles other than the hybrid vehicles were 75% or 50%, depending on the amount of the emissions and fuel economy. While the automobile tax reduction could be applied only first year of purchase, the tonnage tax reduction were in effect until next car inspection.

[6]In short, the acquisition tax is 4.5% for the car price.

[7]The tonnage tax was revised to 5000 JPY/500kg in fiscal year 2010.

[8]As shown in the Table 2, the tax incentives on the automobile taxes took the form of the deduction. The amount of deduction is 300000 JPY, and thus the amount of tax reduction was 15000 JPY at maximum because the acquisition tax rate was 5%. During the periods I study, the prices of all car models exceeded 300000 JPY, so the amount of tax reduction should be 15000 JPY for the car models that satisfied the criteria of eco car in Table 2.

2.2 Replacement subsidy

In addition to the tax reduction, the Japanese government passed the "Green" Vehicle Purchasing Promotion Measures on May 29, 2009 in order to induce consumers to purchase new eco-cars. These measures went into effect on June 19, 2009, but was retroactive to April 10, 2009. These measures aimed at further accerating the reduction of CO2 emissions and improving fuel economy by providing incentives to scrap older, less fuel efficient cars.

The program had two parts: one for consumers who are replacing an older passenger car to a new eco-car ("replacement program") and one for those who are purchasing a new eco-car without an older car to replace ("non-replacement program"). In order to apply the replacement program, consumers had to scrap a passenger car that had been first registered 13 years ago or earlier. Under the replacement program, these consumers were eligible for 250000 JPY if they purchased new cars comply with 2010 fuel economy standards in Table 3. On the other hand, consumers could apply the non-replacement program without restriction on car scrapping but the target of cars that were eligible for the subsidy was more severe as the cars have to comply with ♠ in Table 2. By using the non-replacement program, consumers could get 100000 JPY subsidy.

The introduction of the subsidy policy had great impacts on car ownership in Japan. As shown in Table 1, after the introduction of the policy, the average car age for the existing cars in Japan turned around and decreased for the first time since 1993. The result indicates that the subsidy actually contribute to the consumers' car replacement behavior.

3 Model

We here introduce the structural econometric model of demand and supply to assess the role of environmental policies on a market outcome. I employ a discrete choice method to model a consumer behavior and a multiproduct oligopolistic competition model to reveal firm behavior.

3.1 Demand

The demand model is closely related to Goldberg and Verboven (2001), which allows consumer choices to depend on their income in nested logit framework. Here I base the nested logit model but allows the choices to depends on not only income but also the age of a car that each consumer owns.

I consider a household as a unit that makes a car choice. Under this assumption, market size M_t is the number of households in Japan at time t. Each unit chooses one alternative that gives the highest utility from $J_t + 1$ alternatives: J_t motorcycle models offered at time t, and an outside option representing the decision not to purchase new cars. The outside option includes the used car choice and keeping an existing car.

Consumer i's utility obtains from alternative j at time t is specified as follows.

$$u_{ijt} = v_{ijt} + \epsilon_{ijt}, \tag{1}$$

Here v_{ijt} is deterministic part of the utility obtained from product j and ϵ_{ijt} is a random part of the utility. For the utility obtained from the outside option, I normalize the deterministic part v_{i0t} to be zero. I further decomposed v_{ijt} into two parts, i.e.,

$$v_{ijt} = \delta_{jt} + \mu_{ijt}, \tag{2}$$

where δ_{jt} is common to all consumers and hence is called the mean utility, while μ_{ijt} varies across individuals. The mean utility is specified as

$$\delta_{jt} = \mathbf{x}_{jt}\boldsymbol{\beta} + \xi_{jt}, \tag{3}$$

where $\mathbf{x}_{jt}$ is $1 \times K$ vector of characteristics of car j and $\boldsymbol{\beta}$ is $K \times 1$ vector of parameters to be estimated. ξ_j represents a characteristics and demand shock specific to the car j that are unobservable to researchers but observable to consumers and producers.

μ_{ijt} depends on individual characteristics, income y_{it} and the car ages a_{it}, the ages of the car that consumer i own at the beginning of the time t:

$$\mu_{ijt} = -\alpha_{it}[(1.05 + T_{1jt})p_{jt} - S_{jt}(a_{it}) + T_{2jt}] + \gamma a_{it}, \tag{4}$$

where p_{jt} is the price of car j at time t, and $\alpha_{it} = \frac{\alpha}{y_{it}}$ is the price sensitivity of consumer i and under this setting, high-income consumers are less sensitive to car prices. T_{1jt} is an acquisition tax and T_{2jt} is a sum of tonnage and automobile taxes that consumers have to pay at the time of purchase. S_{jt} is the subsidy for purchase and replacement of low emission and fuel efficient cars that came into effect from Apr. 2009. The amount of subsidy is a function of the age of a car that the consumer i holds:

$$S_{jt}(a_{it}) = \begin{cases} 250000 & \text{if } a_{it} \geq 13, t = 2009, \text{ and the car } j \text{ meets fuel economy standards in Table 3,} \\ 100000 & \text{if } a_{it} < 13, t = 2009, \text{ and the car } j \text{ meets } \spadesuit \text{ in Table 2,} \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

The last term in eq.(4) means that the preference on the outside option depends on the car ages because v_{i0t} is normalized to be zero. If γ is positive, consumers who owns the cars of older ages replace their cars more likely. Here, the parameters to be estimated in μ_{ijt} are (α, γ).

ϵ_{ijt} represents taste heterogeneity on car models. I assume ϵ_{ijt} to follow generalized extreme value that allows substitution pattern of the products to depend on the groups that the cars belongs. I classify all car models into 5 groups: compact, sedan & wagon, minivan, sports utility vehicle(SUV), and specialty cars. In addition, I also define the outside option as one group in the choice set. In total, all the alternatives that each consumer faces are categorized into 6 groups. Under this setting, the probability of consumer i choosing a car j at time t can be decomposed into consumer i's choice probability of the car j conditional on choosing a group $g(j)$, $s_{ij/g(j)}$, and the probability of choosing group $g(j)$, the group that the car j belongs to, $s_{ig(j)}$:

$$s_{ijt} = s_{ijt/g(j)} s_{ig(j)t}. \tag{6}$$

The first term in the above equation is given by:

$$s_{ijt/g(j)} = \frac{e^{v_{ij}/\lambda}}{\sum_{l \in g(j)} e^{v_{ilt}/\lambda}} = \frac{e^{v_{ij}/\lambda}}{e^{I_{ig(j)t}}}, \tag{7}$$

where $G = \{compact, sedan\&wagon, minivan, SUV, specialty\}$, and

$$I_{ig(j)t} = \ln \left(\sum_{l \in g(j)} e^{v_{ilt}/\lambda} \right), \tag{8}$$

which is a logit inclusive value, i.e., expected utility obtained from choosing group $g(j)$. On the other hand, the second term in eq.(6) is given by

$$s_{ig(j)t} = \frac{e^{\lambda I_{ig(j)t}}}{e^{v_{i0t}} + \sum_{g \in G} e^{\lambda I_{ig}}}. \tag{9}$$

Here the utility obtained from the out side option is normalized to be zero.

λ is the distributional parameter of the nested logit and captures the pattern of dependency across products in the same group. To be consistent with random utility maximization, λ have to lie in between 0 and 1.(McFadden (1978)) In particular, if $\lambda = 1$, the nested logit structure reduces to a logit model and thus the substitution pattern among products becomes independent of the groups that the products belong. On the other hand, if λ is close to zero, the dependency across products in the same group becomes stronger and at extreme, the products in the same group become a perfect substitute.

The data available to me is market-level data for each car model rather than individual-level data on car choices. Thus, I compute market share s_{jt} by integrating the individual choice probabilities of eq.(6) over income y_{it} and car age a_{it} distribution:

$$s_{jt} = \int_a \int_y s_{ijt} dP_y(y) dP_a(a), \tag{10}$$

where $P_y(\cdot)$ and $P_a(\cdot)$ are the distributions of income and car ages. I use the empirical distribution functions of income and car ages for each year to approximate the demographics of Japanese households. In constructing the empirical distribution, I assume that each household owns at most one car. Then, the data on the number of cars by car ages corresponds to the car age distribution for the households in Japan. Note that this assumption is problematic because some households owns multiple cars in Japan. Indeed, **?** analyzes the multiple choice behavior in Japanese car markets. However, as indicated in the paper, a significant fraction of households that have multiple cars own a combination of a standard-sized car ($\geq$ 660cc) and light car ($<$ 660cc) rather than multiple standard-sized cars. This paper focuses only on the market for standard-sized cars, and thus the assumption of owning at most a single car does not matter so much. Note also that some of the households do not owns a car. In this case, I set a_i for these households to be zero.

3.2 Multiproduct oligopolistic competition

I now specify the supply side of the model to obtain marginal costs for each product, under the assumption that all manufacturers in the market compete in prices. The variable profit function of firm f is

$$\pi_{ft} = \sum_{j \in J_{ft}} \left[p_{jt} q_{jt} - c_{jt}(q_{jt}) \right], \tag{11}$$

where J_{ft} is the set of cars produced by firm f and $c_j(q_{jt})$ is a cost function of product j.

Solving this profit maximization problem, we have a following first order condition for each car model j:

$$\mathbf{mc}_t = \mathbf{p}_t - \mathbf{\Delta}_t^{-1} \mathbf{s}_t, \tag{12}$$

where $\mathbf{p}_t = (p_{1t}, \ldots, p_{J_t})'$, $\mathbf{s}_t = (s_{1t} \ldots, s_{Jt})'$, and $\mathbf{mc}_t = (c'_1, \ldots, c'_J)'$. c'_j is the first derivative of c_j and hence a marginal cost of product j. I here assume that the marginal costs are constant over quantity. The figure 1.05 captures the 5% consumption tax in Japan. $\mathbf{\Delta}_t$ is a $\#J_t \times \#J_t$ matrix whose (j, r)-th element is $\Delta^*_{jrt} \times H_{jrt}$: Δ^*_{jrt} is an (j, r) elements of $\#J_t \times \#J_t$ substitution matrix of the demand system, i.e.,

$$\frac{\partial s_{rt}}{\partial p_{jt}} = \begin{cases} \int_a \int_y \alpha_i (1.05 + T_{1jt}) s_{ijt} \left[\frac{1}{\lambda} - \left(\frac{1-\lambda}{\lambda} \right) s_{ijt/g(j)} - s_{ijt} \right] dP_y(y) dP_a(a) & \text{if } j = r \\ - \int_a \int_y \alpha_i (1.05 + T_{1jt}) s_{irt} \left[\left(\frac{1-\lambda}{\lambda} \right) s_{ijt/g(j)} + s_{ijt} \right] dP_y(y) dP_a(a) & \text{if } j \neq r, r \in g(j) \\ - \int_a \int_y \alpha_i (1.05 + T_{1jt}) s_{irt} s_{ijt} dP_y(y) dP_a(a) & \text{if } j \neq r, r \notin g(j), \end{cases} \tag{13}$$

and, under the price competition assumption, H_{jrt} takes one if both j and r are produced by the same firm, and takes zero otherwise.

Note that $\mathbf{\Delta}_t$ can be computed from the demand estimates. Hence, the (unobserved) marginal cost vector can be recovered from eq. (12). In the simulation analyses, I use the demand estimates and the marginal costs to obtain counterfactual outcome.

4 Estimation

This paper follows Petrin (2002) that uses micro moments based on the information on the relationships car choices and demographic variables in addition to moment conditions proposed in Berry, Levinsohn, and Pakes (1995) (hereafter, BLP's moments), the standard moment conditions used in the existing literature.

Based on the two sets of moments condition introduced below, I implement 2 step efficient GMM by Hansen (1982).

4.1 BLP's moments

As is usual in the existing literature, I estimate the parameters by setting ξ_{jt} as an error term. The problem in implementing the estimation is that the ξ_{jt} should be correlated with p_{jt}, because the positive unobservable characteristics or demand shocks induce higher prices. Here, I employ the moment assumption on ξ following the literature: $E[\xi_{jt}|\mathbf{x}_{1t}, \ldots, \mathbf{x}_{\#J_t t}] = 0$ for all j. Given the identification assumption, the characteristics of all other products are valid instruments of ξ_{jt} because the other product characteristics are correlated with the price of product j under product differentiation. Based on the assumption, I use the set of instruments employed in Goldberg and Verboven (2001). For $j \in J_{ft}$, the instruments of ξ_{jt} are (1) the sum of characteristic k of other products belonging to the same group, $\sum_{r\in\{g(j)\setminus j\}} x_{rkt}$, (2) the sum of the characteristic k of products belonging to other groups, $\sum_{r\in\{J_t\setminus g(j)\}} x_{rkt}$, and (3) the sum of the characteristic k of products belonging to the same group and made by the same firm, $\sum_{r\in\{J_{ft}\cap g(j)\}} x_{rkt}$.

In implementing the estimation, I use BLP's contraction mapping to obtain mean utility for each car models given $(\alpha, \lambda, \gamma)$. Then, the mean utility can be expressed as the function of these parameters, i.e., $\delta_{jt}(\alpha, \lambda, \gamma)$. Given $\delta_{jt}(\alpha, \lambda, \gamma)$ the moment conditions can be constructed based on ξ_{jt}.

4.2 Micro moments

Car age distribution shown in Table 4 depends on consumers' behavior on scrapping and purchasing of new or used cars. Since my structural model aims at revealing the replacement behavior of consumers according to car ages, the evolution of the car age distribution provides important clues to identify the structural parameters. I here introduce micro moments based on new car sales and the evolution of the car age distribution over time.

Let $n_{a,t}$ be the number of cars of age a at year t. (Each element of Table 4) The idea to construct the micro moments is to match the new car sales by car ages with the changes in car age distribution between two adjacent time periods, $n_{a,t} - n_{a-1,t-1}$: if $n_{a,t}$ is much smaller than $n_{a-1,t-1}$, it is likely that many of the consumers who owned the cars of age $a-1$ scrapped the existing cars and purchased new one at time $t-1$; on the other hand, if $n_{a,t}$ is close to $n_{a-1,t-1}$, it is likely that many of the consumers who owned the cars of age $a-1$ choose to retain their cars at time $t-1$.

However, it is not easy to match new car sales by car ages with $n_{a,t} - n_{a-1,t-1}$. One of the problems comes from the fact that $n_{a,t}$ consists of not only the number of consumers who retain the existing cars of age $a-1$ at time $t-1$ but also consumers who purchased the used cars of age $a-1$ at time $t-1$. Because of the presence of the latter type of consumers, it is possible that there are a number of consumers who purchased new cars even though $n_{a,t} - n_{a-1,t-1} = 0$. To deal with this problem, I focus on changes in car age distribution for the older car ages where the trade in used cars is likely to be less active and thus the share of latter type consumers are tiny. Here I assume that $n_{a,t}$ consists mostly of the number of consumers who retain their existing cars for the car age more than 10.

Under this assumption, $n_{a,t} - n_{a-1,t-1}$ is the number of cars of age $a-1$ scrapped at time $t-1$.[9] Those who scrapped their existing cars at $t-1$ have options (1) to purchase new cars, (2) to purchase used cars, or (3) not to purchase any cars. Let ρ_t to be the share of (1) in those who scrapped their car at time t. Assuming that the share is the same for all car ages, I have three moment conditions:

$$
\begin{aligned}
&E\left[i \text{ purchases new vehicle} | a < a_i < a+1\right] = \rho_t(n_{a,t} - n_{a-1,t-1}), a = 11, 12 \\
&E\left[i \text{ purchases new vehicle} | 13 < a_i\right] = \rho_t(n_{a,t} - n_{a-1,t-1}),
\end{aligned}
\tag{14}
$$

The problem here is that I do not have the information on (3), i.e. those who scrapped but not purchased alternative cars. However, the number of (3) is normally small and thus I set ρ_t to be

$$
\frac{\text{Total new car sales}}{\text{Total new car sales} + \text{Total used car sales}}. \tag{15}
$$

[9]Thus, $n_{a,t} - n_{a-1,t-1} = 0$ means that all the consumers who owned the car of age $a-1$ at time $t-1$ retain their existing cars.

4.3 Data

The dataset used in this paper covers from fiscal year 2005 to 2009. I constructed the dataset based on several independent sources. Price and characteristics data for each automobile model are obtained from the *Saishin Kokusan & Yunyuu-sha Konyuu Guide* (*Current Domestic & Import Cars Purchase Guide*) published by the JAF publishing. Quantity sold for each automobile model is obtained from *Jidousha Touroku Tokei Jouhou: Shinsha-hen* (*New Car Registration Statistics*) published monthly by Japan Automobile Dealers Association. This paper focus only on the standard-sized cars (>660cc). In addition, I use only the data of Japanese cars and do not use the data of the imported cars. Although it is desirable to directly assess the effects on import cars, the detail information on the import cars are unavailable.

I collect the information on the individual characteristics distribution: the number of cars by car ages from *Sho-do Touroku Nen-betsu Jidousha Hoyuu Sharyou-suu Toukei* (*Number of Vehicle holdings by first registration years*) published annually by Automobile Inspection & Registration Information Association, and income distribution from *Kokumin Seikatsu Kiso Chosa* (*Comprehensive Survey of Living Conditions of the People on Health and Welfare*) released annually by the Ministry of Health, Labor and Welfare.

In order to compute ρ_t in the micro moments, I also collect the number of used car sales from *Jidousha Touroku Tokei Jouhou: Chukosha-hen* (*Used Car Registration Statistics*) published monthly by Japan Automobile Dealers Association..

4.4 Estimation results

In addition to the model introduced in Section 3, I also implement standard demand estimation based on a standard nested logit framework as in Berry (1994). The estimation equation is given by:

$$\ln(s_{jt}) - \ln(s_{0t}) = \delta_{jt} - \alpha p_{jt} - (1-\lambda)\ln(s_{jt/g(j)}). \tag{16}$$

In the estimation of the standard nested logit, I do not directly include the volume of tax reduction and subsidy but include a dummy variable for eco-car to see the effects of the environmental policies.

I first implement the estimation of the standard nested logit by OLS and GMM to see whether the bias in parameter estimates are corrected by instrumenting. The data used in the estimation is summarized in the Table 5. Note that the price coefficient should be biased upwardly because of the positive correlation between price and unobserved characteristics. In addition, positive (negative) ξ_{jt} induces higher share within the group where product j belongs: given positive correlation between ξ_{jt} and $s_{jt/g(j)}$, the estimate of λ should also be biased downwardly. As is shown in Table 6 (i) and (ii), the price coefficient $-\alpha$ and λ get lower after instrumenting as is expected. The coefficients on the car characteristics are also reasonably estimated; for example, the coefficient on car size and fuel cost takes positive and negative value, respectively. In particular, the coefficient on the eco-car dummy variable is positive, which suggests that the environmental policies had positive impacts on the car demand.

Now I turn to the results of the estimation with individual characteristics, an income and a car age. I implement the estimations with and without micro moments. The estimation results are summarized in Table 6 (iii) and (iv). First of all, price coefficient $-\alpha$ is negative and significant for both specifications. λ lies in between 0 and 1 and thus the estimation results are consistent with random utility maximization problem. In particular, as the estimate of λ is significantly different from 1, the results indicate that the substitution pattern among products depends on the groups that the products belong. The coefficients on car characteristics have also reasonable sign.

The estimation results also show the effects of car ages on the consumers' car choices: a consumer who owned an older car replaces his car more likely. Note that the estimate of γ is significant in the estimation with micro moments, while it does not significant in the estimation without micro moments. The results suggest that incorporating micro moments plays an important role in identifying the parameters.

5 Simulation

Based on the estimates, we here implement counterfactual simulation to assess the effects of the environmental policy in Japan. I further investigate what would happen if the government expand the scope of eco-cars that can receive the subsidy following the suggestion of the US government.

5.1 Effects of the environmental policies on the Japanese car market

I now investigate the effects of the environmental policies on the market outcome. I simulate counterfactuals in the absence of the environmental policies: no tax exemption and no subsidy.[10] I here focus on the effects of these policies on the firms' profits and the average fuel economy of new car sales.

The effects on the firms' profits are summarized in Table 7. As shown in the table, the firms that gained large benefits from the environmental policies are Honda and Toyota. This is because Toyota produces a larger number of car models equipped Hybrid engine, such as Prius, of which the government supported the purchase especially, compared to other firms.

Table 8 shows the effects of the environmental policies on the average fuel economy of new cars. As is shown in the table, the effects on the average fuel economy are small from 2005 to 2008. However, the changes in the policy in 2009 had a large impact on the average fuel economy: the average fuel economy was improved by about 2.4%.

[10] In implementing simulation, I assume the car ages distributions in counterfactual to be the same as in actual. The assumption is problematic because changes in new car sales in one year should change the car age distribution in the following years. In future analysis, I would like to account for the changes in distribution in the simulation.

5.2 Disguised protectionism?

The environmental policies in Japan has been criticized by US car manufacturers because the subsidy and tax exemption are mostly applicable only to the Japanese automobiles. Although Japanese government slightly altered the eco-car certification for imported cars upon the USTR request, USTR has still criticized the Japanese eco-car certification rule and request the scope of eco-cars. In particular, it proposed a different measuring method of fuel economy that put weight on the driving test on express way that generates higher fuel efficiency.

The purpose of the analysis here is to assess what would happen if the Japanese government applies a new eco-car certification according to the US request. I here consider a situation in which the target fuel economy standard is lowered by 10%. Japan's calculation of the fuel economy was based on 10–15 mode fuel economy under which the ratio of driving on ordinary street to driving on express way is set at 3:1, while the US proposed one was based on the ratio to be 1:1. Since the fuel economy on the express way is smaller than that on ordinary street by about 30%, the fuel economy would be declined by about 10% compared to the current calculation if the US proposed one is applied. Based on this assumption, I construct a new set of cars that applicable to subsidy and assess the impacts of average fuel efficiency of new car sales. The analysis focuses on the effects in 2009 when foreign manufacturers actually criticized the environmental policies in the Japanese car market.

Table 9 shows the effects of the changes in eco-car certification on the firms' variable profits. Since the alternative eco-car certification expand the range of the car models that meets the requirements of subsidy, most firms increase their profits. However, Suzuki and Subaru slightly reduce their profits. This might be because the car models that compete in Suzuki and Subaru cars are subsidized under the alternative certification.

I here compute how much the alternative certification system affects the average fuel economy. In addition, I compute subsidy needed to improve the average fuel economy of new car sales by 0.1km/l to see the efficiency of the subsidy policy in terms of improving fuel economy. The first row in Table 10 shows the result of the effects on average fuel economy. Since the alternative eco-car certification expand the range of the eco-car, the average fuel economy under alternative eco-car certification is lower than that under the actual eco-car certification. Although the decrease in the average fuel economy is tiny, the alternative eco-car certification is inefficient in improving the average fuel economy, as shown in the second row in Table 10: it requires 44.731 bill. JPY under the alternative eco-car certification in order to improve the average fuel economy by 0.1km/l, while it requires 48.007 bil. JPY under the actual eco-car certification. Therefore, expanding the scope of eco-cars from the original one is not efficient and thus the environmental policies introduced in 2009 can be justified in terms of improving fuel economy.[11]

6 Conclusion

This paper examines the Japanese car markets to assess the impacts of environmental policies on the market outcome. Based on the structural econometric model of demand and supply, this paper assesses the environmental policies introduced in the Japanese car market. In the estimation of demand, I incorporate the micro moments in order to identify the effects of the age of a car that a consumer hold at the time of choice.

This paper shows that the environmental policies had a large impacts on the firms' profits. In particular, Honda and Toyota significantly earned from the environmental policies. Although the policy improved the average fuel economy of newly sold cars only a little from 2005 to 2008, the revised policy introduced in 2009 has a large impact on the average fuel economy. In order to investigate whether or not the Japanese environmental policies were the case of disguised protectionism, I further investigates the alternative eco-car certification system suggested by USTR. This paper shows that although the effects on average fuel

[11] Note that since the alternative eco-car certification increases the car replacements, it might be effective in terms of improving the fuel economy in Japan. In this simulation, I found that the alternative eco-car certification system increases the sales by 6465, which is amount to merely 0.238% of total car sales in Japan. Therefore, it is reasonable to conclude that the effects on the average fuel economy for all Japanese cars is also small.

economy under the alternative eco-car certification system is comparable to that under the actual eco-car certification system, the alternative one is inefficient in terms of improving fuel economy: it requires much larger amount of subsidy in order to achieve the same fuel economy level. Therefore, the policies would not be the disguised measure of trade restriction.

References

2009. "An empirical investigation of the pollution haven effect with strategic environment and trade policy." *Journal of International Economics* 78:242–255.

Adda, Jerome and Russell Cooper. 2000. "Balladurette and Juppette: a discrete analysis of scrapping subsidies." *Journal of Political Economy* 108 (4):778–806.

Barrett, Scott. 1994. "Strategic environmental policy and international trade." *Journal of Public Economics* 54:325–338.

Beresteanu, Arie and Shanjun Li. 2011. "Gasoline prices, government support, and the demand for hybrid vehicles in the United States." *International Economic Review* 52 (1):161–182.

Berry, Steven. 1994. "Estimating discrete-choice models of product differentiation." *RAND Journal of Economics* 25 (2):242–262.

Berry, Steven, James Levinsohn, and Ariel Pakes. 1995. "Automobile prices in market equilibrium." *Econometrica* 63 (4):841–890.

———. 1999. "Voluntary export restraints on automobiles: evaluating the trade policy." *American Economic Review* 89 (3):400–430.

Clerides, Sofronis. 2008. "Gains from trade in used goods: Evidence from automobiles." *Journal of International Economics* 76:322–336.

Conrad, Klaus. 1993. "Taxes and subsidies for pollution intensive industries as trade policy." *Journal of Environmental Economics and Management* 25:121–135.

Copeland, Brian R. 1990. "Strategic internaction among nations: negotiable and non-negotiable trade barriers." *Canadian Journal of Economics* 23 (1):84–108.

Ederington, Josh. 2001. “International cordination of trade and domestic policies.” *American Economic Review* 91 (5):1580–1593.

———. 2002. “Trade and domestic policy linkage in international agreement.” *International Economic Review* 43 (4):1347–1367.

Ederington, Josh, Arik Levinson, and Jenny Minier. 2005. “Footloos and pollution-free.” *Review of Economics and Statistics* 87 (1):92–99.

Ederington, Josh and Jenny Minier. 2003. “Is environmental policy a secondary trade barrier? An empirical analysis.” *Canadian Journal of Economics* 36 (1):137–154.

Esty, Daniel C. 1994. *Greening the GATT, Environment, and the Future*. Institute for International Economics.

Goldberg, Pinelopi Koujianou. 1998. “The effects of the corporate average fuel economy standards in the Automobile Industry.” *Journal of Industrial Economics* 46:1–33.

Goldberg, Pinelopi Koujianou and Frank Verboven. 2001. “The evolution of price dispersion in the European car market.” *Review of Economic Studies* 68:811–848.

Hansen, Lars Peter. 1982. “Large sample properties of generalized method of moments estimators.” *Econometrica* 50 (4):1029–1054.

Irwin, Douglas A. 2009. *Free Trade Under Fire*. Princeton University Press, 3rd edition ed.

Kennedy, Peter W. 1994. “Equilibrium pollution taxes in open economies with imperfect competition.” *Journal of Environmental Economics and Management* 27:49–63.

Kitano, Taiju. 2011. “Did temporary protection induce technology adoption? A study of the US motorcycle industry.” Mimeo.

McFadden, Daniel. 1978. “Modelling the choice of residential location.” In *Spatial Interaction Theory and Planning Models*, edited by Anders Karlqvist, Lars Lundqvist, Folke Snickars, and Jorgen W. Weibull. Amsterdam: North-Holland, 75–96.

Parry, Ian W. H., Margaret Walls, and Winston Harrington. 2007. “Automobile externalities and policies.” *Journal of Economic Literature* 45:373–399.

Petrin, Amil. 2002. “Quantifying the benefits of new products: the case of minivan.” *Journal of Political Economy* 110 (4):705–729.

Schiraldi, Pasquale. 2011. “Automobile Replacement: a Dynamic Structural Approach.” *RAND Journal of Economics* 42 (2):266–291.

Vogel, David. 1997. *Trading Up: Consumer and Environmental Regulation in a Global Economy*. Harvard University Press.

Table 1: Average Car Age, 1990 – 2010

Year	Average Car Age
1990	4.40
1991	3.67
1992	3.14
1993	2.93
1994	2.94
1995	3.07
1996	3.28
1997	3.53
1998	3.90
1999	4.37
2000	4.82
2001	5.22
2002	5.63
2003	6.03
2004	6.38
2005	6.66
2006	6.89
2007	7.14
2008	7.26
2009	7.49
2010	7.48

Table 2: Tax Incentives, Fiscal Year 2005 – 2009

FY 2005		Gas-Vehicle		Hybrid-Vehicle
		Imprived Fuel Economy Certification		
		Performing 4% better or more campared to 2010 target fuel economy standards	Meeting 2010 target fuel economy standards or better	2010 target fuel economy standards +25%
Environmental Performance Certification	Emissions down by 75% from 2005 standards	Automobile Tax: 50% reduction Acquisition Tax: 300000 JPY deductible Tonnage Tax: None	Automobile Tax: 25% reduction Acquisition Tax: 200000 JPY deductible Tonnage Tax: None	Automobile Tax: 50% reduction Acquisition Tax: 44% reduction Tonnage Tax: None
	Emissions down by 50% from 2005 standards	Automobile Tax: 25% reduction Acquisition Tax: 200000 JPY deductible Tonnage Tax: None	None	-

FY 2006		Gas-Vehicle		Hybrid-Vehicle
		Imprived Fuel Economy Certification		
		2010 target fuel economy standards +20%	2010 target fuel economy standards +10%	2010 target fuel economy standards +25%
Environmental Performance Certification	Emissions down by 75% from 2005 standards	Automobile Tax: 50% reduction Acquisition Tax: 300000 JPY deductible Tonnage Tax: None	Automobile Tax: 25% reduction Acquisition Tax: 150000 JPY deductible Tonnage Tax: None	Automobile Tax: 50% reduction Acquisition Tax: 44% reduction Tonnage Tax: None

FY 2007		Gas-Vehicle		Hybrid-Vehicle
		Imprived Fuel Economy Certification		
		2010 target fuel economy standards +20%	2010 target fuel economy standards +10%	2010 target fuel economy standards +25%
Environmental Performance Certification	Emissions down by 75% from 2005 standards	Automobile Tax: 50% reduction Acquisition Tax: 300000 JPY deductible Tonnage Tax: None	Automobile Tax: 25% reduction Acquisition Tax: 150000 JPY deductible Tonnage Tax: None	Automobile Tax: 50% reduction Acquisition Tax: 40% reduction Tonnage Tax: None

FY 2008		Gas-Vehicle		Hybrid-Vehicle
		Imprived Fuel Economy Certification		
		2010 target fuel economy standards +25%	2010 target fuel economy standards +15%	2010 target fuel economy standards +25%
Environmental Performance Certification	Emissions down by 75% from 2005 standards	Automobile Tax: 50% reduction Acquisition Tax: 300000 JPY deductible Tonnage Tax: None	Automobile Tax: 25% reduction Acquisition Tax: 150000 JPY deductible Tonnage Tax: None	Automobile Tax: 50% reduction Acquisition Tax: 36% reduction Tonnage Tax: None

FY 2009		Gas-Vehicle		Hybrid-Vehicle
		Imprived Fuel Economy Certification		
		2010 target fuel economy standards +25%	♠2010 target fuel economy standards +15%	♠2010 target fuel economy standards +25%
Environmental Performance Certification	Emissions down by 75% from 2005 standards	Automobile Tax: 50% reduction Acquisition Tax: 75% reduction Tonnage Tax: 75% reduction	Automobile Tax: 25% reduction Acquisition Tax: 50% reduction Tonnage Tax: 50% reduction	Automobile Tax: 50% reduction Acquisition Tax: 100% reduction Tonnage Tax: 100% reduction

Note: All the consumers can obtain subsidy when purchasing the cars that satisfy ♠.

Table 3: 2010 Target Fuel Economy Standards (km/l)

Weight	Fuel Economy Standards	Fuel Economy Standards+10%	Fuel Economy Standards+15%	Fuel Economy Standards+20%	Fuel Economy Standards+25%
– 703kg	21.2	23.3	24.4	25.4	26.5
703 – 828kg	18.8	20.7	21.6	22.6	23.5
828 – 1016kg	17.9	19.7	20.6	21.5	22.4
1016–1266kg	16.0	17.6	18.4	19.2	20.0
1266–1516kg	13.0	14.3	15.0	15.6	16.3
1516–1766kg	10.5	11.6	12.1	12.6	13.1
1766–2016kg	8.9	9.8	10.2	10.7	11.1
2016–2266kg	7.8	8.6	9.0	9.4	9.8
2266kg–	6.4	7.0	7.4	7.7	8.0

Table 4: Car age distribution, 2005 – 2010 (Number of cars by car ages)

Car age	2005	2006	2007	2008	2009	2010
1	1022998	1000633	893269	903196	631084	884592
2	3360166	3323627	3089041	2899000	2753322	2618982
3	3371919	3344078	3305518	3066885	2883932	2738161
4	3384903	3301118	3273161	3222259	3006745	2826529
5	3380193	3337076	3247963	3209111	3172801	2972044
6	3287717	3272803	3230018	3126308	3118174	3095997
7	3105332	3184605	3163291	3104485	3021215	3057364
8	3209156	2952492	3029445	2983129	2966970	2928299
9	3548638	3074905	2829798	2895774	2857176	2884513
10	3380220	3279890	2854238	2626986	2720941	2698472
11	2822653	3053283	2999782	2614486	2419562	2554663
12	2287247	2459407	2702221	2642966	2323367	2181251
13+	6615036	7163363	7611664	8174404	8923956	8978053

Source: *Sho-do Touroku Nen-betsu Jidousha Hoyuu Sharyou-suu Toukei* (English translation: *Number of Vehicle holdings by first registration years*), Automobile Inspection & Registration Information Association.
Note: The figure in the table is the number of cars at the beginning of a fiscal year. The figure of car age 1 is the number of cars that is registered only from Jan. – Mar. for each year and thus smaller than the number for the other car ages. The figure of car age 13+ is the number of cars that registered more than 13 years ago.

Table 5: Summary Statistics

Variables	Mean	Std. Dev.
Sales	23481	30418
Price (in mil. JPY)	2.5134	1.3849
Car Size = Length*Width*Height (m^3))	3.8688	1.168
HP (ps)/Weight(1000kg)	8.1242	2.4121
Engine Displacement (1000cc)	2.111	0.8301
Wheelbase (m)	2.669	0.1894
Fuel Cost = Gasoline Price(JPY)/Fuel Economy(km/l)	10.336	2.9627
Eco-car dummy	0.1369	0.3438
Num. of Obs.	577	

Table 6: Estimation results

	Standard Nested Logit (Linear Model)						Nested Logit with Individual characteristics					
	(i) OLS			(ii) GMM			(iii) No micro moments			(iv)Micro moments		
Variables	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
Car Size	0.377	0.047	***	0.299	0.058	***	0.349	0.049	***	0.349	0.056	***
HP/Weight	-0.009	0.026		0.085	0.034	**	0.149	0.061	**	0.147	0.083	*
Engine Displacement	0.204	0.094	**	0.266	0.157	*	0.640	0.174	***	0.836	0.249	***
Wheelbase	0.598	0.234	**	0.819	0.340	**	1.274	0.325	***	1.474	0.453	***
Fuel Cost	-0.220	0.018	***	-0.191	0.023	***	-0.153	0.022	***	-0.189	0.020	***
Eco-car dummy	0.254	0.072	***	0.762	0.104	***	-	-		-	-	
Constant	-7.580	0.553	***	-11.051	0.852	***	-11.329	0.628	***	-10.833	0.852	***
$-\alpha$	-0.103	0.057	*	-0.471	0.151	***	-13.622	2.402	***	-15.987	2.402	***
λ	0.597	0.025	***	0.892	0.040	***	0.806	0.002	***	0.804	0.002	***
γ	-	-		-	-		-0.01	0.042		0.041	0.020	**
$R^2/J-stat$ (dof)	0.63			36.25(16)			14.22(16)			16.45(16)		

Table 7: Effects on variable profits by firms (in mil. JPY)

	(i) Actual Variable Profits				
	2005	2006	2007	2008	2009
Daihatsu	6013	9777	4721	3185	3051
Honda	272850	229038	233828	212787	273539
Mazda	109161	95844	92042	74949	79214
Mitsubishi	45642	40923	47630	29618	38611
Nissan	374857	298110	284993	241613	255577
Subaru	77147	58541	50283	44348	47734
Suzuki	39019	40465	40609	38468	28460
Toyota	1083195	1027185	1000488	865932	1052414
Total	2007884	1799883	1754594	1510900	1778601
	(ii) Counterfactual: No Environmental Policy				
	2005	2006	2007	2008	2009
Daihatsu	5581	9130	4448	2986	2772
Honda	239149	200863	206632	186431	200567
Mazda	97324	85135	82698	69511	71668
Mitsubishi	40556	36370	43189	26693	33538
Nissan	338932	267933	257233	219441	216363
Subaru	74390	55583	47560	41420	44213
Suzuki	34949	35698	37249	34402	23942
Toyota	981522	927235	911125	781504	846552
Total	1812403	1617947	1590134	1362387	1439615
	(iii) Effects of the Environmental Policies: (i) – (ii)				
	2005	2006	2007	2008	2009
Daihatsu	433	647	273	199	279
Honda	33701	28174	27196	26356	72973
Mazda	11837	10710	9345	5439	7546
Mitsubishi	5086	4553	4441	2925	5073
Nissan	35925	30176	27760	22172	39214
Subaru	2757	2959	2723	2929	3521
Suzuki	4070	4767	3359	4066	4518
Toyota	101673	99950	89363	84428	205862
Total	195481	181936	164460	148513	338986
	(iv) Rate of Change				
	2005	2006	2007	2008	2009
Daihatsu	7.75	7.08	6.14	6.65	10.08
Honda	14.09	14.03	13.16	14.14	36.38
Mazda	12.16	12.58	11.30	7.82	10.53
Mitsubishi	12.54	12.52	10.28	10.96	15.13
Nissan	10.60	11.26	10.79	10.10	18.12
Subaru	3.71	5.32	5.73	7.07	7.96
Suzuki	11.65	13.35	9.02	11.82	18.87
Toyota	10.36	10.78	9.81	10.80	24.32
Total	10.79	11.24	10.34	10.90	23.55

Table 8: Effects on Average Fuel Efficiency

	Actual(km/l)	Counterfactual(km/l)	Difference	Rate of Change(%)
2005	15.686	15.665	0.022	0.137
2006	15.938	15.906	0.032	0.202
2007	16.414	16.359	0.055	0.335
2008	17.054	17.018	0.036	0.212
2009	19.234	18.785	0.449	2.388

Table 9: Effects of the change in eco-car certification (in mil. JPY)

	(i) Actual	(ii) Counterfactual: Alternative eco-car certification	Effect of Subsidy	Rate of Change
Daihatsu	3051	3081	29	0.95
Honda	273539	273542	2	0.00
Mazda	79214	79411	198	0.25
Mitsubishi	38611	38644	33	0.08
Nissan	255577	255756	178	0.07
Subaru	47734	47636	-98	-0.21
Suzuki	28460	28404	-56	-0.20
Toyota	1052414	1055571	3157	0.30
Total	1778601	1782044	3443	0.19

Table 10: Effects of alternative eco-car certification system

	Actual Certification System	Alternative Certification System
Average Fuel Economy (km/l)	19.234	19.213
Effects of subsidy on average fuel economy (km/l)	0.449	0.427
Subsidy required to improve the average fuel economy by 0.1 km/l (bil. JPY)	44.731	48.007