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Quality Regulation in the Used Car Market and New Car Sales

by

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I. Introduction

All the used cars must be inspected by the governmental agency every two years to check if they satisfy various standards of quality in Japan.(1) Usually owners take their cars to dealers. Dealers check the cars, repair them, replace some of its parts and then take the cars to the governmental agency in place of owners. Owners pay money (something like $500 or $1000 depending on the condition of the car) to dealers, which includes inspection fee paid to the government.

Thus the minimum level of cars' qualities are regulated in Japan. Owners must pay something like $500 or $1000 every two years to keep their used cars. The older the car becomes, the worse its condition becomes and so the more money is needed at the time of car inspection. This Japanese system of car inspection is said to have the effect of decreasing the demand for used cars and increasing the demand for new cars by reducing the competition from used cars. Thus it is often believed to increase the profit of new car manufacturers such as Toyota and Datsun.

The purpose of this paper is to examine if there is really the above mentioned effect of the quality regulation of used cars by setting up a simple model of simultaneous equilibrium of new and used car markets.

There are two major ways through which the quality regulation of used cars affect the demand for new cars.(2) One is the substitution effect. New and used cars are close substitutes.(3) The substitution effect of the regulation works in two opposite ways as follows. If the regulation reduces the number of used cars in usage, then it reduces the number of close substitutes for new cars and so increases the demand for them ceteris paribus.

If the regulation increases the quality level of used cars, then used cars become more close substitutes for new cars and so it decreases the demand for new cars.[4] Thus the net effect of the substitution effect on new car demand is not obvious.

The other effect of the quality regulation of used cars is the present value effect. This effect will work also in two opposite ways as follows. New car price is the present value of its service flow in use and its resale price as a used car. The resale price is the trade-in price, which is equal to the used car price minus the margin of used car dealers. The total price of a used car is the used car price plus inspection fee and the associated repair cost. So the quality regulation will, ceteris paribus, lower the demand price for used cars. This will work to lower new car price. On the other hand the quality regulation increases the quality of used cars, which will, ceteris paribus, increase the demand price of used cars. This will work to increase new car price.[5] Thus the net effect of the present value effect on new car demand is not obvious, too.

Therefore it is not obvious whether or not the quality regulation of used cars increases the demand for new cars. This paper will do comparative static analyses to see the effects of the increase of the required quality level of used cars on the sales volume and price of new cars, and the profit of the new car manufacturer among others.

II. Model

We assume that all the used cars have the same quality level v before the repair at the time of car inspection. The required quality level of used cars is u_1 which is higher than v.(6) u_1 is given exogenously by the government. All the used cars are assumed to have the same quality u_1 after the inspection. The fixed inspection fee is β_0. The repair cost is $\beta_1(u_1:v)$. The total cost of the used car inspection $\beta(u_1)$ is the sum of β_0 and $\beta_1(u_1)$. β_0 is much smaller than $\beta_1(u_1)$, and is assumed sometimes to be zero. The marginal repair cost $\beta_1'(u_1)(=\beta'(u_1))$ is assumed sometimes to be a constant α for simplicity. Under the assumption of zero inspection fee and constant marginal repair cost, $\beta(u_1) = \alpha(u_1 - v)$.

The used car market is perfectly competitive and the price of the used car is denoted as p_1. Buyers of new cars can sell them as used cars at p_1, after they use them as new cars. Used cars deteriorate much after use and so they are not resold again but are thrown away at zero cost.

New cars are supplied by a monopolist at price p_2. All the new cars have the same quality u_2 which is given exogenously. New cars deteriorate from the quality level u_2 to v after use. The quality of used cars increases from v to the required level u_1 by the repair, but u_1 is assumed to be lower than u_2. Marginal cost of producing a new car is a constant c and is equal to average production cost.

We assume a stationary state where the production of new cars is constant over time. Then the number of used cars is equal to the number of new cars, because used cars are thrown away after use in our model.

Other goods than cars are summarized as one good called numéraire whose price is one. The quality of the numéraire good u_0 is an exogenously given positive number which is smaller than u_1. Thus we have assumed that $0 < u_0 < u_1 < u_2$.

Consumers buy at most one car. They are distributed uniformly over

[0,b] on the income axis with height 1. So the income level t is different among consumers. But all the consumers have the same utility function of Shaked and Sutton (1982) type. Let z be the quantity consumed of the numéraire good. Then the utility of a new car buyer is $u_2 z$. The utility of a used car buyer is $u_1 z$. The utility of a consumer without any car is $u_0 z$.

III. Consumer Demands for New and Used Cars

We have to analyze consumer behavior in order to derive demands for new and used cars. Consumers are divided into three groups according to their behavior. The first group of consumers buys new cars, the second group buys used cars, and the third group does not buy any car. We are going to obtain the conditions that characterize each group.

First we will obtain the condition for buying a new car. The buyer of a new car must pay p_2, but can sell it at p_1 as a used car after he uses it. So assuming the perfect capital market implicitly, the budget constraint of a consumer of income t is written as inequality (1) below. A new car buyer of income t buys $t+p_1-p_2$ units of the numéraire good. So he attains the utility level of $u_2(t+p_1-p_2)$ by buying a new car. If he buys a used car instead of a new car, he has to pay the used car price p_1 and the car inspection cost β, and so he buys $t-p_1-\beta$ units of the numéraire and thus attains the utility level of $u_1(t-p_1-\beta)$. Therefore inequality (2) below is the condition under which a consumer of income t prefers buying a new car to buying a used car. Similarly inequality (3) below is the condition under which a consumer of income t prefers buying a new car to living without any car. The utility level of living without any car is of course $u_0 t$.

$$\begin{cases} t \geqq p_2 - p_1 & \text{------- (1)} \\ u_2(t+p_1-p_2) \geqq u_1(t-p_1-\beta) & \text{----------- (2)} \\ u_2(t+p_1-p_2) \geqq u_0 t & \text{----------- (3)} \end{cases}$$

Those consumers whose income levels satisfy the above conditions (1), (2), (3) buy new cars. (3) is rewritten as $t \geqq u_2(p_2-p_1)/(u_2-u_0)$. Since $u_2/(u_2-u_0)$ is larger than one, $u_2(p_2-p_1)/(u_2-u_0)$ is larger than p_2-p_1. So if (3) is satisfied, (1) is satisfied. (2) is rewritten as $t \geqq \{u_2p_2-(u_1+u_2)p_1 - u_1\beta\}/(u_2-u_1)$. The inequality $\{u_2p_2 - (u_1+u_2)p_1 - u_1\beta\}/(u_2-u_1) \geqq u_2(p_2-p_1)/(u_2-u_0)$ is equivalent to $p_2 \geqq [\{u_1(u_2-u_0) + u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$. Therefore the income range of consumers who buy new cars is as follows.

(a) When $p_2 \geqq [\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$, consumers of income range $[\{u_2p_2-(u_1+u_2)p_1 - u_1\beta\}/(u_2-u_1),\ b]$ buy new cars.

(b) When $p_2 \leqq [\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$, consumers of income range $[u_2(p_2-p_1)/(u_2-u_0),\ b]$ buy new cars.

Similarly those consumers whose income levels t satisfy the following conditions buy used cars.

$$\begin{cases} t \geqq p_1+\beta & \text{----------- (4)} \\ u_1(t-p_1-\beta) \geqq u_2(t+p_1-p_2) & \text{----------- (5)} \\ u_1(t-p_1-\beta) \geqq u_0 t & \text{----------- (6)} \end{cases}$$

So the following income range of consumers buy used cars.

(a) When $p_2 \geqq [\{(u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$, it is the income range $[u_1(p_1+\beta)/(u_1-u_0),\ \{u_2p_2 - (u_1+u_2)p_1 - u_1\beta\}/(u_2-u_1)]$.

(b) When $p_2 \leqq [\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$, there is no range of t that satisfies (4), (5) and (6) at the same time. So there are no consumers who buy used cars.

Similarly those consumers whose income levels t satisfy the following conditions do not buy any car.

$$\begin{cases} u_0 t \geqq u_2(t+p_1-p_2) & \text{----------- (7)} \\ u_0 t \geqq u_1(t-p_1-\beta) & \text{----------- (8)} \end{cases}$$

So the following income range of consumers do not buy any car.

(a) When $p_2 \geqq [\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$, it is the income range $[0,\ u_1(p_1+\beta)/(u_1-u_0)]$.

(b) When $p_2 \leqq [\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$, it is the income range $[0,\ u_2(p_2-p_1)/(u_2-u_0)]$.

Arranging the above results, we have the following consumer demands for new and used cars, because consumers are distributed uniformly over [0,b] with height 1.

(a) When $p_2 \geqq [\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$, the demand for new cars is $b-\{u_2p_2-(u_1+u_2)p_1-u_1\beta\}/(u_2-u_1)$. The demand for used cars is $\{u_2p_2-(u_1+u_2)p_1-u_1\beta\}/(u_2-u_1) - u_1(p_1+\beta)/(u_1-u_0)$. Consumers of income range $[0,\ u_1(p_1+\beta)/(u_1-u_0)]$ do not buy any car.

(b) When $p_2 \leqq [\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$, the demand for new cars is $b-u_2(p_2-p_1)/(u_2-u_0)$. Consumers of income range $[0,\ u_2(p_2-p_1)/(u_2-u_1)]$ do not buy any car. There is no demand for used cars.

IV. Profit Maximization of a New Car Manufacturer

As we saw in the previous section, the new car demand is different in the cases (a) and (b) above, depending on the value of p_2. First we will examine the case (a) where $p_2 \geqq [\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$. Let x be the number of new cars. Then the demand function for new cars is as follows.

$$x = b-\{u_2p_2-(u_1+u_2)p_1-u_1\beta\}/(u_2-u_1) \qquad (9)$$

This gives the following inverse demand function.

$$p_2 = \{(u_2-u_1)b+(u_1+u_2)p_1+u_1\beta\}/u_2 - (u_2-u_1)x/u_2 \qquad (10)$$

So the profit maximizing behavior of the new car manufacturer is described as follows in case (a).

$$\begin{cases} \max\limits_{x} \quad \pi = \left[\dfrac{(u_2-u_1)b+(u_1+u_2)p_1+u_1\beta}{u_2} - \dfrac{(u_2-u_1)x}{u_2}\right]x - cx \\ \text{subject to} \quad p_2 \geqq \dfrac{\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta}{u_2(u_1-u_0)} \end{cases}$$

Unconstrained solution x^* of the above maximization problem is as follows.

$$x^* = \{(u_2-u_1)b+(u_1+u_2)p_1+u_1\beta-u_2c\}/2(u_2-u_1) \qquad (11)$$

Putting this value into (10), we have the following.

$$p_2^* = \{(u_2-u_1)b+(u_1+u_2)p_1+u_1\beta+u_2c\}/2u_2 \qquad (12)$$

The attained profit π^* is as follows.

$$\pi^* = \{(u_2-u_1)b+(u_1+u_2)p_1+u_1\beta-u_2c\}^2/4u_2(u_2-u_1) \qquad (13)$$

We will show later in section V that the new car price p_2^* satisfies the constraint for the plausible values of the parameters, after we obtain the equilibrium price of the used car.

Next we consider the case (b). The behavior of the new car manufacturer is formulated as follows.

$$\begin{cases} \max_{x} & \pi = \left[\dfrac{(u_2-u_0)b+u_2p_1}{u_2} - \dfrac{(u_2-u_0)x}{u_2}\right]x - cx \\ \text{s.t.} & p_2 \leqq \dfrac{\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1 + u_1(u_2-u_0)\beta}{u_2(u_1-u_0)} \end{cases}$$

The unconstrained solution of the above maximization is as follows.

$$\left.\begin{aligned} x^* &= \{(u_2-u_0)b+u_2p_1-u_2c\}/2(u_2-u_0) \\ p_2^* &= \{(u_2-u_0)b+u_2p_1+u_2c\}/2u_2 \\ \pi^* &= \{(u_2-u_0)b+u_2p_1-u_2c\}^2/4u_2(u_2-u_0) \end{aligned}\right\} \quad ---------- (14)$$

We will show in section V that the new car price p_2^* above of case (b) does not satisfy the constraint for the plausible values of the parameters and that the new car manufacturer will adopt the policy of case (a). That is, it will adopt the production policy (11) or the price policy (12).

V. Equilibrium of the Used Car Market

We will examine the cases (a) and (b) in turn. First we will take case (a). The demand y^D for used cars is as follows in this case.

$$\begin{aligned} y^D &= \{u_2p_2^* - (u_1+u_2)p_1 - u_1\beta\}/(u_2-u_1) - u_1(p_1+\beta)/(u_1-u_0) \\ &= \{(u_2-u_1)b - (u_1+u_2)p_1 - u_1\beta + u_2c\}/2(u_2-u_1) - u_1(p_1+\beta)/(u_1-u_0) \end{aligned}$$

The supply y^S of used cars is equal to the supply x^* of new cars. So from (11) it is given as follows.

$$y^S = \{(u_2-u_1)b + (u_1+u_2)p_1 + u_1\beta - u_2c\}/2(u_2-u_1)$$

From the market clearing condition $y^D = y^S$, the equilibrium price p_1^* of the used car is as follows.

$$p_1^* = \{u_2(u_1-u_0)c - u_1(u_2-u_0)\beta\}/\{u_1(u_2-u_0)+u_2(u_1-u_0)\} \quad ------ (15)$$

Putting this value into (11) and (12), the new car price and its production are as follows.

$$p_2^* = \frac{(u_2-u_1)b}{2u_2} + \left[\frac{1}{2} + \frac{(u_1-u_0)(u_1+u_2)}{2\{u_1(u_2-u_0)+u_2(u_1-u_0)\}}\right]c - \frac{u_1(u_2-u_1)\beta}{2\{u_1(u_2-u_0)+u_2(u_1-u_0)\}} \quad \text{-----------(16)}$$

$$x^* = b/2 - u_1u_2(c+\beta)/2\{u_1(u_2-u_0)+u_2(u_1-u_0)\} \quad \text{---------(17)}$$

The profit of the new car manufacturer is as follows.

$$\pi^* = \frac{(u_2-u_1)[\{u_1(u_2-u_0)+u_2(u_1-u_0)\}b - u_1u_2(c+\beta)]^2}{4u_2\{u_1(u_2-u_0)+u_2(u_1-u_0)\}^2} \quad \text{------(18)}$$

From (15) and (16), the new car price and the used car price are related as follows.

$$p_2^* = (u_2-u_1)b/2u_2 + [\tfrac{1}{2} + u_1(u_1-u_0)/2\{u_1(u_2-u_0)+u_2(u_1-u_0)\}]c + p_1^*/2 \quad \text{------(19)}$$

Let us check if p_1^* of (15) and p_2^* of (16) satisfy the constraint of case (a), that is, $p_2^* \geqq [\{u_1(u_2-u_0)+u_2(u_1-u_0)\}p_1^* + u_1(u_2-u_0)\beta]/u_2(u_1-u_0)$. From (15) and (16), this constraint is equivalent to the following inequality.

$$(c+\beta)/b \leqq \{u_1(u_2-u_0)+u_2(u_1-u_0)\}/u_1u_2 \quad \text{----------- (20)}$$

If the average income b/2 is somehwere around five million yens, then it will be safe to assume that the highest income b is higher than ten million yens. The new car production cost c will not be very much larger than 1,300,000 yens on the average. The car inspection cost will be smaller than 200,000 yens on the average. So the left-hand side of (20) will be less than 0.15.

The right-hand side of (20) is an increasing function of u_1 and u_2. u_1 will not be much smaller than $1.1\ u_0$. The right-hand side of (20) is

2/11, when $u_2 = u_1$ and $u_1 = 1.1\,u_0$. So the right-hand side will be larger than 2/11. Therefore the right-hand side will be larger than the left-hand side for the plausible values of the parameters. So the unconstrained solution (11) or (16) satisfies the constraint of case (a).

Now we will examine case (b). Here the demand y^D for used cars is zero. The supply y^S is equal to the supply x^* of new cars. So from (14) it is given as follows.

$$y^S = \{(u_2-u_0)b + u_2 p_1 - u_2 c\}/2(u_2-u_0) \qquad \text{(21)}$$

When $(u_2-u_0)b > u_2 c$, y^S is larger than y^D for all the nonnegative values of p_1. So the equilibrium price p_1^* is zero in the case. Then p_2^* is zero from the constraint of the profit maximization in case (b). But the unconstrained value of p_2 is positive from (14). So the ~~constrained~~ unconstrained solution does not satisfy the constraint of the profit maximization, and so the constraint is binding. The profit of case (b) is equal to the profit of case (a) when the constraint is binding in the profit maximizations of both cases. Since the unconstrained maximization yields a larger profit than the constrained maximization, the new car manufacturer does not adopt the policy of case (b) when $(u_2-u_0)b > u_0 c$.

When $(u_2-u_0)b \leqq u_2 c$, the market clearing condition $y^S = y^D$ occurs when and only when $y^S = y^D = 0$. So from (21), the equilibrium price p_1^* of used cars is $p_1^* = \{(u_2-u_0)b - u_2 c\}/u_2$. Then $p_2^* = (u_2-u_0)b/u_2$ from (14). So the constraint of the profit maximization of case (b) holds when and only when the following inequality holds.

$$u_2 c/(u_2-u_0)b \leqq u_1(u_2-u_0)/\{u_1(u_2-u_0) + u_2(u_1-u_0)\}$$

The right-hand side of the above inequality is less than 1. The left-hand side is larger than 1 from the condition of $(u_2-u_0)b \leqq u_2 c$. So the unconstrained solution (14) does not satisfy the constraint of case (b) when $(u_2-u_0)b \leqq u_2c$, too. Therefore the constraint of the profit maximization of case (b) is binding and, by the same reasoning as in the previous paragraph, the new car manufacturer does not adopt the policy of case (b) in this case, too.

Therefore the new car manufacturer does not adopt the policy of case (b) but adopt the policy (11) of case (a), both when $(u_2-u_0)b > u_2c$ and when $(u_2-u_0)b \lneqq u_2c$.

VI. Comparative Statics

Obviously from (15) and (16), both the used car price p_1^* and the new car price p_2^* increase, ceteris paribus, when the production cost c of a new car increases. When the car inspection cost β increases without increasing the quality u_1 of used cars (e.g., owing to the increase of the fixed inspection fee β_0), the used car price p_1^* decreases ceteris paribus as is seen from (15).

The increase of β without increasing u_1 increases the new car price p_2^* so long as the used car price p_1 is kept constant, as is seen from (12). This will be consistent with the sense of the men in the street, but this is a partial equilibrium analysis, because only the equilibrium of the new car market is considered and the used car price is a given constant here. When the equilibrium of the used car market as well as that of the new car market is taken into consideration, the increase of β decreases the new car price p_2^* by decreasing the used car price p_1^*, as is seen from (15) and (16). So the result of this general equilibrium analysis is opposite from that of the above partial one. Of course the correct result is not the partial equilibrium but the general equilibrium result.

We obtain the following equation from (15).

$$\frac{\partial p_1^*}{\partial u_1} = \frac{(u_2-u_0)[u_0 u_2(c+\beta) - u_1\beta'\{u_1(u_2-u_0)+u_2(u_1-u_0)\}]}{\{u_1(u_2-u_0)+u_2(u_1-u_0)\}^2} \quad \text{-----}(22)$$

So if $\beta'(u_1)=0$ (that is, u_1 increases without increasing the repair cost), the increase of the quality u_1 of the used car increases its price p_1^*. If $\beta'(u_1)\neq 0$, then there will be a unique quality level u_1^* of the used car that maximizes p_1^*, as we will show below.

Let ϕ be as follows.

$$\phi = u_0 u_2(c+\beta) - u_1\beta'\{u_1(u_2-u_0)+u_2(u_1-u_0)\} \quad \text{-----------} \ (23)$$

Then the sign of $\partial p_1^*/\partial u_1$ is the same as the sign of ϕ from (22). ϕ will be positive when $u_1=u_0$.(7) But ϕ is a monotone decreasing function of u_1 and it is negative for sufficiently large values of u_1.(8) So there will be a unique value u_1^* of u_1 such that ϕ is positive when $u_1 > u_1^*$, zero when $u_1=u_1^*$ and negative when $u_1 < u_1^*$. So p_1^* is the maximum when $u_1=u_1^*$, because $\partial p_1^*/\partial u_1$ and ϕ have the same sign.

The increase of the used car quality u_1 decreases the new car price p_2^*, so long as the used car price p_1 and the inspection cost β are kept constant.(9) Let us check this partial equilibrium result in the general equilibrium setting, ~~when~~ where p_1 and β change as u_1 increases. From (16), we have the following equation.

$$\frac{\partial p_2^*}{\partial u_1} = \frac{1}{2u_2}\ [p_1^* + \beta + \frac{u_0 u_2(u_1+u_2)(u_2-u_0)(c+\beta)}{\{u_1(u_2-u_0)+u_2(u_1-u_0)\}^2}$$

$$- b - \frac{(u_1+u_2)(u_2-u_0)u_1\beta'}{\{u_1(u_2-u_0)+u_2(u_1-u_0)\}}] \quad \text{-----------} \ (24)$$

Let $\theta = u_0 u_2 (u_1+u_2)(u_2-u_0)/\{u_1(u_2-u_0) + u_2(u_1-u_0)\}^2$, $k = u_2/u_1$ and $\ell = u_1/u_0$. Then $\theta = k(k+1)(k\ell-1)/\{(k\ell-1) + k(\ell-1)\}^2$ and $k, \ell > 1$. θ is a decreasing function of ℓ and an increasing function of k.(10) k will be less than 4 and ℓ will be larger than 1.1 in the real world. When $k = 4$ and $\ell = 1.1$, θ is less than 4.71. So θ will be less than 4.71 for all the relevant values of k and ℓ. It will be safe to assume that p_1^* is less than 1.5 million yens, that c is about 1.5 million yens or less and that β is about 0.2 million yens or less. When $\theta = 4.71$, $p_1^* = c = 1.5$ million yens and $\beta = 0.2$ million yens, $p_1^* + \beta + \theta(c+\beta)$ is 9.707 million yens. So $p_1^* + \beta + \theta(c+\beta)$ will be less than 9.707 million yens. The highest income b will be larger than 10 million yens. So from (24), $\partial p_2^*/\partial u_1$ will be negative in the real world. Thus when the required quality u_1 of used cars is forced to increase by law, new car price p_2^* falls in the general equilibrium model, too.

From (11) and (17), the increase of the new car production cost c decreases the production level x^* of new cars in both the partial equilibrium and the general equilibrium models. From (9) and (11), both the demand x for new cars and the profit-maximizing production x^* of them increase when the inspection cost β increases without increasing the used car quality u_1. These partial equilibrium effects of β will be consistent with the sense of the men in the street, but this effect of β on x^* is wrong in the general equilibrium setting where the used car price p_1^* is not a given constant but the equilibrium price of the used car. This is obvious from (17). That is, (17) implies that x^* decreases after all when β increases in the general equilibrium model.

We have the following equation from (9).

$$\partial x/\partial u_1 = -[u_2(p_2-p_1-\beta) - u_1\beta'(u_2-u_1)]/(u_2-u_1)^2 \qquad \text{- - - - - - - - (25)}$$

From the constraint of case (a) stated before, $p_2 > p_1 + \beta_1$. So if $\beta'(u_1)$ is not large, $\partial x/\partial u_1$ is negative. Especially if the used car quality u_1 increases without increasing repair cost (that is, $\beta'(u_1) = 0$), the demand x for new cars declines. This is because used cars become more close substitutes for new cars when u_1 approaches u_2.

It is obvious from (11) that the production level x^* increases when the used car quality u_1 increases holding the used car price p_1 constant. Let us check this partial equilibrium result in the general equilibrium framework. Let ϕ be defined as (23) above, then we have the following equation from (17).

$$\partial x^*/\partial u_1 = u_2\phi/2\{u_1(u_2-u_0) + u_2(u_1-u_0)\}^2 \qquad \text{- - - - - - - - - - - (26)}$$

If $\beta'(u_1) = 0$, then $\phi = u_0u_2(c+\beta) > 0$ and so the above partial equilibrium result holds also in the general equilibrium model.

But in general $\beta'(u_1)$ is positive. As we saw before, there will be a unique value u_1^* of u_1 that ϕ is positive when $u_1 > u_1^*$, zero when $u_1 = u_1^*$ and negative when $u_1 < u_1^*$. Since $\partial x^*/\partial u_1$ and ϕ have the same sign from (26), x^* is the maximum when $u_1 = u_1^*$. In other words, there will be a unique value u_1^* of u_1 that maximizes p_1^* and x^* at the same time. So if the used car quality v before the inspection is higher than u_1^*, then the car inspection law reduces the new car production. If v is lower than u_1^*, then the new car production increases by the imposition of the car inspection law which requires the used car quality to be kept above u_1 where $v < u_1 < u_1^*$.

It is obvious from (13) and (18) that the increase of the production cost c decreases the profit π^* of the new car manufacturer in both the partial and the general equilibrium analyses. The increase of the inspection cost β without affecting u_1 increases π^* in the partial equilibrium setting (13), but it decreases π^* in the general equilibrium setting (18). Of course the general equilibrium result is correct.

Let $\delta = -(u_2-u_1)b + (3u_2-u_1)p_1 + (2u_2-u_1)\beta + 2(u_2-u_1)u_1\beta' - u_2c$, then we have the following equation from (13).

$$\partial\pi^*/\partial u_1 = \{(u_2-u_1)b + (u_1+u_2)p_1 + u_1\beta - u_2c\}\delta/(u_2-u_1) \quad ----- (27)$$

So $\partial\pi^*/\partial u_1$ and δ will have the same sign. $\partial\delta/\partial u_2 = -b + 3p_1 + 2\beta + 2u_1\beta' - c$ will be negative for the plausible values of b, p_1, β, $u_1\beta'$ and c.(11) $b - 3p_1 - 2\beta - 2u_1\beta' + c$ will be positive for the plausible values of them. So $\delta > 0$ will be equivalent to $u_2 < \varepsilon u_1$ where ε is defined as follows.

$$\varepsilon = 1 + (2p_1 + \beta - c)/(b - 3p_1 - 2\beta - 2u_1\beta' + c) \quad --------(28)$$

If $2p_1 + \beta \leqq c$, then $\varepsilon \leqq 1$ and so $\delta < 0$ by our assumption that $u_2 > u_1$. So the increase of u_1 decreases π^* monotonously in this case. If $2p_1 + \beta > c$, then $\varepsilon > 1$ and so the increase of u_1 increases π^* when $u_2 < \varepsilon u_1$ but it decreases π^* when $u_2 > \varepsilon u_1$. Summing up these results, the car inspection may increase π^* when $u_2 < \varepsilon u_1$ but it decreases π^* when $u_2 > \varepsilon u_1$. This is a partial equilibrium result where the used car price p_1 is given constant.

Let us check the above partial equilibrium result in the general equilibrium framework. Let $h = u_1(u_2-u_0) + u_2(u_1-u_0)$, then $h > 0$ and we have the following equation from (18).

$$\partial\pi^*/\partial u_1 = -[\{hb - u_1u_2(c+\beta)\}h + 2(u_2-u_1)\{hb - u_1u_2(c+\beta)\}\{(2u_2-u_0)b - u_2(c+\beta) - u_1u_2\beta'\}h + 2(u_2-u_1)(2u_2-u_0)\{hb - u_1u_2(c+\beta)\}^2]/4u_2h \quad --(29)$$

So $\partial\pi^*/\partial u_1$ is negative if $hb - u_1u_2(c+\beta) > 0$ and $(2u_2-u_0)b - u_2(c+\beta) - u_1u_2\beta' > 0$.

$hb - u_1u_2(c+\beta) > 0$ is equivalent to the following inequality.

$$(c+\beta)/b \leqq \{u_1(u_2-u_0) + u_2(u_1-u_0)\}/u_1u_2 \qquad \text{-----------} \quad (30)$$

The left-hand side of (30) will be less than 0.17. The right-hand side is an increasing function of u_1 and u_2. It will be the case that $u_2 \geqq 1.05\ u_1$ and $u_1 \geqq 1.07\ u_0$ in the real world. The right-hand side is a little larger than 0.175 when $u_2 = 1.05\ u_1$ and $u_1 = 1.07\ u_0$. So (30) will hold for the plausible values of the parameters. Similarly $(2u_2-u_0)b - u_2(c+\beta) - u_1u_2\beta'$ will be positive.(12) So $\partial\pi^*/\partial u_1$ will be negative for the plausible values of the parameters. Therefore the car inspection law will decrease the profit of the new car manufacturer in the general equilibrium analysis.

VII. Conclusion

The Japanese inspection law of the used car quality is often supposed to decrease the demand for used cars, to increase the demand for new cars by reducing the competition from used cars and thus to increase the profit of new car manufacturers such as Toyota and Datsun. The main conclusion of this paper is that the used car inspection law will decrease the profit of the new car manufacturer for the plausible values of the parameters in the general equilibrium framework where both the equilibrium of the new car market and that of the used car market are taken into consideration.

We have also shown that the new car price decreases as the required quality level of the used car increases. There will be a unique level u_1^* of the used car quality that maximizes both the new car production and the used car price at the same time. So as long as the required quality of the used car is less than u_1^*, the increase of the required quality will increase the new car production. When the required level becomes larger than u_1^*, its increase will decrease the new car production.

All the above results are obtained in the general equilibrium framework. We have done these and some other comparative static analyses in the general equilibrium as well as in the partial equilibrium setting where the used car price is given constant. The partial equilibrium results are often opposite to the general equilibrium ones. The partial equilibrium results are often consistent with the sense of the men in the street, but of course the general equilibrium result is correct. Therefore this paper shows as a by-product that the partial equilibrium analysis is sometimes wrong.

Now if the used car inspection law is not for the benefits of new car manufacturers such as Toyota and Datsun, what other economic functions does it do? First it is obvious that it protects many small dealers who do repair works before the inspection by making jobs to them. Second the quality regulation of used cars will work to avoid "lemons" of Akerlof (1970) when the qualities of used cars are uncertain, and so it may protect consumers.(13) But the present quality level of used cars may be too high from the viewpoint of social welfare in Japan. Now the present author faces the problem of determining the optimum level of the required quality of the used car in the uncertainty of the used car quality as a next research topic.

Footnotes

(1) The first inspection is made at the car age of three years and then the inspection is done every two years.

(2) These effects are recognized by Benjamin and Kormendi (1974) in studying the effect of the existence of the used durable goods market on the profit of the new durable goods manufacturer by using diagrams.

(3) Ohta and Griliches (1976) shows that new and used cars are the same goods (perfect substitutes), differing only in the "quantity " of the good contained per market unit, by testing the null hypothesis of the equality of the imputed prices of physical characteristics between new and used cars in the hedonic regression.

(4), (5) Benjamin and Kormendi (1974) does not consider the quality of the durables explicitly and so does not consider these aspects of the substitution and the present value effects.

(6) In Japan dealers seem to make the quality of used cars much higher than the legally required level to obtain larger profits. In this case u_1 is equal to the average actual quality of used cars after the repair. The actual quality level u_1 will, however, be an increasing function of the legally required level. So we say that u_1 is the required quality level for simplicity.

(7) When $u_1 = u_0$, $\phi = u_0\{u_2(c+\beta-u_1\beta') + u_0u_1\beta'\}$. If $\beta'(u_1)$ is constant, then $u_1\beta'$ is the cost of repairing a car from the quality level of zero to u_1. This is smaller than the cost c of producing a new car, because the new car quality u_2 is higher than u_1.

(8) $\partial\phi/\partial u_1 = -(\beta' + u_1\beta'')\{u_1(u_2-u_0) + u_2(u_1-u_0)\} - u_1\beta'(2u_1-u_0) < 0$,

because $\beta''(u_1) \geqq 0$. It is obvious from (23) that ϕ is negative when u_1 is sufficiently large.

(9) From (12), $\partial p_2^*/\partial u_1 = -(b-p_1-\beta)/2u_2 < 0$, if p_1 and β are kept constant, because $b > p_1 + \beta$.

(10) Let $g = \{(k\ell-1)+k(\ell-1)\}^3 > 0$. Then $\partial\theta/\partial\ell = -k^2(k+1)(2k\ell+k-3)/g < 0$ and $\partial\theta/\partial k = \ell^2[(k+1)(k\ell-1)(k-1)+\{k(k\ell-1)+k\ell(k+1)\}(2k\ell-k-1)/g > 0$.

(11) Use the similar arguments in footnote (7) and the arguments similar to those below equation (24).

(12) $(2u_2-u_0)b - u_2(c+\beta) - u_1u_2\beta' = \{b-(c+\beta)\}u_2 + u_2(b-u_1\beta') > 0$. This is because $u_1\beta'$ is the variable cost of repairing a car from zero quality level to u_1 if β' is constant and so $u_1\beta'$ will be less than c since $u_2 > u_1$.

(13) This possibility is suggested to the author by Professor Y. Kanemoto of the University of Tsukuba.

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