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“ Global Warming and Transport Policies ”

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Abstract

The Japanese government has advocated a wide range of policy measures to reduce greenhouse gas emissions from transportation, e.g. improvements of gas mileage, development of alternative fuel vehicles, shifts to walking, bicycles and public transportation for passenger transportation and to trains and ships for cargos, greening of highways. The details of these policies and their effectiveness are not clear, however. Furthermore, virtually no analysis has been provided on the costs and benefits of these policy measures. Unfortunately, the Japanese government has been slow to develop the data infrastructure needed for such an evaluation. This article reviews the studies conducted in the U.S. and Europe, and examines what sort of research is necessary in Japan.

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1. Introduction

The Japanese government is organized in such a way that ministries and agencies have extreme monopoly power over their jurisdictions. The lack of coordination that results from this structure makes it difficult to understand and evaluate Japanese greenhouse gas policies. In the area of transport where many ministries are involved, this problem is especially acute. The following is the outline of policies put forth by relevant ministries and agencies.

The Agency of Natural Resources and Energy says it will

> significantly tighten fuel-efficiency standards (employing the top-runner method), based on automobile energy conservation laws, to achieve around a 20% (gasoline fueled vehicles) or a 15% (diesel vehicles) improvement in fuel efficiency from 1995 to 2010.

The agency also points to the need of increased public burden.

> To achieve the above automobile performance, consumers must raise the rate of premium gasoline usage from the current 20% to 50%. The cost of purchasing a new vehicle will inevitably rise. For example, a hybrid passenger car is more expensive than a traditional gasoline car by 500,000 to 1,000,000 yen.

However, no specific measures are detailed for raising the rate of premium usage and proliferating high-cost vehicles of improved fuel efficiency.

The Ministry of Transport says it is

1. improving the fuel efficiency of automobiles;
2. encouraging the proliferation of low-pollution vehicles, such as electricity-powered cars;
3. promoting the use of public transport, such as busses and trains, which are the most energy efficient; and
4. encouraging the modal shift from trucks to railway and maritime transports for freight movements along trunk routes.

However, it is not clear whether these policies are taking real effects.

The Road Council of the Ministry of Construction proposes the following policies. In regard to road usage, the government should

1. promote walking for movements of short-distances;
2. promote bicycles as an inner-city transport mode;
3. promote the use of public transport, such as railways, busses, and trams; and
4. promote the use of fuel-efficient and energy conservation vehicles.

In regard to road construction and management, the government should

1. create a road environment rich in greenery, and form networks of "green roads";
2. achieve a road system which can secure a smooth flow of automobile traffic;
3. form road networks facilitating efficient land use with a low burden on the environment, and assisting regional infrastructures; and
4. reduce environmental burden in road development and management.

As described above, Japan's efforts to reduce greenhouse gas encompass comprehensive areas, such as improving the fuel efficiency of automobiles, promoting vehicles powered by alternative energies, encouraging walking, bicycle riding, and the use of public transport, encouraging the modal shift to railway and maritime transport, and introducing greens to road systems. However, it is unclear what the content of these policies are and whether they are effective. An even greater problem is the lack of analysis on how effective these policies are, and whether they are optimum, given the magnitude of burden the public must shoulder. Left unchecked, the government may implement policies which impose extremely high costs on consumers.

What is most needed now is to systematically organize measures intended for greenhouse gas reduction, and assess their cost effectiveness from the perspective of the national economy as a whole. Unfortunately, the Japanese government falls behind in compiling data necessary for such assessment. The following chapters examine European and U.S. studies, and discuss future research direction in Japan, as a preparation for a fully fledged policy assessment.

2. International Comparison of CO_2 Emission

First, let us examine basic data on Japan's greenhouse gas emission. Although CO_2 is not the sole cause of global warming, it accounts for the largest portion of greenhouse gas, with a notable significance in the area of transport. For this reason, we focus on CO_2 in this report.

The figures below illustrate the amount of CO_2 emission by country. The United States releases the largest amount of CO_2, accounting for over 22% of the world's overall emission. The country also records the largest per-capita emission. Japan's per-capita CO_2 emission is less than half the U.S. figure.

Figure 1: CO_2 Emission by Country (1996)

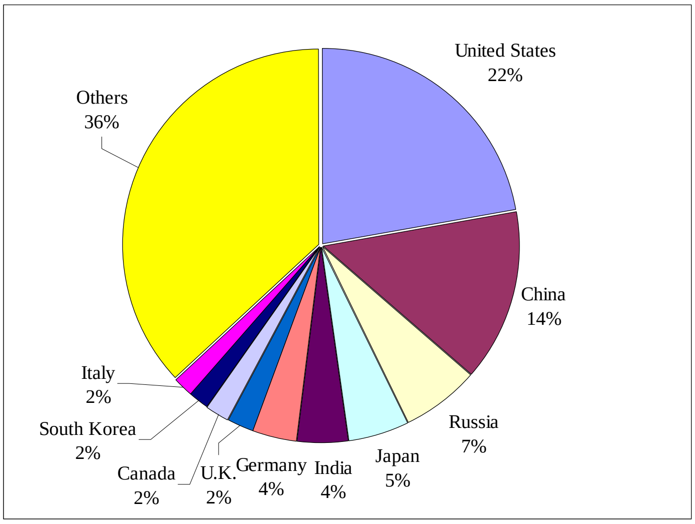
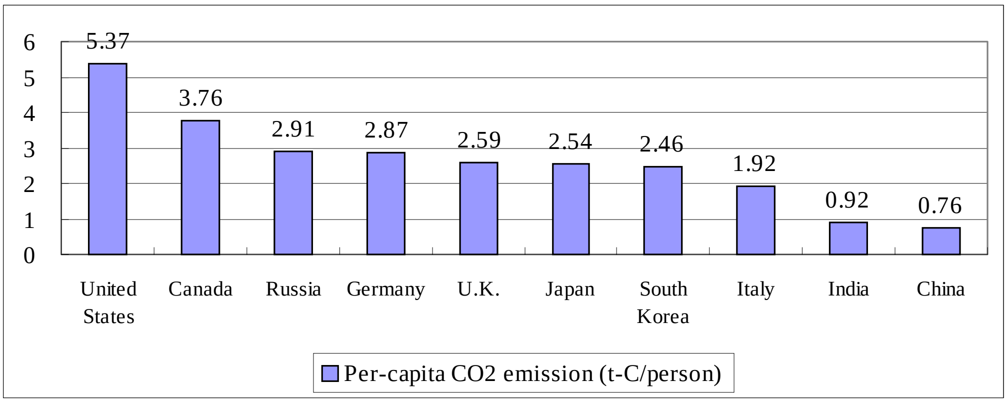
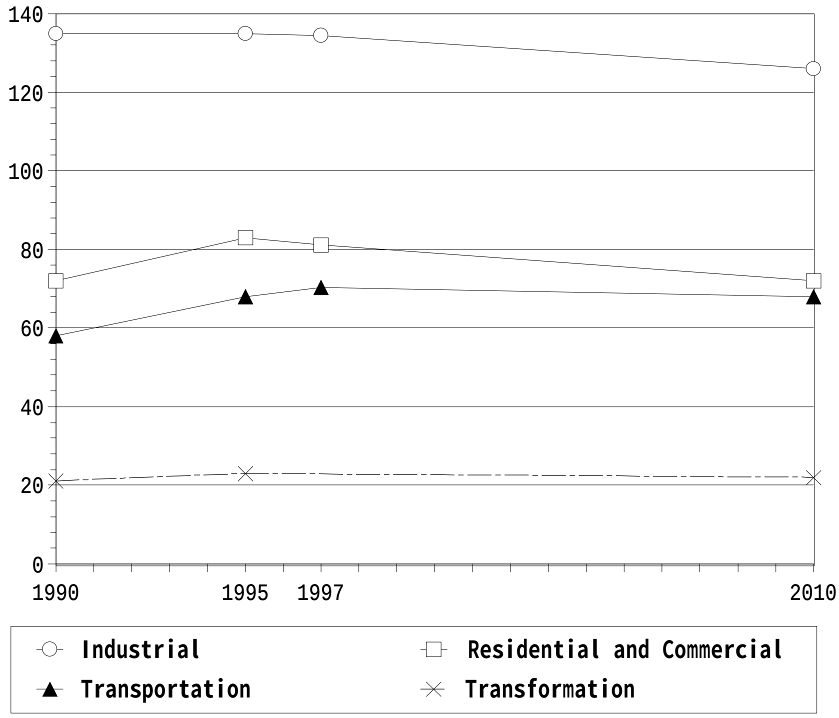


Figure 2: Per-Capita CO_2 Emission by Country (1996) (t-C/person)



The Kyoto Protocol, adopted in the 1997 COP3 (3rd Conference of the Parties to United Nations Framework Convention on Climate Change), defines targets for major industrialized nations to reduce greenhouse gas emission. The Protocol calls on Japan to achieve a 6% reduction against the 1990 figure between 2008 and 2012, allowing a 17% increase for the transport sector, but mandating a 0% increase for the residential and commercial sector and a 7% reduction for the industrial sector. However, as shown in the next figure, the CO_2 emission actually rose by 21.3% in the transport sector, 13.4% in the residential and commercial sector, and 0.6% in the industrial sector between 1990 and 1997. To achieve the Kyoto targets, the nation must reduce the emission by approx. 3% in the transport sector, 11% in the public welfare sector, and 7% in the industrial sector over the next 10 years.

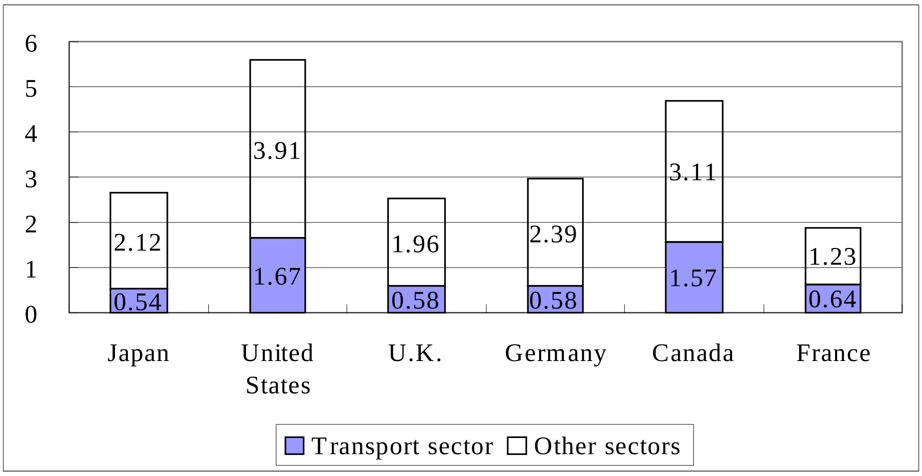
Figure 3: CO_2 Emission by Sector (Japan) (unit: million tons of carbon)



Note: The 2010 values are target figures.

The next graph makes an international comparison of per-capita CO_2 emission between the transport and other sectors. It shows Japan has the lowest level of CO_2 emission in the transport sector. However, Japan registers the largest rate of CO_2 emission increase at 22.2% between 1990 and 1997. (The United States records a 10.3% increase, U.K. 6.0%, Germany 7.8%, Canada 18.4%, and France 12.7%.)

Figure 4: International Comparison of Per-Capita CO_2 Emission (1997)



Source: Greenhouse Gas Inventory Data, United Nations Framework Convention on Climate Change.

Note: The figures are in the ton of carbon. The emission for the transport sector represents CO_2 resulting from fuel combustion. There is a slight variance in values with the Figure 3 data, because the statistics are taken from different sources.

Automobiles are the largest source of CO_2 emission in the transport sector, posting a large rate of increase each year. As shown in the next tables, the rate of increase is especially high among passenger cars at 25% in 5 years. Automobiles represent a major source of CO_2 emission in other countries as well. Energy consumption by automobiles is on the rise in the United States, although not as much as in Japan, reporting a 10% increase in 5 years when trucks and passenger vehicles are combined. One of the characteristics of U.S. figures is that energy consumption is down for passenger vehicles, while it has risen significantly for light trucks. This is partially attributable to the U.S. definition of light trucks, which encompasses SUVs (Sports Utility Vehicles). As a result, such vehicles are subject to lower fuel efficiency regulations compared to passenger vehicles.

Table 1: Transport Sector Energy Consumption by Usage (Japan) (million kl of crude oil)

	FY1990	FY1995	Rate of increase
Passenger vehicles	39.1	48.8	25%
Passenger-use aircraft	3.1	4.0	29%
Passenger transport total	48.6	58.6	21%
Freight vehicles	27.3	30.2	11%
Freight aircraft	0.4	0.6	50%
Freight transport total	31.9	35.0	10%

Source: Q&A on Global Warming and COP3, Ministry of International Trade and Industries, 1997.

Table 2: Transport Sector Energy Consumption by Usage (United States) (trillion Btu)

Year	Autos	Light trucks	Other trucks	Highway subtotal	Air	Non-highway subtotal	Total transportation
1990	8,707	4,467	3,329	16,690	2,059	4,966	21,656
1995	8,519	5,717	3,950	18,390	2,117	5,175	23,565
Rate of increase	-2%	28%	19%	10%	3%	4%	9%

Source: TRANSPORTATION ENERGY DATA BOOK: EDITION 19, Stacy C. Davis, Oak Ridge National Laboratory, September 1999. Table 2.7.

3. Cost Burden on Typical Passenger Vehicle Owners

Before examining measures against greenhouse gas, let us check the structure of cost burden on typical passenger vehicle owners. Table 3 is based on estimation by the Japan Automobile Manufacturers Association. Although the association estimates that a typical passenger vehicle travels 5,700 km per annum, the Road Transport Statistics data says personal-use passenger vehicles drive just under 10,000 km per unit per annum. This is why the table includes figures based on the annual travelling distance of 10,000 km.

The table shows that the cost of gasoline represents a relatively small portion of the overall automobile maintenance costs. When the insurance cost is included, gasoline accounts for only around one-fifth of the overall costs, even at the annual travelling distance of 10,000 km. Table 3 calculates accumulated cost burden for the average automobile life-span of 9 years at the discount rate of 0%. When converted to an annual figure, the gasoline cost comes to approx. 80,000 yen at 10,000 km per year. That means, even if the fuel efficiency improves from 12km/liter to 20km/liter, the annual saving in gasoline costs will be only about 32,000 yen, less than the amount of the automobile levy, presenting a minor incentive for cutting back on gasoline consumption.

The Road Transport Statistics shows that the overall travel distance of passenger cars has increased by approx. 13.7% in the five year period to 1995. According to Table 1, the energy consumption of those vehicles grew by 25% in the same period, demonstrating no improvement in fuel efficiency.

It should be noted, however, that whether or not a rise in the gasoline tax improves fuel efficiency depends on the costs of technological development. The accumulated gasoline cost over a 9 year period is currently 724,000 yen. Improving the fuel efficiency to 20km/liter will save approx. 290,000 yen. Since the calculation assumes the discount rage of 0%, the actual saving will be smaller, but comes to at least 200,000 yen. Therefore, when comfort and other characteristics are identical, consumers should choose a vehicle with the fuel efficiency of 20km/liter, even if it is 200,000 yen more expensive. If the carbon tax of 20 yen per liter is introduced, the accumulated cost of gasoline will increase to approx. 874,000 yen. This would translate into the saving of about 350,000 yen at the fuel efficiency of 20km/liter. In this case, consumers can pay an additional 50,000 yen toward the improvement of fuel efficiency.

Table 3: Cost Burden of Passenger Vehicles

	Lifecycle Cost (10,000 yen)		Cost per liter (yen/liter)
	5,700 km per annum	10,000 km per annum	
Vehicle price	180.0	180.0	
Automobile Tax	35.5	35.5	
Motor vehicle weight tax	17.0	17.0	
Motor vehicle acquisition tax	8.1	8.1	
Consumption tax	9.0	9.0	
Total vehicle cost	249.6	249.6	
Gasoline price after tax	15.4	27.0	36.0
Fuel tax	23.0	40.4	53.8
Consumption tax, import tax, etc.	2.9	5.1	6.8
Total fuel cost	41.3	72.4	96.6

Note: Calculated on the premise of a 1.8 million yen vehicle at the fuel efficiency of 12km/liter. Additional costs include premiums for the compulsory third-party liability insurance, voluntary auto insurance, and on-going maintenance costs.

Most of revenues from the fuel tax is allocated to road construction and maintenance.

If the levy is considered as a road usage fee, consumers are paying approx. 4.5 yen/km. As the expressway toll is 24.6 yen/km for ordinary passenger vehicles, there is a significant disparity in the cost of road usage between toll-free roads and expressways.

4. Greenhouse Gas Reduction Measures in the Transport Sector

A significant portion of greenhouse gas, generated in the transport sector, is CO_2 emission from automobiles (passenger vehicles and trucks). Table 4 lists government policies for reducing CO_2 emission from automobile traffic. The policies can be broken down into 3 categories; cutting travelling distance of automobiles, improving fuel efficiency of gasoline- and diesel-powered vehicles, and reducing the amount of carbon emission. These can be further broken down by policy type, such as direct regulation, levies, and assistance, each of which should be thoroughly assessed for its effectiveness and cost. Since there has been hardly any research of the kind conducted in Japan, we review major European and U.S. studies in this chapter. The objective is not to simply list various studies, but to indicate what kind of studies can be conducted in Japan. Note that these studies are organized in the way slightly different from classifications used in Table 4.

Table 4: Structure of Greenhouse Gas Reduction Policies in the Transport Sector

Vehicle Travel Focused	Fuel Economy Focused	Carbon Content/Fuels Focused
Travel pricing Road pricing VMT fees Fuel pricing Provision for alternative modes Transit investment Bicycle support strategy Parking policies Parking pricing Land use planning Development regulation Others Support for telecommuting Restriction on automobile use (e.g., No Car Day)	Traffic management Easing congestion Improving the traffic signal system Educating drivers Vehicle technology improvements Fuel efficiency regulation Support for technological development Choice of high fuel-efficiency vehicles Disseminate fuel economy information Linking fuel economy to automobile acquisition levy Linking fuel economy to automobile ownership levy	Alternative fuel vehicle Support for the proliferation of alternative fuel vehicles R & D on alternative fuel vehicles Carbon tax Carbon tax

Note: This table is modeled after Exhibit 5-2 by U.S. Department of Transportation (1998), with modifications in line with situations in Japan.

4.1. Pricing Policies

As pricing policies, we examine road pricing, fuel levy, and carbon tax. Road pricing raises the cost of automobile travelling, thus decreasing the travelling distance and subsequently cutting CO_2 emission. The fuel levy and carbon tax would not only increase the travel costs, but also provide incentives for choosing cars with better fuel efficiency, or opting to driving methods for lower fuel consumption. There are varying estimations on the effect of such policies.

Price Elasticity

According to The U.S. Department of Transportation (1998), the travel distance elasticity with respect to travel cost is betweent -0.20 and -1.00. As a whole, estimation in the 1980s reported high elasticity estimates, with the long-run elasticity of around -0.95. The figure dropped in the 1990s to register the long-run elasticity of -0.38, as estimated by Haughton and Sarkar (1996).

Estimation also varies on the effect of fuel levy. In Table 5, listing estimation examples in the 1980s compiled by Goodwin (1992), the long-run fuel consumption elasticity with respect to fuel cost is over -0.7.

Table 5: Average Price Elasticity Estimation of Fuel Consumption

	Defined as short or long run		No term definition
	Short run	Long run	
Time series	-0.27	-0.71	-0.53
Cross section	-0.28	-0.84	-0.18

Source: Goodwin (1992)

According to Dahl and Sterner (1991), the price elasticity of gasoline demands is -0.22 to -0.31 in short run, and -0.80 to -1.01 in long run. The income elasticity is 0.44 to 0.52 in short run, and 1.10 to 1.31 in long run.

Harvey (1994) conducted a case study of San Francisco, and concluded that increasing the gasoline tax by 2 dollars per gallon will reduce automobile travel distance by 8.1% and CO_2 emission by 30%.

Road Pricing

Unlike the fuel levy or carbon tax, road pricing is not expected to encourage consumers to choose vehicles of high fuel efficiency. Yet, easing traffic congestion will raise the average travel speed, consequently improving fuel efficiency. A study by the Southern California Association of Governments shows that charging 0.15 to 0.25 dollars/mile on a 800 mile stretch of highway for 4 hours during morning peak hour, would increase the travel speed by 10 to 20%, and reduce the travel distance by 8 to 12 % (U.S. Department of Transportation, 1998).

Daniel and Bekka (2000) conducted a simulation for road networks in the state of Delaware. Even in a scenario whereby the price elasticity of travel distance is as small as -0.5, the road pricing system is found to reduce air pollution by 15 to 31% along congested routes.

Fuel Levy

Haughton and Sarkar (1996) estimated the effects of a fuel levy. Their study shows that a rise in gasoline prices will not reduce gasoline consumption per unit distance unless the prices go beyond the peak figure in the past. However, the study found that a price hike surpassing the past peak will have a significant impact, with the short-run elasticity of -0.09 to -0.17 and long-run elasticity of -0.51 to -0.66. A drastic rise in fuel levy would also deliver a major effect. Raising the gasoline levy (currently at 0.317 dollars) by 1 dollar per gallon would cut the short-run gasoline consumption by 7 to 10%, and by 15 to 20% over a decade.

The U.S. Department of Transportation (1998) quoted the DRI estimation (1991) (concluding that the gasoline levy must be raised to 0.28 dollars/gallon in 2000 and 0.48 dollars/gallon in 2010 in order to maintain CO_2 emission at the current level) to point out that a major hike of such a magnitude in gasoline prices would deal a serious blow to commuters on low income.

Koopman (1995) created a simulation model for the EC, comparing the financial effects of the fuel levy, carbon tax, automobile ownership tax, and fuel regulations. The table below indicates social welfare losses resulting from a 10% reduction in CO_2 emission, showing that the carbon tax would be most beneficial to the welfare of economy as a whole. These calculations do not take into account any benefits of preventing global warming. This is why economic welfare is down in all cases. The introduction of the carbon tax would cause the least loss.

Table 6: Economic Effects of CO_2 Emission Reduction

	Welfare to the overall economy	Producers and consumers	Tax revenue	Fuel consumption per km	Automobile ownership	Total travel distance
Fuel levy	-1.9	-4.3	2.4	-7.1	-3.6	-4.4
Carbon tax	-1.8	-4.2	2.5	-7.1	-3.3	-4.3
Uniform rise in car ownership levy	-5.0	-22.7	17.8	0.0	-18.4	-12.3
Automobile levy according to CAFE regulations / fuel efficiency	-2.2	-1.3	-0.8	-11.8	-1.9	1.0

Source: Koopman (1995)

Denis and Koopman (1998) made a slightly different simulation, using the revised version of the same model. Their report cites inferior effectiveness of road tolls and fuel levy compared to emission regulations and levy on emission dependent vehicles, when the MCPF (Marginal Cost of public Funds) is assumed as 1.0. This conclusion is attributable to the discount rate of 50%, applied on the assumption that consumers are highly short-sighted. It is questionable whether this premise is appropriate, when a study (by Goldberg in 1996) shows consumers do not act short-sightedly. Note that, when the MCPF is 1.25, the fuel levy and road toll are rated superior. As a matter of fact, the social costs of these options become negative in this case. This is because increased tax revenues allow for cuts in other taxes, thus reducing distortions caused by those taxes.

4.2. Providing Alternative Transport

Many countries adopt a policy of promoting the use of public transportation over automobiles, as a way of cutting the emission of greenhouse gas. However, the U.S. Department of Transportation pointed to the need of selecting locations where there are a sufficient number of potential passengers, reporting in 1998 that public transports consume more energy per passenger per mile than automobiles on the national average. Since Japan has a higher concentration of population than the United States, public transports are relatively more favored. Yet, when considering energy consumption during the construction and manufacturing, public transportation may become less energy efficient in locations of low demands. Table 7 estimates the level of passenger concentration public transportion must achieve in order to make them comparable in CO_2 emission to passenger vehicles. The results indicate that constructing a light transit system or tram in small cities may actually increase CO_2 emission.

Table 7: Passenger concentration by public transport type, at which CO_2 emission per person per km becomes equal to that of passenger vehicles (unit: person / carriage)

Metropolitan areas	Railway	Subway	Light transit system	Tram	Bus
Operation	5.4	5.0	3.5	5.2	4.6
Operation, carriage production, and repair	6.0	5.8	4.0	6.0	4.6
Operation, carriage production, repair, infrastructure construction, and maintenance	8.8	11.7	10.6	10.9	-
Current average passenger concentration (national average)	57.4	59.4	14.3	20.8	10.7
Non-metropolitan areas	Railway		Light transit system	Tram	Bus
Operation, carriage production, and repair	6.2		5.4	8.0	6.2
Operation, carriage production, repair, infrastructure construction, and maintenance	9.2		7.5	10.5	6.7
Current average passenger concentration (national average)	13.4		16.1	16.5	-

Note: Based on the assumption that a passenger vehicle carries on average 1.34 people (based on the FY1994 Road Traffic Census figure).
Source: Ministry of Construction estimation from the Annual Railway Statistics

The U.S. Department of Transportation (1998) also cited that supporting the use of bicycles or parking islands would have minimal effects.

4.3. Improving the Traffic Management

Although hardly recognized in Japan, road traffic management, such as controlling traffic signals, also has an impact on fuel consumption. The traffic signal system, newly introduced in Los Angeles, is estimated to reduce signal delay by 44%, automobile stoppage by 41%, and fuel consumption by 13% (according to the U.S. Department of Transportation, 1998).

The United States is also discussing a policy of setting the speed limit on motorways at 55 miles per hour to reduce fuel consumption.

4.4. Fuel Efficiency Regulations and Fuel Efficiency Tested Levies on Car Acquisition / Ownership

The United States imposes fuel efficiency regulation called CAFE (Corporate Average

Fuel Economy) on automobile manufacturers, and the Gas-Gazzler Tax on passenger vehicles with low fuel efficiency. There are several reports evaluating these policies.

Greene (1997) considers the CAFE regulation effective. Fuel levies are regarded less effective, with a recent estimation putting the fuel cost elasticity of travel demands at around -0.1 in the short run and -0.2 in the long run.

In contrast, Dowlatabadi, Lave and Russel (1996) concludes that further tightening of CAFE would generate too much costs for too small benefits. Their arguments are:

(1) The higher the fuel efficiency goes, the smaller the amount of emission reduction resulting from efficiency improvement will be. (When the fuel efficiency improves from 5km/liter to 10km/liter, fuel consumption is reduced by 1 liter per 10km. However ,when the fuel efficiency improves from 10km/liter to 20km/liter, the reduction will be only 0.5 liters per 10km.)
(2) The United States has numerous other greenhouse gas reduction measures with greater cost performance than tightening CAFE.
(3) The cost of tightening CAFE to 46.8 mile/gallon amounts to as much as 530 dollars per ton of CO_2.

Goldberg (1996) analyzed consumer behavior empirically and reached the following conclusion:

(1) In the short run, automobile usage (travel distance per unit) does not respond to changes in fuel prices.
(2) The decision to purchase a car is affected by the price and fuel costs of the car.
(3) Consumers are not short-sighted in purchasing a car.
(4) The gasoline tax must be set at 780% in order to bring about a reduction in fuel consumption to the same extent as CAFE. (The U.S. gasoline tax is currently 10 cents per liter. The tax rate of 780% translates into 78 cents per liter. The average price of cars in 1987 was 12,000 dollars, with the annual fuel cost of approx. 300 dollars on average.
(5) The Gas-Guzzler Tax has a minimum effect on reducing fuel consumption. This is because higher tax rates are applied to expensive models with small price elasticity.

In Japan, a model on the effects of a "green-conscious motor vehicle taxation system" (as proposed by the Council for Transport Policy on May 20, 1999) was used to analyze the effects of levies on automobile acquisition / ownership, linked to fuel efficiency. The results show that such levies would improve the fuel efficiency of passenger vehicles by 6.23% and reduce 1.91 million t-c of CO_2 emission. However, since details of the model and parameters used are not made public, it is difficult to assess how appropriate the results are.

Hayashi, Kato, and Ueno (1999) used a different model and obtained the following results:

(1) Levies on automobile acquisition / ownership would affect the way consumers decide whether to keep or scrap a car or which model they should buy. However,

an automobile usage levy such as a fuel tax would have a negligible effect.

(2) A fuel tax hike would reduce CO_2 emission caused by driving. A progressive levy on the acquisition / ownership of automobiles with low fuel efficiency, would also reduce CO_2 emission caused by driving.

It is also difficult to assess the credibility of these results. For example, their conclusion that levies on automobile usage would not affect a consumer decision on whether to keep / scrap a car or which model to buy, is based on a demand function using the acquisition / ownership levy and usage levy as separate explanatory variables. Such a formula may not necessarily correspond to consumer's rational choices.

4.5. Converting to Alternative Fuel Vehicles

Japan is among many countries advocating the use of vehicles powered by alternative fuels, such as electricity, natural gas, and ethanol. However, according to the U.S. Department of Transportation (1998), such vehicles yield little benefits in preventing global warming. According to U.S. Department of Energy estimation, shown in Table 8, there is little difference in CO_2 emission between alternative fuels and gasoline, when the upstream processes are included. Also, CNG has no global warming advantage, as it generates, in addition to CO_2, methane, a gas with significant global warming effects. As for electricity-powered vehicles, if they use electricity generated from coal, the overall amount of CO_2 emission would be greater than that of gasoline-powered cars. Although Japan's dependency on coal is not very significant, we must carefully examine to what extent alternative fuel vehicles are effective in the context of global warming.

Table 8: U.S. DOE estimation of CO_2 emission per travel distance (gram / mile)

Fuel	Vehicle usage	Upstream	Total
Gasoline	272.4	74.9	347.3
Methanol from natural gas	270.4	112.7	383.1
Ethanol from corn	301.1	24.4	325.5
CNG	204.7	43.5	248.2
LPG	235.4	28.1	263.5

Source: Exhibit 5-8, US DOT (1998).

5. Policy Tasks in Road transport

Measures against global warming form only one of many policy tasks in road transport. They need to be build in a way in line with other tasks. Road transport policy tasks can be classified into 3 categories; (1) providing road transport services to motor vehicles and pedestrians; (2) using road space for communal and disaster control purposes, and (3) controlling external effects of road transport, such as air and noise pollution. Table 9 lists specific policy tasks in each of the 3 categories. We must formulate a coherent system of policy measures which can simultaneously solve such a variety of tasks.

One type of measure can be applied to multiple tasks. For example, a fuel levy would contribute to controlling road usage as a kind of road toll, and addressing global warming through reducing fuel consumption.

Table 9: Policy Tasks in Road transport

Road transport services (motor vehicles, pedestrians, bicycles, and parking)	Road space services (communal drainage, subways, landscape, and disaster control)	Control of road transport's external impacts
Usage fees Congestion tax, road damage costs Traffic control Traffic signals, parking regulations	Usage fees Communal drainage Fixed asset tax External diseconomies of road construction	Roadside (local) environment Noise Localized air pollution (NOx, PM, ozone) Measures against global warming

When addressing wide-ranging policy tasks, it is essential to take a systematic approach. The first-best policy of charging the users “prices” that equal the social marginal costs is the best starting point. Needless to say, the first-best policy is not always feasible. Yet, those who do not understand what the first best policy is are not capable of devising the second best policy.

Unfortunately, Japan has conducted almost no assessment of the social marginal costs in road transport. The next chapter presents assessment examples in the United States and Europe.

6. External costs of automobiles

The United States has spent a large amount of time and money in studying the cost structure of road transport. The most recent one was released in 1997, with the previous one dating back to 1982. According to the Executive Summary of the report,

> “The primary objective of this study is to analyze highway-related costs attributable to different highway users as a basis for evaluating the equity and efficiency of current Federal highway user charges. The principal basis for evaluating the equity of the Federal highway user fee structure in this study, as in previous Federal HCASs, is to compare the responsibility of different vehicle classes for highway program costs paid from the Federal Highway Trust Fund (HTF) to the user fees paid into the HTF by the different vehicle classes. The closer that user fee payments match the cost responsibility for a particular vehicle class, the more equitable the user fee structure is for that class.”

The core section of this study is the distribution of road construction / maintenance costs among various vehicle types. The study also estimates the social marginal costs, including external costs such as congestion and noise. It says it will release costs related to air pollution, when the estimation work is complete. However, the figure has yet to be released.

The next table indicates the estimation of social marginal costs. It shows that the costs related to pavement and noise are high among large trucks with heavy axle weight, while passenger vehicles generate only one several tenth to several hundredth of the costs. The difference is not as significant for congestion costs, but large trucks produce costs several times that of passenger vehicles.

In the United States, the cost burden of passenger vehicles is currently 2.6 cents per mile on average. Therefore, the burden is greater than the social marginal cost in regional areas, but is far smaller in urban areas. Similar situation exists for single-chassis trucks, whose cost burden is 11.23 cents, and multi-chassis trucks, whose cost burden is 15.23 cents.

Table 10: External (Marginal) Costs of Automobiles: 1997 Federal Highway Cost Allocation Study

	Marginal Costs (cents per mile)					
	Pavement	Congestion	Crash	Air Pollution	Noise	Total
Autos/Rural Interstate	0.0	0.78	0.98	TBD	0.01	1.77
Autos/Urban Interstate	0.1	7.70	1.19	TBD	0.09	9.08
40 kip 4-axle S.U. Truck/Rural Interstate	1.0	2.45	0.47	TBD	0.09	4.01
40 kip 4-axle S.U. Truck/Urban Interstate	3.1	24.48	0.86	TBD	1.50	29.94
60 kip 4-axle S.U. Truck/Rural Interstate	5.6	3.27	0.47	TBD	0.11	9.45
60 kip 4-axle S.U. Truck/Urban Interstate	18.1	32.64	0.86	TBD	1.68	53.28
60 kip 5-axle Comb/Rural Interstate	3.3	1.88	0.88	TBD	0.17	6.23
60 kip 5-axle Comb/Urban Interstate	10.5	18.39	1.15	TBD	2.75	32.79
80 kip 5-axle Comb/Rural Interstate	12.7	2.23	0.88	TBD	0.19	16.00
80 kip 5-axle Comb/Urban Interstate	40.9	20.06	1.15	TBD	3.04	65.15

Source: Table ES-6, Federal Highway Administration (1997).

Assuming the exchange rate of 120 yen to the U.S. dollar, the social marginal cost of passenger vehicles is 1.3 yen/km in rual highways and 6.8 yen/km in urban highways. When the fuel efficiency is 12km/liter, the optimal fuel levy, equal to the social marginal cost, would be 15.9 yen/liter in rural highways and 81.7 yen/liter in urban highways. Japan's current gasoline levy is in between these figures at 36 yen/liter. Since the Japan Highway Public Corporation charges 24.6 yen/km as highway toll, as explained earlier, the total burden in Japan is at a much higher level than the social marginal cost in urban highways in the United States. To determine whether Japan's fuel levy and highway toll are at the appropriate level, we must assess the social marginal cost of automobile transport in Japan.

A group of researchers in Britain assessed the external costs of automobile-generated air pollution. Their estimation, as shown in Table 11, shows that diesel oil generates large external costs both in regional and urban areas. Especially, in urban areas, the cost reaches 2.717 pence/km (equivalent of 5.434 yen/km at the exchange rate of 200 yen to the British pound). The largest portion of diesel oil's external costs is attributed to health hazard caused by suspended particulate matters (SPM), which has recently captured media attention in Japan.

This estimation puts the external costs of global warming at as small as 0.1 pence/km.

Table 11: External diseconomies cost of automobile air pollution (pence/km)

Emission	Impact	Damage Costs (in p/km)					
		Rural Emissions			Urban emissions		
		Petrol	Gas	Diesel	Petrol	Gas	Diesel
Carbon dioxide	Global warming	0.093	0.073	0.068	0.109	0.085	0.095
Methane	Global warming	0.000	0.005	0.000	0.000	0.006	0.000
Nitrous oxide	Global warming	0.003	0.003	0.001	0.006	0.006	0.001
Carbon monoxide	Global warming	0.001	0.001	0.000	0.003	0.001	0.001
Particulates	Health	0.003	0.000	0.151	0.003	0.000	1.692
Particulates	Building materials	0.000	0.000	0.003	0.000	0.000	0.035
Sulphur dioxide	Health	0.024	0.001	0.014	0.173	0.001	0.182
Sulphur dioxide	Crops	0.000	0.000	0.000	0.000	0.000	0.000
Sulphur dioxide	Timber	0.018	0.001	0.011	0.021	0.001	0.015
Sulphur dioxide	Building materials	0.005	0.000	0.003	0.036	0.000	0.038
Sulphate aerosol	Health	0.033	0.001	0.020	0.038	0.001	0.027
Oxides of nitrogen	Health	0.013	0.007	0.029	0.076	0.054	0.113
Oxides of nitrogen	Timber	0.022	0.013	0.051	0.036	0.023	0.049
Oxides of nitrogen	Building materials	0.006	0.003	0.013	0.034	0.024	0.051
Nitrate areosol	Health	0.101	0.057	0.228	0.163	0.103	0.219
Ozone from NO_x	Health	0.045	0.026	0.102	0.073	0.046	0.098
Ozone from NO_x	Crops	0.003	0.001	0.006	0.004	0.003	0.006
Benzene	Health	0.012	0.000	0.004	0.126	0.001	0.052
Ozone from VOC	Health	0.110	0.017	0.017	0.145	0.018	0.041
Ozone from VOC	Crops	0.006	0.001	0.001	0.008	0.001	0.002
Non-methane VOC	Global warming	0.003	0.000	0.000	0.003	0.000	0.001
Sub-totals		0.500	0.211	0.723	1.060	0.375	2.717

Source: Table 6, Eyre N.J., E. Ozdemiroglu, D.W. Pearce, and P. Steele, 1997.
Note: In this table, "Petrol" represents gasoline, "Gas" represents natural gas, and "Diesel" represents diesel (light) oil.

Apart from the two examples quoted above, there are other estimations of external costs of automobiles. They generally estimate high external costs for air pollution. Gomez-Ibanes says these figures are estimated too high because of the following reasons:

(1) In many cases, parking costs do not represent external costs.
(2) The external cost portion of accident costs is over-estimated.
(3) The estimation uses control costs, rather than damage costs.
(4) The estimation includes both road construction costs and external costs of congestion, amounting to double counting.
(5) The estimation uses the average costs rather than marginal costs.

Of these criticisms, (3) applies to the air pollution and global environment costs. Gomez-Ibanez says, in terms of damage, the external costs of air pollution should be 1 to 2 cents per mile per person, except for in Los Angeles and other exceptions. Incidentally, the British estimation, shown in Table 11, represents damage costs, thus quoting low external costs for rural areas.

Table 12: Automobile External Costs (unit: cent per passenger per mile, based on 1990 prices)

	WRI study (all times, all roads)	T&E study (all times, all roads)	NRDC study (all times, all roads)	CLF study (peak, expressway)	Litman study (peak, urban)
Government facilities and services					
Capital	0.8		0.4	2.8	2.2
Operating & maintenance	0.9		2.4	0.3	3.5
Other government (police/fire/ justice)	1.8		0.3-0.9	1.2	1.4
Subtotal	3.4		3.1-3.7	4.3	7.1
Externalities					
Congestion			0.4		15.5
Air pollution	1.0	3.82	4.0-7.0	6.6	7.5
(of which, climate change)	(0.7)	(0.90)	(2.2-4.6)		(1.1)
Noise pollution	0.1		0.1-0.2	0.1	0.9
Water pollution			0.1		1.2
Solid waste					0.2
Accidents	1.4	2.74	3.3	0.6	3.2
Energy	0.7		1.5-5.0	1.9	2.6
Parking	2.7		0.8-3.2	5.2	10.9
Other			0.01		8.2
Subtotal	5.9	6.8	10.2-19.2	14.4	50.2
User payments					
Fares, tolls			0.0	0.0	0.0
Taxes		3.4	0.7	3.0	2.0
Subtotal	1.0	3.4	0.7	3.0	2.0
Net subsidy	8.3	3.4	12.6-22.2	15.7	55.3

Source: Table 1.1, Gomez-Ibanez (1997)

Note: Estimation figures are quoted from the following:

WRI: MacKenzie, J.J., R.C. Dower, and D.D.T. Chen (1992)
T&E: Kagoson, P. (1993)
NRDC: Miller, P. and J. Moffet (1993)
CLF: Apogee Research Inc. (1994)
Litman: Litman, T. (1994)

Small and Kazimi (1995) assessed the external costs of air pollution, mainly for California. They put the cost of localized air pollution, such as NOx, SOx, and PM, at 0.03 dollars per mile per passenger vehicle (1992, Los Angeles). The figure for trucks is 16 times the passenger vehicle value.

Their study also covered the external costs of global warming. However, citing difficulty in assessing damage costs, they quote control costs, as determined by Manne and Richels (1992). In working out the control costs, they calculated the rate of the carbon tax required to stabilize CO_2 emission at the 1990 level by the year 2000, and reduce it by 20% over 10 years. According to the calculation, the external costs progressively rise to 208 dollars per 1 ton of carbon. Based on the figure, the external cost of automobiles was estimated at 3.1 cents per mile per unit (or 17.7 cents/liter).

This survey of past studies indicates that the external costs of global warming may be estimated at only 2 yen per one liter of gasoline in terms of damage cost. However, in terms of control cost for achieving the targets set in the COP3 agreement, the external costs may be as high as 20 yen per liter.

7. Global Warming and Road Transport Policy Structure

As stated earlier, measures for controlling global warming are only one part of road transport policy tasks, and should be coordinated with other tasks. As the starting point, we should examine the first-best policy where people are asked to pay, in some form or other, the social marginal costs. As examined in the previous chapter, external diseconomies such as congestion, air pollution, and noise make up a significant proportion of the social marginal costs in road transport. The important question is how such costs should be allocated to road users.

In the area of road transport, quantitatively significant social marginal costs consist of congestion externalities, road damage, greenhouse gas, localized air pollution, and noise. These costs are discussed in detail below.

7.1. Congestion externalities

As seen in the U.S. estimation examples, congestion externalities account for the largest portion of external costs quantitatively. Congestion externalities fluctuate greatly according to regions, routes, and time zones. It is usually large in urban areas and small in rural areas. A notable difference is also observed between peak hours and off-peak hours (late night and early morning). Ideally, fees should be increased on congested routes and time zones, and dropped elsewhere. Until now, such an optimum system of congestion charges has been considered impractical. However, technological hurdles in implementing the system are being cleared. An "automatic fee collection system" is about to be introduced to Japanese highways. When the system becomes widespread, it will not be difficult to set fees according to the degree of congestion. When all vehicles become compatible with the system, the introduction of congestion fees will be a real possibility.

In around 10 years time, we may see the introduction of the optimum congestion fee system. However, for the time being, there is no choice but putting up with less than perfect charging systems. One of the most extreme examples is the current fuel levy. Since fuel consumption is inevitably linked with the amount of automobile travel, the levy can be deemed as an imperfect form of road usage charge. It may serve as a congestion tax if the charge is fluctuated according to the degree of congestion. However, it is currently levied at a fixed rate.

Road tolls for highways are currently also fixed. Some roads are waving tolls at night when traffic is sparse. Expanding such flexibility in more precision will give road tolls the function of congestion charges. It is desirable for at least toll roads to adopt variable charges in different areas and time zones, according to the degree of congestion.

7.2. Road damage

The amount of road damage by motor vehicles varies from model to model. Concerning pavement damages, there is a well-known fourth power rule, in which pavement wears in proportion to the fourth power of the axle weight (weight on each axle). The rule indicates it is heavy-weight trucks and busses, rather than light vehicles such as passenger vehicles, that damage pavement. This theory is reflected in Table 10, which shows low external costs in pavement for passenger vehicles, and high costs in big trucks with large axle weight.

Japan has numerous bridges crossing rivers and elevated roads running over built-up areas. The costs of maintaining and repairing such structures are created mostly by large trucks. Construction costs are also high, in order to build roads that can withstand large trucks.

In view of these factors, large trucks should bear the costs of road damage, in accordance with their axle weight. Just like congestion externalities, road damage is caused by the use of roads. The burden should therefore be distributed according to the degree of road usage. The optimum policy would be to introduce a truck levy, charged in line with axle weight and travel distance. This is not entirely impossible, as there are some U.S. states already implementing such a tax system. Yet, there remains a possibility that some drivers may manipulate the odometer to falsify travel distance. Measuring travel distance correctly is no easy task.

Japan's automobile weight tax is supposed to be a form of burden sharing for road damage. However, the narrow difference in tax rates between passenger vehicles and large trucks signifies that it is not serving as a road damage levy.

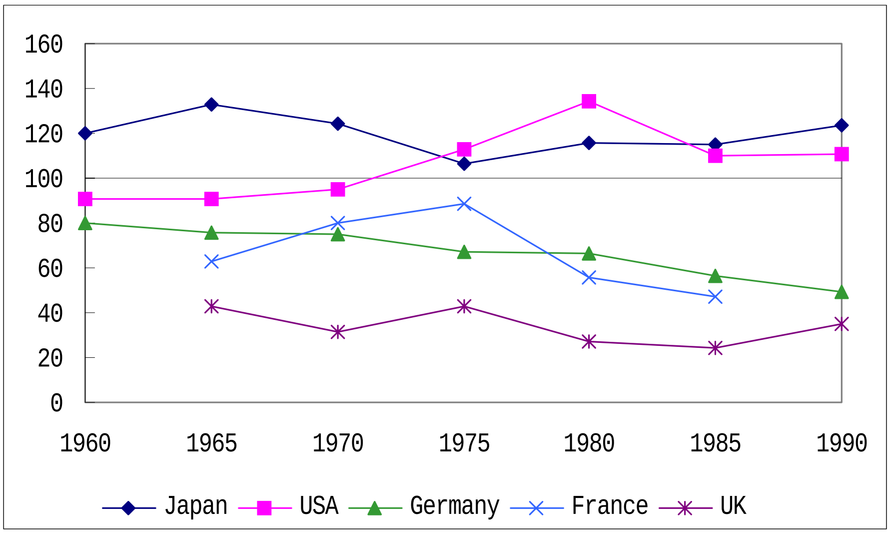
7.3. Greenhouse gas

As for greenhouse gas, the best solution would be levies according to the amount of emission. This can be achieved by simply linking the fuel levy to the volume of greenhouse gas emission.

What is important in greenhouse gas is that it is generated from almost all areas of production and consumption activities, and that costs for reducing it vary significantly. Forcing areas requiring high reduction costs to cut emission would prove to be extremely costly for the Japanese economy as a whole. Rather than targeting specific areas, it is more desirable to introduce the carbon tax, uniformly levied across the entire economy.

European countries levy fuel taxes as a source of general revenues, often collecting more than road project expenditures, as shown in Figure 5. In this case, the excess portion can be interpreted as a pseudo carbon tax. This does not apply to Japan and the United States, where road project expenditures exceed revenues from automobile related taxes. However, this perspective needs further examination, with some arguing that a portion of road project expenditures, related to urban street planning and adjustments, should be covered by other taxes such as the property tax.

Figure 5: International Comparison of Road Project Expenditures and Automobile Related Taxes



Source: International Comparison by Data --- Transport Related Data Collection ---, compiled by the Highway Economic Research Division, Road Bureau, Ministry of Construction.
Note: Levies at the same rate as the consumption tax, value added tax, sales tax, and other fiscal services should be excluded, but it is unclear if this is the case.

7.4. Localized air pollution

Localized air pollution by NOx, SPM, VOC, etc. is more difficult to address than greenhouse gas, in that the amount of emission depends on the type of fuel, and that modifying cars is currently the cheapest way of reducing auto exhaust.

In considering measures against localized air pollution, there are five points to consider. Firstly, light oil generates a large amount of NOx and SMP, yet is costly to control such emission with current technologies. Secondly, even though technological innovation is expected in the future, we must provide appropriate incentives. Thirdly, some measures should be taken on second-hand vehicles, as insufficiently maintained / repaired cars and old cars release a greater amount of exhaust. Fourthly, how cars are driven also affect the amount of gas emission. Controlling the amount of harmful emission relies largely on driver awareness. Finally, it is technologically possible to monitor the actual amount of emission by laser and other means. However, it would be costly to monitor all cars on the road.

Considering the above points, it appears most practical to introduce a car ownership levy, according to the emission levels gauged at the time of automobile registration / renewal.

Currently, light oil is subject to a lower rate of fuel levy than gasoline, subsequently boosting demands for diesel engine vehicles. The rate variation between oil types needs to be abolished.

7.5. Noise

The policy structure in regard to automobile noise contains even more complex elements than in the case of localized air pollution. Firstly, as seen in Table 10, large trucks and busses are the main source of noise, implying significant differences in external costs among vehicle types. Secondly, roadside land use greatly affects the level of damage. Traffic noise causes major damage when a trunk route runs through residential areas. However, the damage is small when such a road is laid through areas with commercial buildings only. The United States and European countries ban the use of land along trunk routes for residential purposes, but such a measure is difficult in Japan, given the current land use. Thirdly, there are many ways of reducing noise. Our task is to identify the optimum combination of such measures. Measures against noise pollution include:

(1) Sound-proofing roadside residential homes.
(2) Measures on road structures, such as installing sound shield walls, securing space for environmental facilities, using the sound-absorbing pavement materials, laying roads underground, and employing the canal structure.
(3) Imposing noise regulations and providing assistance for the development of noise-control technologies for automobiles
(4) Measures for reducing the flow of large trucks into city areas, such as developing by-pass routes, introducing fees, and imposing traffic regulations.
(5) Introducing land use policies, such as changing roadside land use, and providing grants for building noise shielding structures.

7.6. Linking costs for providing road services and costs for addressing environmental issues: Fiscal Problems

For road users causing external diseconomies, the first best policy is to ask them to pay for the social marginal costs that they are responsible for. It is often difficult to enforce this first best policy, but the second best policy is often expected to amount to some form of user burden, such as a fuel tax. The question is whether the fees and taxes collected from users should be allocated specifically to expenditures for road projects and environmental measures, or whether the money should be treated as general revenue.

Congestion and Road Damage

The financial burden of congestion externalities and road damage can be considered a price for using road services, and naturally linked to road services charges. The system of road specific revenues is obviously based on this perception. The problem here is that allocating all revenues from charges on congestion and road damage may lead to too much or too little road services. This problem has been debated for many years, with the following conclusion. (See Kanemoto (1997) and Newbery (1994) for details.)

The existence or non-existence of economy of scale determines whether revenues from the optimum congestion fees can cover the construction, maintenance, and repair of the optimum road capacity. If there is economy of scale, such revenues are not sufficient to pay for necessary expenditures, causing road operators to go into the red. On the other hand, if there is diseconomy of scale, revenues surpass expenditures, generating profits. In other words, whether the charges paid by users can cover the optimum road investment depends on the economy of scale in providing road services. We cannot draw a clear conclusion, because Japan has yet to conduct a study on economy of scale in connection with actual road services. According to studies in other countries, there is no notable economy or diseconomy of scale.

However, areas with a small amount of traffic may have economy of scale, because their fixed costs for road construction is proportionately high in relation to demands. In urban areas, on the other hand, the large number of intersections may generate diseconomy of scale. Another issue which should be noted is that urban streets in commercial and residential areas serve a multitude of functions including space for pedestrians or disaster control purposes. Therefore, costs for such roads should not be borne solely by automobile users.

The relationship between economy of scale and road revenue / expenditure holds even in an incomplete charging system. For example, when there is only a uniform fuel levy, it can be regarded as a type of incomplete congestion charge. Even in this case, if there is a constant returns to scale in road services, implementing the optimum road construction should balance the revenues and expenditures in road projects. This outcome is used as the backbone of Newbery's argument (1994) that the earmarked funds for road porjects raised through fuel taxes are desirable.

Environment externalities

A similar analysis can be made in examining whether all revenues from taxes on environment externalities, such as the carbon tax, should be allocated to environmental measures. The conclusion should be basically the same. However, it is difficult to believe that there is constant returns to scale in environmental policy measures. I am not aware of any empirical studies conducted in this issue, but it is likely that there is a major diseconomy of scale. In this case, tax revenues would significantly surpass the optimum expenditures for environmental measures, thus making the introduction of a purpose specific revenue system totally out of question.

8. Problems of the Current System in Japan

When putting forth a new policy, such as measures against greenhouse gas, the government must often rectify problems in existing policies. This chapter cites several problems as examples.

8.1. Burden on Road Users

Japan's automobile levies are structured as shown in the next Table. Levies on acquiring and owning motor vehicles comes to as much as levies associated with driving. The social costs of automobiles are mostly associated with car usage, rather than car ownership. Therefore, in order to control externalities, it is rational to reduce the weight of levies on motor vehicles themselves. An introduction of new taxes, such as carbon tax may be coupled with a reduction in motor vehicle taxes.

Table 13: Tax Burden of Automobiles

(100 million yen)

Acquisition stage	(1) Motor vehicle acquisition tax	4,700	Levies on motor vehicles	48,000
	(2) Consumption tax	8,600		
Ownership stage	(3) Motor vehicle tax	17,400		
	(4) Light vehicle tax	1,100		
	(5) Motor vehicle weight tax	11,200		
Driving stage	(6) Gasoline tax	27,200	Levies on fuel	47,000
	(7) Local road tax	2,900		
	(8) Light oil tax	13,000		
	(9) Oil gas tax	300		
	(2) Consumption tax	3,600		
Total				90,000

Source: Motor Vehicles and Taxes, 1999, jointly compiled by 15 automobile-related organizations.

Note: The figures are projected tax revenues for FY1999 (except for the consumption tax figures, which are estimated by the Japan Automobile Manufacturers Association). (1) and (5) to (9) are purpose specific taxes (revenues specifically for road expenditures), and the rest are general revenues. Note that three quarters of the motor vehicle weight tax is general revenues for the central government (80% of which is earmarked for road expenditures by the government), and the remaining quarter is purpose specific road revenues for regional governments.

When compared with Europe and the United States, Japan's fuel tax is lower than that of European countries, but higher than that of the United States. However, levies on car acquisition and ownership are higher than European counterparts. A large portion of tax revenues in European countries represents the value added tax, which effectively correspond to Japan's consumption tax in that the VAT is imposed on all car-related consumption. As a result, the motor vehicle tax portion is much smaller than in Japan.

Table 14: International Comparison of Taxes on Automobile Acquisition and Ownership (Japan Automobile Manufacturers Association estimation)

(10,000 yen)	Japan	Germany	U.K.	France	United States
Motor vehicle tax	35.5	14.4	27.8	5.5	2.6
Motor vehicle tonnage tax	17.0				
Motor vehicle acquisition tax	8.1				
Registration tax		0.4		2.4	
Subtotal	60.6	14.8		7.9	
Consumption tax	9.0				
VAT		28.8	31.5	37.1	
Sales tax					14.8
Total (approx.)	70	44	59	45	17

(Reference) International Comparison of Fuel Levies --- Gasoline

(10,000 yen)	Japan	Germany	U.K.	France	United States
Fuel tax	23.0	31.0	47.7	41.8	6.2
Consumption tax, import levy, etc.	2.9	6.8	10.4	8.9	1.4
Total (approx.)	26	38	58	51	8

(Remarks) Above figures are the accumulated total for the average automobile life span of 9 years.

Assumptions: Automobile price 1.8 million yen, average monthly travelling distance 475 km, fuel efficiency 12km/liter, exchange rates 129 yen to the U.S. dollar, 22 yen to the French franc, 74 yen to the German mark, and 213 yen to the British pound.
Source: Japan Automobile Manufacturers Association estimation

The burden on automobile users do not stop with levies on motor vehicles and fuel. They must also pay road tolls. Compared to Europe and the United States, Japan has a higher proportion of toll roads. We have yet to obtain statistics on road toll burden, but it can be estimated from the following data on road project expenditures. As stated earlier, the Japan Highway Public Corporation charges 24.6 yen/km (ordinary passenger vehicles) as expressway toll, which is notably higher than the gasoline levy of approx. 4.5 yen/km.

Table 15: Road Project Expenditures

FY	General roads	Toll roads	Regional roads	Total	Project costs per unit (1000 yen)
1990	43,675	27,399	26,253	107,328	188.1
1991	44,685	30,311	39,647	114,643	193.2
1992	53,110	33,874	46,937	133,921	210.1
1993	63,568	36,918	50,156	150,642	204.6
1994	50,130	36,476	49,368	135,974	218.7
1995	66,131	35,677	50,937	152,745	215.2
1996	54,572	34,236	53,342	142,151	209.4
1997	51,873	33,729	50,948	136,560	209.8

Source: Road Bureau, Ministry of Construction, and Japan Automobile Manufacturers Association.

Another problem of Japan's automobile related taxes is the disparity between commercial and private-use vehicles. Considering that commercial vehicles tend to travel longer distance, the disparity goes against the need to control externalities.

Table 16: Disparity in automobile acquisition / ownership levies between commercial and private-use vehicles.

	Private-use passenger vehicle	Commercial-use passenger vehicle
Motor vehicle tonnage tax (yen/0.5t.year)	6,300	2800
Motor vehicle acquisition tax	5%	3%

Road Revenue System

In examining the structure of road users' financial burden, we have explained how most of road-related tax revenues are earmarked for road construction and improvement. Now, let us identify problems of the current road revenue system.

Firstly, as stated earlier, there is a significant disparity in charges between toll roads and toll-free roads. From the congestion control point of view, there may be cases whereby toll for low-traffic roads had better be lowered.

Secondly, most toll roads adopt uniform charges. It is desirable to introduce charges according to the level of congestion.

Thirdly, Japan has a major disparity among different oil types. The fact that light (diesel) oil is levied lower than gasoline is effectively increasing the number of diesel engine vehicles. In view of problems associated with NOx and SPM, diesel engine vehicles should not be given a preferential treatment. LPG-powered vehicles enjoy even lower tax rate, and automobiles powered by natural gas, such as CNG and LNG, are totally tax free. In comparison, the United States is making efforts to distribute tax burden according to social marginal costs.

Table 17: Disparity among Different Oil Types

	Gasoline	Light oil	LPG	CNG	LNG
Japan (yen/liter)	53.8	32.1	9.8	-	-
United States (cent/gallon)	18.3	24.3	18.3	4.3	18.3

Fourthly, when the motor vehicle tonnage tax should be levied primarily on heavy vehicles such as large trucks, the government currently levies passenger vehicles at a high tax rate as well.

9. Conclusion

The best approach to addressing global warming is to introduce the carbon tax, uniformly imposed on the entire economy. The area of transport already has fuel levies in place, and only needs to adjust them according to the amount of greenhouse gas emission. Therefore, when political consensus is reached, there should be little administrative difficulty. The drawbacks of the carbon tax are cited as follows:

(1) Because of consumers' short-sightedness, fuel price hikes should only cause a

minor shift to vehicles with high fuel efficiency. (Denis and Koopman, 1998)

(2) The rate of the carbon tax must be set reasonably high in order to make it effective, thus delivering a major income re-distribution effects. In the United States, some argue that such a tax imposes excessive burden on low-income automobile commuters. In Japan, burden is greater for people in rural areas, highly dependent on motor vehicles.

As for the first drawback, there are some studies, including the one by Goldberg (1996), showing that consumers are not short-sighted. The second drawback can be resolved to a certain extent by reducing levies on automobile acquisition and ownership.

The carbon tax is desirable in that a blanket levy on the entire economy would lead to steady reduction of greenhouse gas emission from areas where reduction costs are low. Partial application of the carbon tax, for example only in the transport area, would cancel its advantages.

In actual policy implementation, there are hardly any cases whereby the first best policy could be adopted. Analysis of the second best policy is far more complex, and the estimation of price elasticity of demands would be required. For example, we must look into the following:

(1) What are the effects of fuel and carbon levies on the travel distance and fuel efficiency of automobiles?
(2) Further construction and improvement of roads are expected to increase automobile travel distance. By how much will it increase? (The rate of increase was around 2% per annum from 1990 to 1995, and less than 1% from 1995 to 1997 due to decrease in the amount of freight transport.)
(3) Some argue that road improvement eases traffic congestion, thus improving fuel efficiency. To what extent can this be expected? (According to Ota (1997), there is a positive correlation between road improvement and gasoline consumption.)
(4) Are the effects of automobile acquisition / ownership levies, linked to fuel efficiency and its regulations on auto manufacturers, greater than those of fuel and carbon levies?

In addition, measures against global warming must be coordinated with approaches to other policy tasks. Therefore, we need to resolve the disparity in levies among different oil types or between commercial and private-use vehicles. We must also examine the issues of congestion charges and financial burden for road damage, taking into consideration the possible shift to an electronic fee collection system.

As has been reiterated, the Japan government has conducted hardly any estimation of external costs or price elasticity of demands. These must be studied urgently, in order to adopt rational policies.

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