Impacts on living expenditure by feebate system in Japanese automobile market

Keiko HIROTA, Kiyoyuki MINATO, Japan Automobile Research Institute

1. SYNOPSIS

This paper outlines an attempt to design a model of CO_2 reduction: “feebate”. The impact of feebate is evaluated by change in living expenditure.

2. ABSTRACT

After the Kyoto Conference (COP3), the Japanese transport sector has been required to reduce 16 % of Carbon Dioxide (CO_2) emissions by 2010. The Japanese government has decided to improve the fuel economy standard in 2010, which improves it an average of 22.8 % for passenger cars from the 1995 level. However Japanese consumers tend to prefer heavier passenger cars such as four-wheel drive or recreational vehicles.

Due to the difficult target of COP3, political implementations should be not only automotive technologies but also non-technical measures. Since Japanese vehicle taxes are expensive compared to other OECD countries, the “feebate system” is proposed. Fee / rebate is imposed / refunded according to a new car’s fuel economy.

The feebate system would change consumer preference toward energy saving vehicles. Elasticity analysis shows that changes in tax level have the highest impact on acquisition. The feebate system is simulated in place of acquisition tax.

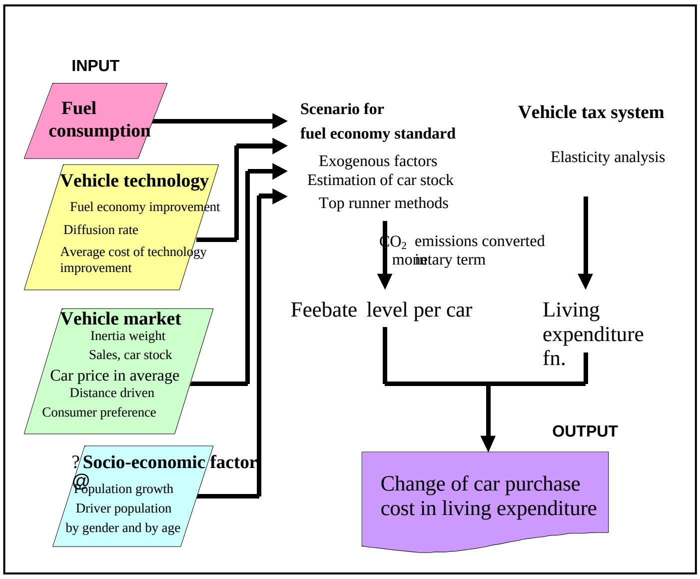
To determine sales projection, population growth, and drivers‘ genders and ages are taken into account. Our estimations for the fuel economy technology improvement rate until 2010 provide three scenarios. The contribution of this paper will be to propose an optimal feebate level according to CO_2 emission reduction. Supposing that feebate is equal for CO_2 emission reductions in the three scenarios of fuel economy, feebate levels per passenger car are calculated to 2010. These feebate levels would change the annual living expenditure purchase cost. In consequence, we have to decide upon an option: how severe to make the fuel consumption standard and/or how high to raise fees for CO_2 reduction.

3. FUEL ECONOMY AND JAPANESE AUTOMOBILE INDUSTRY

Overview of energy consumption trends in Japan

In general, traffic volumes and energy consumption increase year by year. In other words, CO_2 emissions from road transport increase each year. If the government does not take political steps to implement CO_2 emissions reduction, Japan will not hit the target for 2010: 16% reduction from the 1995 level in the transport sector. Concerning policy for CO_2 reduction, the Japanese government seems to appreciate technological progress. In contrast, non-technical measures are underestimated due to difficulties of implementation. As a support to technological implementations, a financial adaptation "feebate system" is introduced in this paper. This paper proposes a non-technical measure that will complement technology to reach the 2010 target. Figure 1 shows the model calculation process.

Figure 1. Flowchart for the model



Fuel consumption

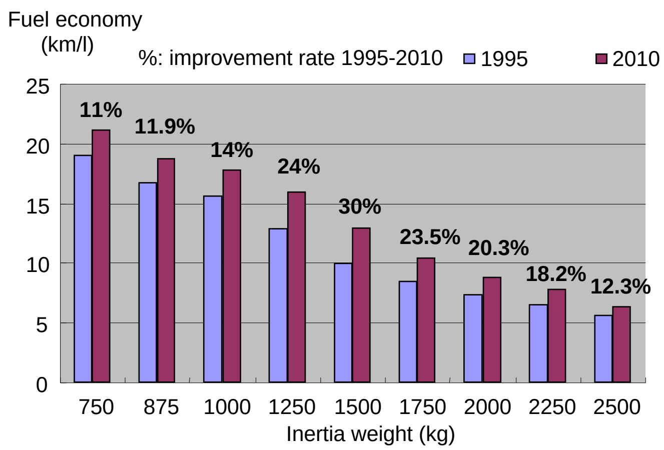
In 1979, the Japanese fuel economy standard was determined under the Energy Conservation Law of the Ministry of International Trade and Industry (MITI). On April 1st, 2000, new fuel economy standards for gasoline / diesel passenger cars were carried out toward a 2010 goal. The strategy of fuel economy improvement is one of the government perspectives toward 2025[i] as follows. Figure 2 represents the projected fuel economy standard for gasoline passenger cars in 2010.

- Promote development of the automobile fuel cell as a new power source.
- Further develop and disseminate clean-energy vehicles and low-pollution vehicles.
- Promote lighter vehicle weights.

The advantages of the top runner and classification by inertia group may promote high efficiency cars in each category group. CAFE differs from the Japanese system in that the

latter cannot trade off between low efficiency heavy cars and high efficiency small cars because each inertia group fixes the improvement rate of fuel economy.
The disadvantage of the Japanese system is the low incentive for weight reduction. The heavier car category has a lower improvement rate. There are some manufacturers who may shift their products to the heavier category. It would make it easier to respect the Energy Conservation Law. Weight reduction requires high research and development costs. This fuel economy standard provides less incentive for lighter weight materials.
The fuel economy standard level obstructs introduction of imported products. If we compare domestic cars and imported cars, domestic cars have a higher efficiency value, which is a potential obstacle to foreign automobile industries selling products in the Japanese market.

Figure 2. Fuel economy standard 1995 and 2010



The annual rate of energy consumption decreased from 1988 to 1993. This meant that fuel efficiency improved[ii]. In 1994, energy consumption increased, although annual traffic volume increased only slightly. Sales of sport utility vehicles (SUV) have increased since 1994. These heavy cars consume more gasoline because of vehicle weight. That is why energy consumption has a higher rate instead of decreasing with traffic volume.

Vehicle market and socio-economic factors

Car sales projection is one of the most important elements in determining fuel consumption and the CO_2 emissions level in the road transport sector. This section describes the projection of new car sales toward 2010, and includes consumer preference. According to the population projection data of the Institute of Population and Social Security, the number of family members has decreased. However, the number of cars has increased in accordance with income growth. According to the Road Security white paper and the JAMA report, the number of female drivers and elderly drivers might increase toward 2010[iii].

Scenarios description of technological improvement

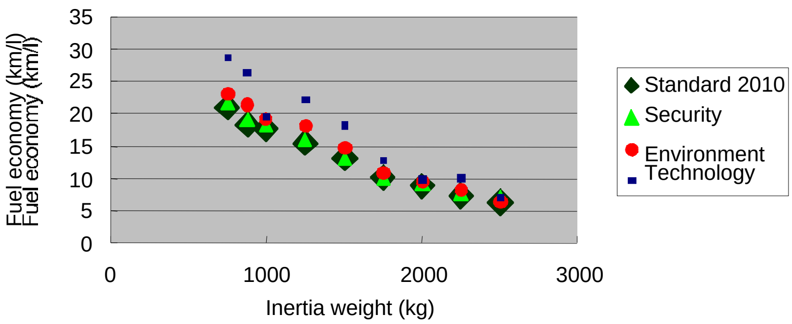
The proposed scenarios are more severe fuel economy values for gasoline passenger cars, because the scenarios integrate road security and emissions gas regulations, which affect increases in weight and fuel consumption. Here are the three scenarios developed from the fuel economy standard of 1995. Each scenario has a different technological improvement and diffusion rate (Table 1).

Table 1. Scenario description

Scenarios	Summary of the description
Regulation	Fuel economy standard 2010 + Safety + Noise + Emission standard 2005
Environment	Estimation of Environmental Agency
Technology	Maximum rate of technological improvement

Figure 3 is the result of the scenario descriptions. Scenarios "regulation" and "technology" are based on data of the MOT report. Scenario "environment" is estimated using data of the Environmental Agency Report.

Figure 3. Fuel economy standard 2010 and 3 scenarios – gasoline passenger car



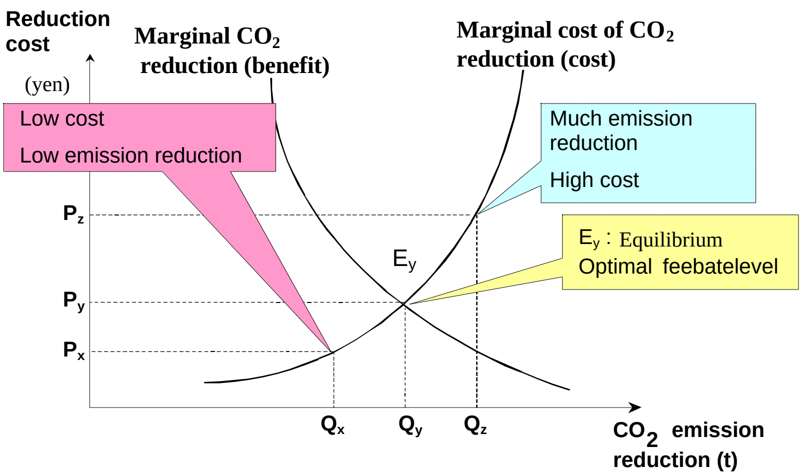
Scenario “regulation” supports technologies based on safe car bodies, safety devices, and ITS technologies in the market. The scenario “regulation“ includes emission gas regulation and noise regulation. Through noise control by both vehicle technology and road infrastructure, the noise of motor vehicles cruising on roads could be reduced by 2 to 3 decibels.

4. FINANCIAL ADAPTATION FOR FUEL ECONOMY IMPROVEMENT

Japanese vehicle tax system

The vehicle tax level in Japan is high enough. The revenue is not used directly for environmental protection. So these days, tax reform toward CO_2 reduction and fuel efficiency is discussed. What level is optimal for fuel economy scenarios in terms of CO_2 reduction? In this section, optimal feebate levels will be calculated.
From the point of view of cost-benefit analysis, the benefit curve represents marginal CO_2 emissions reduction. The cost curve represents marginal cost of CO_2 reduction. The equilibrium point completes optimal marginal CO_2 reduction and marginal cost. By applying the three scenarios of fuel economy, we find the optimal levels of emissions and feebate (Figure 4).

Figure 4. Feebate estimation by cost benefit analysis



Elasticity analysis of Japanese vehicle taxation

Tax increases affect both the short term and the long term. In the short term, price changes affect living expenditure directly. Consumers have to adjust their expenditure attitude under budget constraints. In the long run, consumers adjust living expenditure for vehicle maintenance and fuel consumption by increasing their income level.

Demand elasticity measures these behavioural changes. In this paper, demands of new car sales, total number of cars, energy consumption and distance driven are analysed by change of vehicle tax levels from 1976 to 1998. The equation (1) represents the original estimation model of elasticity substitution. The elasticity is expressed as follows[iv]:

$$y = ax^b \qquad (1)$$

a: parameter
x: taxes (acquisition tax, vehicle tax, vehicle tonnage tax, gasoline tax)
y: demand (new car sales, car stocks, energy consumption)
b: elasticity

The elasticity indicates the demand increase (in %) induced by a price increase (in %). The model is estimated econometrically as the following model. Elasticity between acquisition tax and new car sales is 0.56, which is the lowest value. This means that acquisition tax increases by 1%, and demand of new car sales decreases by 0.44%. If we look at demand sides, gasoline tax has the highest elasticity. This means that car owners do not reduce distance driven enough for the gasoline tax increase. For simulation of feebates in the next chapter, we apply the feebate on acquisition tax.

Marginal CO_2 emissions: With respect to CO_2 emissions by scenario, CO_2 emissions are estimated at 2.5 million tons-C per year, from the fuel economy standard of 2010. 1.73 Mt-C/year is emitted from the standard of 2010. 1.69 Mt-C/year is emitted from the Regulation scenario, 1.53 M-C/year from the Environment scenario and 1.3 Mt-C/year from Technological scenario[v]. These marginal emission reductions from the standard to the three scenarios do not come free of charge. The differences between the standard and the scenarios are made up for by feebate revenue.

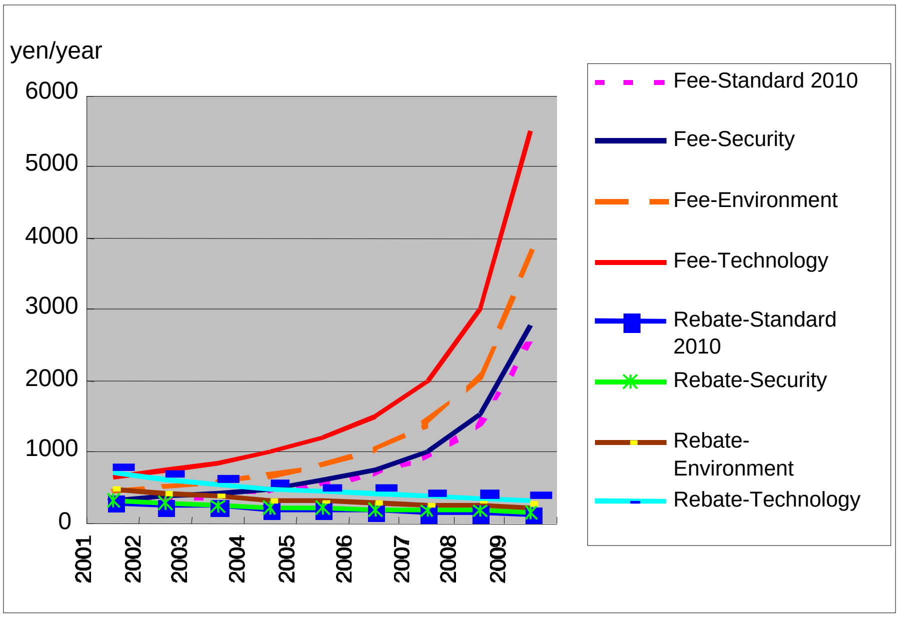
Marginal CO_2 reduction cost: The following equation (2) describes the simulation of feebate revenue based on the fuel economy scenario. With respect to the cost of fuel economy improvement, the Department of Energy in the US estimates the costs of the parts. JARI report 1999[vi] and JAMA estimate the rate of improvement. Using these two types of data, we estimate the average cost of fuel-efficient improvement. It costs 1995US $84 per vehicle to improve fuel economy by 1 %. It costs 1995US $89 for a 2-3 % fuel efficiency improvement. It costs US$101 for 4 % in fuel efficiency improvement. It costs US 1995 $125 for more than 4% in fuel economy improvement. Using sales of the year 1995 and their fuel economy values, we can determine feebate revenue by inertia weight.

$$FR = \sum_{i=1}^{n} \left[FE_{real} - FE_{standard} \right] * fee_n \qquad (2)$$

FR: feebate revenue
FE_{real}: fuel economy of a car
$FE_{standard}$: fuel economy standard
fee: cost of fuel economy improvement
n: improvement rate *n*=1-4

Optimal feebate levels: How high a rebate can consumers receive and how much will other consumers have to pay in fees? Marginal CO_2 emissions are converted to monetary terms. According to the Ministry of Transport, CO_2 reduction costs US $ 13.6 /t-CO2[vii]. Then we have to estimate the number of cars. When marginal costs are divided by the number of cars under each scenario that is the fee by scenario. When the costs are divided by the number of cars in the upper range of each scenario, that is the rebate by scenario.
The levels of fee and rebate change. They depend on which year a consumer buys. The closer to the year 2010, the higher the fee the consumer has to pay. The level of rebate does not climb as high when compared to the fee level, but it may be an incentive to buy a less energy consumptive car (Figure 5).

Figure 5. Optimal feebate levels by standard and scenario



5. SIMULATION OF FEEBATE

Impact of feebate on living expenditure

The feebate[viii] system adjusts prices of new cars in favour of fuel consumption. Gas-guzzlers are charged fees. Gas sippers get rebates. Feebate encourages both consumers and producers to choose fuel-efficient vehicles. In the short term, price incentives encourage consumers to buy cheaper, more fuel-efficient vehicles. Demand-side responses influence total vehicle sales. This effect is reflected in the sales-weighted average of fuel consumption.
If consumers become aware of the advantages of purchasing fuel-efficient cars, producers would manufacture fuel-efficient cars. The incentives of feebate also affect the supply side[ix]. In the long run, car manufactures will tend to produce more fuel-efficient cars because feebates may help pay for additional fuel-economy technology.
If optimal feebate levels are introduced in Japan, how will it impact on living expenditure? In this section, we discuss the effects of changes of annual vehicle purchase costs on living expenditure per household. Impacts on living expenditure must be different on fee and rebate sides in the case that a consumer buys a vehicle once between 2001 and 2010.
Trend of expense per household could be expressed as Constant Elasticity System Function (CES function). Supposing that the cost of a private car consists of purchase **X** and maintenance costs **Y** (3).

$$U = \gamma\,(\delta X^{-\rho} + (1-\delta)Y^{-\rho})^{-\frac{1}{\rho}} \qquad (3)$$

X: average price of a private vehicle
Y: annual maintenance cost
U: annual cost for a private vehicle
ρ : elasticity
δ : coefficient of vehicle diffusion
γ : coefficient of efficiency

For the projection from 2001 to 2010, the expenditure on a private car is increased at average rate of 6.7% between 1976 and 1998. The function is linealised by Taylor’s series. While price change will influence expenditure in the same period in the static model, the time lag between price change and expenditure will be considered in the dynamic model. This is because car purchase cost increases when income of previous year increases. The time lag “polynomial distributed lag model” $\mathbf{U_{t-1}}$ is integrated in the equation (4) If car price changes, effect of car price is supposed to influence purchase cost next year.

$$\log U^{*}_{t} = \beta_0 + \beta_1 \log X_t + \beta_2 \log Y_t + \beta_3 \log \left(\frac{X_t}{Y_t}\right)^2 + \varepsilon_{t1} \qquad (4)$$

where $\log U^{*}_{t}$ is estimated expenditure in period *i*.

$$\log U_t - \log U_{t-1} = \theta\,(\log U_t^{*} + \log U_{t-1}) + \varepsilon_{t2} \qquad (5)$$

Where,

$\beta_0 = \log\gamma$ $\quad\quad$ $\beta_1 = \delta$ $\quad\quad$ $\beta_2 = 1-\delta$ $\quad$ $\beta_3 = -\frac{1}{2}\rho\delta(1-\delta)$

U: utility (annual purchase cost of private car)
X: price of private car
Y: maintenance cost of private car
ε : disturbance
t : time
θ is adjustment speed. $0 \le \theta \le 1$ $\quad \theta = 0.8$

From (5) and (6), it yields (7)

$$\log U_t = \theta\beta_0 + \theta\beta_1 \log X + \theta\beta_2 Y + \theta\beta_3 \left(\log\frac{X}{Y}\right)^2 + (1-\theta)\log U_{t-1} + \varepsilon_t \quad (6)$$

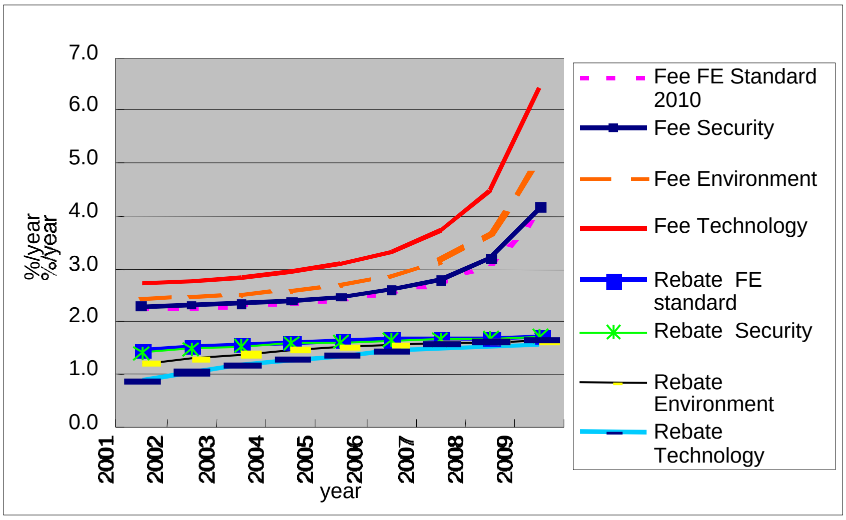
where
$\varepsilon = \theta\varepsilon_{t1} + \varepsilon_{t2}$

The estimation of the dynamic model is as follows: ( )=t value. Under the feebate system, the fee is added to the car price, while car price is reduced on the rebate side in ***X'***.

$$LogU_t = -4.686 + 0.663\log X' + 0.306\log Y + 0.340\left(\log\frac{X}{Y}\right)^2 + 13.7\log U_{t-1} + \varepsilon_t$$

(7) (-4.034) (1.888) (21.923)
(0.831) (7.223)
X': car price + fee, car price -rebate
R^2 = 0.981 Adjusted R^2 = 0.976
Durbin Watson statistics = 2.45
In order to estimate impacts on living expenditure, data of the annual report on the family income and expenditure survey[x] is used for purchase cost projection toward 2010**.** In 1995, most real fuel economy on new gasoline passenger car sales was below the fuel economy standard of 2010. All new cars are supposed to clear the fuel economy standard of 2010 or the three scenarios by 2010.
The annual expenditure on gasoline passenger car purchase was between 1.51% and 1.84 % during 1987-1995. Introduction of the feebate system diversifies expenditures of the gasoline passenger car between fee and rebate sides. A consumer who buys a gas sipper vehicle reduces expenditure to less than 1.84%. A consumer who buys a gas-guzzler vehicle has to pay more than 1.84%.
It is clear that a more severe standard, or FE scenario, allows higher CO_2 reduction. However, higher reduction requires a higher fee. The exponential curves are fee levels. The linear curves are rebates. The rebate level is not high enough, but imposition of the fee may be incentive, in itself, to buy a more fuel-efficient car. When a consumer buys a better FE car, he/she can reduce living expenditure purchase costs. If we look at the figure by time intervals, we see the fee level increase by 2-3 times from 2001 to 2009. Rebate levels grow 1.3-1.7 times from 2001 to 2009 (Figure 6).

Figure 6. Impact on car purchase cost in living expenditure



6. CONCLUSION

Technological progress and diffusion rates determine fuel economy scenarios towards 2010. Exogenous factors, such as safety and noise, are added (Security Regulation scenario). The Japanese Environmental Agency's scenario follows the same scenarios without the security and noise factors (Environment scenario). The technological scenario is developed simply by technological advancement (Technology scenario). Following the classification of top runner methods, three different scenarios of fuel economy improvement are introduced in the simulation of feebate. Since new car sales depend on consumer preference, drivers' genders and generations are integrated for the projection. The feebate distorts car price, which impacts living expenditure.

Feebate levels are determined by CO_2 emissions of each fuel economy scenario. More severe fuel economy scenarios emit less CO_2. Among the three scenarios, the technology scenario is the severest. However, reduction cost will increase in order to stabilize the CO_2 level by 2010. In consequence, the technology scenario has the highest feebate level. For those who buy fuel-efficient vehicles, car price is reduced by the feebate system. For those who buy less

efficient vehicles, car price will be raised. Since Japan has to complete the target by 2010, impacts of living expenditure will gradually increase by 2009.
For further development of the model, some issues, such as follow, should be concerned. Fuel efficiency does not mean CO_2 reduction directly. A consumer who buys a fuel-efficient vehicle may drive longer distances. That causes increase of CO_2 emissions. For reduction of CO_2 emissions, feebate should be combined with not only acquisition tax, but also other vehicle taxes. With respect to technological aspects, clean energy vehicles such as hybrid vehicles and fuel cell vehicles will be launched into the market. The vehicle tax system should be reformed to encourage consumers to buy clean energy vehicles. In this paper, the consumer side is the focus. Impacts on intra-industry or inter-industry should be evaluated, too.

APPENDIX 1: NEW CAR SALES PROJECTION (THE NUMBER OF CARS)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
750	362232	344917	326194	306004	284290	260988	236037	209369	180917	177073	118377
875	640710	662516	685063	708378	732486	757415	783192	809846	837408	865907	895376
1000	916280	947463	979708	1013051	1047528	1083179	1120042	1158161	1197576	1238334	1280478
1250	1194240	1202607	1211032	1219517	1228061	1236665	1245329	1254054	1262839	1271687	1280596
1500	973540	974514	975488	976464	977440	978418	979396	980375	981356	982337	983319
1750	403724	404127	404531	404936	405341	405746	406152	406558	406965	407372	407779
2000	47476	47523	47571	47618	47666	47714	47761	47809	47857	47905	47953
2250	8673	8682	8691	8699	8708	8717	8725	8734	8743	8752	8760
2500	629	630	630	631	632	632	633	634	634	635	635

APPENDIX 2: FEEBATE REVENUE (1995 US $)

	IW750kg	IW875kg	IW1000kg	IW1250kg	IW1500kg	IW1750kg	IW2000kg	IW2250kg	IW2500kg
Standard 2010	44490856	40671067	83207136	1.28E+08	1.21E+08	50127162	5897387	1010050	78058
Regulation	47961226	57619872	84173170	1.28E+08	1.21E+08	50130822	5899883	1078750	78250
Environment	51917261	67292479	91157178	1.41E+08	1.21E+08	50203564	5904875	1078750	78250
Technology	53693125	67292479	94239071	1.44E+08	1.21E+08	50213875	5904875	1078750	78250

APPENDIX 3: FEE AND REBATE PER VEHICLE

	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fee-Standard 2010	313	352	403	470	565	707	943	1416	2571
Fee-Security	336	379	433	506	608	760	1015	1523	2774
Fee-Environment	460	517	592	691	829	1037	1384	2075	3787
Fee-Technology	663	746	853	997	1197	1497	1998	3000	5494
Rebate-Standard 2010	287	256	250	211	193	179	166	155	146
Rebate-Security	325	289	260	236	216	199	185	173	162
Rebate-Environment	499	437	389	351	319	293	270	251	234
Rebate-Technology	728	637	567	510	464	425	393	365	340

APPENDIX 4: IMPACT ON LIVING EXPENDITURE: CHANGE OF ANNUAL PURCHASE COST IN LIVING EXPENDITURE (%)

(purchase cost/living expenditure)%		**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Fee	FE Standard 2010	2.2	2.3	2.3	2.4	2.4	2.5	2.7	3.1	4.0
	Security	2.3	2.3	2.3	2.4	2.5	2.6	2.8	3.2	4.2
	Environment	2.4	2.5	2.5	2.6	2.7	2.9	3.1	3.7	5.0
	Technology	2.7	2.8	2.8	2.9	3.1	3.3	3.7	4.5	6.4
Rebate	FE standard	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.7
	Security	1.4	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7
	Environment	1.2	1.3	1.4	1.5	1.5	1.5	1.6	1.6	1.6
	Technology	0.9	1.1	1.2	1.3	1.4	1.4	1.5	1.5	1.6

7. BIBLIOGRAPHY

Beaumais Olivier and Katheline Schubert. (1996) “Les modèles d‘équilibre général appliqué à l’environnement : développements récents.” Rev. écon. Pol. (3) mai-juin.

Chung, W, Y. Jung Wu and J. David Fuller. (1997)“Dynamic energy and environment equilibrium model for the assessment of CO2 emission control in Canada and the USA.” *Journal of Energy Economics.* Vol. 19

Denis, Cecile., Gert Jan Koopman and Hank Mees “EUCARS: A partial equilibrium European Car emissions Simulation model.” European commission DOCII/525/94

De Melo. Jaime. “Computable general equilibrium models for trade policy analysis in developing countries: A survey.”

Endo. Kennichirou, Masayoshi Tanishita and Shigeru Kajima. “Jidousya kanrenzeisei no henjou niyoru nenpi syouhiryou sakugenkouka no bunnseki.“ (Vehicle taxes and Fuel economy analysis) (In Japanese).

Edmonds. Jae , Marshall Wise and David W Barns.(1995) “Carbon coalitions” *Energy Policy*. Vol. 23 Num.4/5.

Eskeland, Gunnar S, Emmanuel Jimenez and Lili Liu(1998). “ Price that clear the air: Energy Use and pollution in Chile and Indonesia.“ *The Energy Journal*. Vol.19 No.3

Green D.L. and J. DeCicco. (2000) Engineering-Economic Analyses of Automotive Fuel Economy Potential in the United States. Oak Ridge national Laboratory. February.

Green, David. “Transportation, Energy and Environment: Global Policy Issues for the Early 21st Century”

Green, David L. (1997) “Why CAFÉ worked.” Oak Ridge National Laboratory. August.

Green, David L. and Yuehui Fan. (1994) “ Transportation energy efficiency trends, 1972-1992.” Draft, Tennessee: Oak Ridge National Laboratory, September 16.

Japan Automobile Research Institute (1999), *JARI Report* . Tokyo:Japan Automobile Research Institute. November.

Johannsson, Bengt. (1998) "Will new technology be sufficient to solve the problem of air pollution caused by Swedish road transport?" *Transport policy* 5

Jonathan, G Koomey, Nathan C Martin, Marilyn Brown, Lynn K Price and Mark D Levine. (1998) "Cost of reducing carbon emissions: US building sector scenarios." *Energy Policy*. Vol.26 No.5

Jorgenson. Dale W. and Peter J. Wilcoxen. "Energy, the environment and economic growth." *Handbook of natural resource and energy economics.* Chapter 27.

Hayashi. Yoshitugu, Hirokazu Kato and Youichi Ueno. "Jidousya kannrennzei no kazei leberu to zeikan balansu ni yoru CO2 sakugenn kouka no sai ni kannsuru bunnseki. (In Japanese) (Vehicle tax levels and CO_2 emissions level) " *Unnyu seisaku kennkyuu*. (1999)Vol.2 No.1 Spring

Laitner Skip, Stephen Bernow and John DeCicco.(1998) "Employment and other macroeconomic benefit of an innovation-led climate strategy for the United States. " *Energy Policy* Vol.26 No.5.

Neij Lena (1997) "Use of experience curves to analyze the prospects for diffusion and adoption of renewable energy technology." *Energy Policy*. Vol.23 No.13

Nordhaus. William D. (1995)"The ghosts of climate changes past and the specters of climate change future." *Energy Policy*. Vol. 23 Num. 4/5.

Proops, J.L.R, M. Faber and G. Wagenha. *Reducing CO2 emissions*. Berlin: Springer-Verlag.

Pireddu. Giancarlo. "Externalities and the efficiency effects of eco-taxes. A computable general equilibrium approach."

Richels. Richards and Jae Edmonds (1995) "The economics of stabilizing atmospheric CO2 concentrations." *Energy Policy*. Vol. 23 Number 4/5.

Rikuun Toukei Youran (In Japanese) (Road Transport statistics). (1999) Tokyo: Ministry of Transport.

Robinson, Sherman and David W. Roland-Holst (1988). "Macroeconomic structure and computable general equilibrium models." *Journal of Policy Modeling*.

Shoven. John B. and John Whalley. "General Equilibrium with taxes: A computational procedure and an existence proof." *Review of economic studies*.

Thorpe, Steven (1994) "The Effects of Fuel Economy Standards on Automobile Sales and Average Fuel Efficiency", Working Paper, Department of Economics, University of Colorado. Steven G. Thorpe. (1994), Department of Economics, University of Colorado at Boulder, August.

Sogo Enerugi Tokei (In Japanese) (Energy Statistics) (1999) Agency of Resource Energy.

OECD/ ECMT. (1995) *Urban travel and sustainable development*

Japan Automobile Manufacture Association. (2000) *Jyouyousya shijyou doukou cyousa(In Japanese) (Report of pessenger vehicle market).* Tokyo.:JAMA,March.

National Welfare and Population Institute. *Nihon no Syourai suikei jinnkou*.(In Japanese)(Population projection in Japan) http://www1.ipss.go.jp/tohkei/mainmenu.asp.

Petroleum Energy Center(PEC). (2000) *Haisyutu gasu teigen gijyutu to sono kosuto wo kouryo shita jidousya, nenyrou no shijyou jittai yosoku cyousa houkoku.(In Japanese) (Report for market projection for vehicle and fuel with emission reduction technology)*. Tokyo.:PEC, March.

U.S. Department of Energy Office of Policy. Effects of Feebates on vehicle fuel economy, carbon dioxide emissions, and consumer surplus. Technical report two. February 1995.

8. ENDNOTES

[i] ECMT. Variabilisation and differentiation strategies in road taxation. CEMT/CS/ENV(99)9. (13)

[ii] The high price in 1979 (second oil shock) forced consumers to save energy so that oil demand diminished . Then the price decreased toward 1985. In 1985, price of oil went down. It was considered a rebound effect of the oil shock in 1979. IFP school in October, 1999.

[iii] The proportion of female driver =

Increased rate of females in households 2000-2010*Increase rate of females with driver licenses 2000-2010*Decrease rate of population 2005-2010

The proportion of elderly (aged 60-79) drivers =Increased rate of elders in households 2000-2010*Decrease rate of population 2005-2010

[iv] Ohnishi, Masakazu(1982). *Jyuyouyosoku to conputa puroguramu.(Demand projection and computer program).* Tokyo:Nikkankougyousya,129.

[v] Calculation model $FE(km/l) = FEsta * D * Tech$

FEsta: fuel economy standard 1995 D: diffusion rate (%)

FE: Fuel economy Tech: Technology advancement

[vi] Minato Kiyoyuki. (1999). *JARI Report 1999.* Tsukuba: Japan Automobile Research Institute.

[vii] International Energy Agency. (1999) *Energy price & tax.* Second quarter, 365.

[viii] The feebate term is a combination of “fee” and “rebate”.

[ix] U.S. Department of Energy. (1995). Effects of feebates on vehicle fuel economy, carbon dioxide emissions, and consumer surplus. February, IX-X.

[x] Statistics Bureau Management and cooperation agency government of Japan (1998). *Annual report on the family income and expenditure survey.* Tokyo: Statistics Bureau, 348.