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ENVIRONMENT DIRECTORATE
ENVIRONMENT POLICY COMMITTEE

**Working Party on Pollution Prevention and Control
Working Group on Transport**

**ENVIRONMENTALLY SUSTAINABLE TRANSPORT (EST)
PHASE 3: POLICY INSTRUMENTS FOR ACHIEVING EST**

**Volume 2
Case Study: provided by Japan**

This document is part of the report on Phase 3 of the four-phase project on Environmentally Sustainable Transport (EST) [ENV/EPOC/PPC/T(99)6/FINAL]. The report on Phase 3 comes in two volumes: i) the synthesis report of the case studies with the different policy packages, and ii) as an annex volume, the compilation of the seven studies prepared by the participating countries. Phase 3 concerned the identification of policy instruments and measures for achieving EST. It is based on individual case studies carried out by ten countries.

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FOREWORD

This document is part of the report on Phase 3 of the four-phase project on Environmentally Sustainable Transport (EST) [ENV/EPOC/PPC/T(99)6/FINAL]. The report on Phase 3 comes in two volumes: i) the synthesis report of the case studies with the different policy packages, and ii) as an annex volume, the compilation of the seven studies prepared by the participating countries. Phase 3 concerned the identification of policy instruments and measures for achieving EST. It is based on individual case studies carried out by ten countries. These studies form the annex to the report on Phase 3 of the EST project, and are as follows:

- ANNEX 1: **Alpine Region** - *EST Synthesis report* (Austria, France, Italy and Switzerland)
[ENV/EPOC/PPC/T(99)6/FINAL/ANN1]
- ANNEX 2: **Canada** - *Environmentally Sustainable Transportation Study - Québec Windsor Corridor*
[ENV/EPOC/PPC/T(99)6/FINAL/ANN2]
- ANNEX 3: **Germany** - *Environmentally Sustainable Transportation Study*
[ENV/EPOC/PPC/T(99)6/FINAL/ANN3]
- ANNEX 4: **Japan** - *A Meso-Scale Estimation of Future CO₂ Emissions in Transport*
[ENV/EPOC/PPC/T(99)6/FINAL/ANN4]
- ANNEX 5: **The Netherlands** - *Environmentally Sustainable Transportation: Implementation and Impacts for the Netherlands for 2030*
[ENV/EPOC/PPC/T(99)6/FINAL/ANN5]
- ANNEX 6: **Norway** - *Environmentally Sustainable Transport - Case Study: The Greater Oslo area*
[ENV/EPOC/PPC/T(99)6/FINAL/ANN6]
- ANNEX 7: **Sweden** - *An Environmentally Sustainable Transport System in Sweden*
[ENV/EPOC/PPC/T(99)6/FINAL/ANN7]

The overall purposes of the OECD EST project are to characterise EST and to establish guidelines for the development of policies that would result in the achievement of EST. The basic techniques used are scenario construction and backcasting.

- **Phase 1**, of the EST project—completed in 1996—involved a review of relevant activities of Member countries as well as the development of the definition of and criteria for EST.
- **Phase 2**, carried out in 1997 and 1998, has been the scenario-development phase. It has mainly comprised construction by participating Member countries of a business-as-usual (BAU) scenario and three scenarios for 2030 consistent with the EST criteria. It has also involved some preliminary consideration of the backcasting and other analyses to be undertaken during Phase 3.

- **Phase 3**, carried out in 1999 comprised the core of the backcasting exercise. It mostly consisted of the identification of packages of policy instruments and measures whose implementation would result in achieving the EST3 scenarios constructed during Phase 2. Phase 3 involved also refinement of the EST3 scenario and assessment of the social and economic implications of the BAU and EST3 scenarios.
- **Phase 4**, conducted during 2000 comprised refinement of the definition and the criteria for achieving EST and the development of guidelines for policies for moving towards EST.

The work has been carried out by six teams of experts from nine countries, each with a separate geographical focus to describe how this environmentally desirable objective may be achieved. The six case studies include Sweden, the Netherlands, Germany, the Quebec-Windsor corridor in Canada, the Greater Oslo region and the Alpine region comprising parts of Austria, France, Italy and Switzerland. Related studies have been undertaken by Japan and for the Central and Eastern European region within the context of the Central European Initiative of Environment Ministers (CEI). The case study on EST for Japan is also included in the Annex, while the EST study for the CEI has been published separately.

The reports and expert papers of all Phases of the project are also available on OECD's Internet site (<http://www.OECD.org/env/ccst/est>).

**A Meso-Scale Estimation
of Future CO₂ Emissions in
Transport — Japan**

EST Committee of Japan

May 1999

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A MESO-SCALE ESTIMATION OF FUTURE CO₂ EMISSIONS IN TRANSPORT — JAPAN

1. Introduction

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2. Overview of OECD Project “Environmentally Sustainable Transport (EST)”

2.1 Introduction

In 1995, OECD started a project called “Environmentally Sustainable Transport (EST)”. The EST project has been seeking to demonstrate what an environmental framework for strategies to achieve EST might look like, taking into account environmental issues that manifest their effects at very different geographic scales like global, regional and local. It is an attempt to establish a basis upon which a diverse range of policy-makers and economic actors can communicate, and a framework within which goals, objectives, targets or standards could be set by governments and actions initiated.

The major purposes of this study can be stated as follows:

- i. To examine and refine the concept of Environmentally Sustainable Transport (EST).
- ii. To determine the kind of actions required to achieve EST.
- iii. To develop guidelines for the achievement of EST that could be of use to Member countries, i.e. Germany, Netherlands, Sweden, Canada, Norway, Austria, France, Italy and Switzerland, in formulating policies and measures whose implementation would be in EST.

The OECD’s EST project has four phases as stated below:

Phase 1: This phase involves a review of relevant activities of Member countries as well as the development of the definition of EST and criteria for EST. Phase 1 was completed in 1996.

Phase 2: This phase is the Scenario development phase. It comprises several scenarios constructed by participation of Member countries. These scenarios are business-as-usual scenario (BAU) and other three scenarios, which involves future technical prospects and transport policies for 2030, consistent with the EST criteria. This phase involves some preliminary considerations of the backcasting and other analyses to be undertaken during Phase 3 as stated below.

Phase 3: This phase has been conducted during the remainder of 1997 and early 1998. Phase 3 mostly consists of identification of packages of policy instruments whose implementation would result in achieving the scenarios constructed during Phase 2, with a focus on the EST3 scenario known as optimum-combination scenario. Phase 3 also involves refinement of EST 3 scenario and assessment of the social and economic implications of the BAU scenario and EST3 scenarios.

Phase 4: This phase is planned for completion in 1999. Phase 4 comprises refinement of the definition and criteria for achieving EST and the establishment of guidelines for policy development in connection with EST.

2.2 *Definition and Criteria of EST*

2.2.1 *Definition*

The report of Phase 1 of the EST project (OECD, Environmental Criteria for Sustainable Transport: Report on Phase 1, 1996) contains a discussion in meanings of EST and its relationships to the broader concept of sustainable development. For transportation to be sustainable, a brief definition of EST which was developed during the Phase 1 project is stated as follows:

Transportation that does not endanger public health or ecosystems and meets needs for access consistent with (a) use of renewable resources at below their rates of regeneration, and (b) use of non-renewable resources at below the rates of development of renewable substitutes.

2.2.2 *Criteria*

The definition of EST stated above was elaborated in terms of criteria for attainment of EST. The elaboration considered impacts on air and water from local, regional and global perspectives.

Six kinds of criteria were developed during Phase 1 as being the minimum number required to address the wide range of transportation impacts as follows:

- 1. Transport-related emission of nitrogen oxides (NO_x) have been reduced to the extent that the objectives for ambient NO_x and for ozone levels as well as for nitrogen deposition are achieved.*
- 2. Emissions of volatile organic compounds (VOCs) have been reduced to the extent that excessive ozone levels are avoided, and emissions of carcinogenic VOCs from vehicle transportation have been reduced to meet acceptable risk levels.*
- 3. Emissions of particulates have been reduced to the extent that harmful ambient air levels are avoided.*
- 4. Climate change is being prevented by achieving per-capita carbon dioxide emissions from fossil fuel use for transportation consistent with the global protection goals for the atmosphere.*
- 5. Land surface in urban areas is used for the movement, maintenance and storage of motorised vehicles, including public transport vehicles, such that the objectives for ecosystem protection are met.*
- 6. Noise caused by transportation should not result in outdoor noise levels that present a health concern or serious nuisance.*

The EST definition and criteria developed during Phase 1 are general in nature and extremely preliminary. They are to be developed further during and after the EST project. The six EST criteria have been quantified during Phase 2 of the EST project. These numerical criteria which were given during Phase 2 project are as follows:

a)	CO ₂ emissions	-	80% reduction between 1990 and 2030.
b)	NO _x emissions	-	90% reduction between 1990 and 2030.
c)	VOC emissions	-	90% reduction between 1990 and 2030.
d)	Particulate	-	90% less PM ₁₀ emissions between 1990 and 2030.
e)	Noise	-	a negligible level of serious noise nuisance in 2030.
f)	Land use	-	a good living climate inside urban areas in 2030 and indirect land use in 2030 represents half the 1990 level.

2.3 Scenario Construction

2.3.1 Backcasting approach and scenario construction

Policy development can be shaped in the light of present circumstances or future goals.

In the former case, forecasts based on current trends provide the basis for determining what may be required to accommodate or counteract those trends.

In the latter case, goals are set and there is a working backwards (which is referred to in the OECD report as backcasting approach) from the goals to determine what must be done to reach them.

The former kind of policy development results in doing what is possible to avoid an unwanted future. The latter kind results in doing what is necessary to achieve a wanted future. The major distinguishing characteristics of backcasting approach is a concern not of what is likely to happen in the future, but more how a desirable future can be attained. It is thus an explicitly normative approach.

Policy development often involves both approaches stated above, although usually with more emphasis on present circumstances than on goals for the future. Engaging in forecasting rather than backcasting approach is especially appealing when setting goals may be controversial or when desired goals may appear to be unattainable. Moreover, an approach based on forecasting is likely to be incrementalist and responsibly cognisant of current realities. By contrast, an approach based on backcasting may involve large and even disruptive changes, and may appear to be extremely idealistic.

A backcasting approach may nevertheless be preferable if effective change is sought. Transportation may well be a sector for which such an approach could be especially valuable. In most cases, current policies and measures have not significantly reduced the overall environmental impacts of transportation.

Scenario development is a necessary preliminary to a backcasting exercise. A future or several alternative futures which is developed as scenarios must be described with rigor if there is to be a valid exercise of identifying policy instruments whose implementation might lead to the achievement of one or another of the scenarios.

Thus, the EST project comprises two substantial work items: One is construction of scenarios and the other - the backcasting approach - is identification of the actions that would need to be taken to ensure attainment of the scenarios.

2.3.2 Scenarios

The OECD project adopted 4 kinds of scenarios, i.e. business-as-usual scenarios (BAU) and the other 3 kinds of scenarios.

1. BAU Scenario

The business-as-usual scenario (BAU) is a reference scenario that reflects the continuation of present trends in transportation. It assumes present and planned legislation and technology supplemented by moderate changes considered likely to occur.

2. EST Scenarios

EST Scenarios comprise three kinds of scenarios, i.e. EST1, EST2 and EST3 scenario.

EST1 scenario is the *high technology scenario*. It is assumed that the amount of passenger and freight transport was to be the same as determined for the BAU scenario for the particular area of study. The EST criteria were to be achieved entirely through technological change, identified in the characterizations of EST1.

EST2 scenario is the *capacity-constraint scenario*. It is assumed that the level of technology was to be the same as for the respective BAU scenarios. The EST criteria were to be achieved entirely through managing and reducing the demand for passenger and freight transport. The amount and types of the reductions were identified in the characterizations of EST2.

EST3 scenario is the *optimum-combination scenario*. It is assumed that the EST criteria were to be achieved through a combination of technological change and demand management. The nature and extent of the changes were included in the characterizations of EST3.

3. Overview of EST related studies in Japan

In this chapter, we overview the Studies concerning global environmental issues and quantified effects of counteracts which have been conducted by Japanese Government.

3.1 Introduction

In December 1997, the COP3 were held in Kyoto, Japan. At that Conference, the Japanese Government submitted it's own proposed target of reduction of emission between 1995 and 2010. In this chapter, we give an overview of the research which was conducted by Japanese Government, National Environment Agency.

3.2 Procedure

(1) Adopted Scenarios

Four kinds of scenarios in 2010 that was adopted in the Government research are as follows:

a) BAU Scenario

The BAU scenario assumes the present and planned technology, present economic trends and legislation supplemented by changes as considered likely to occur.

b) High Technology Scenario

The amount of passenger and freight transport is assumed to be the same as determined for the BAU scenario. This scenario is evaluated from the point of view of such technological changes as development of low emission vehicles.

c) Capacity-Constraint Scenario

The level of technology is assumed to be the same as for the respective BAU scenario. This scenario is evaluated from the point of view of managing and reducing demand for passenger and freight transport.

d) Optimum-Combination Scenario

Above scenario b) and c) were combined as the optimum-combination scenario. It is assumed that the EST criteria were to be achieved from the point of view of a combination of technological change and demand management.

3.3 Assumptions

(1) Assumptions common to all scenarios

Demographic and economic factors are commonly assumed as follows:

Factors	Assumed Annual Rate of Growth
Annual Rate of Economic Growth	2.9% until 2000, 1.9% between 2000 and 2010, and 1.4% between 2010 and 2020
Annual Rate of Population Growth	0.1% until 2010, -0.3% between 2010 and 2020

(2) Assumptions for each scenario

The assumptions for each scenario are summarized as follows:

(1) Assumptions for the BAU scenario

Factors	Assumed Annual Growth Rate
Car-ownership and Usage	Substantial increase in annual growth rate of car ownership, i.e., 1.4% until 2010, and 0.6% between 2010 and 2020. Annual growth rate of passenger car use is 1.8% until 2010, and 1.0% between 2010 and 2020.
Van and Truck Usage	Slight decrease in annual growth rate of truck use, i.e., 0.5% until 2010, and -0.1% between 2010 and 2020.
Rail	A certain increases in passenger movement, but slight decreases in freight movement.
Aviation	Substantial increase in passenger movement, and moderate increase in freight movement.
Inland and Coastal Shipping	Current level continues in passenger movement, and slight increase in freight movement.
Modal Split	General shift to automobile use for passenger movement, and slight change respecting freight movement.
Transport-related Infrastructure	Current rate of provision of infrastructure continues.
Fuel Prices	Not considered.
Others	Continuation of present trends concerning general features of individual life-style.

(2) Assumptions for the High Technology Scenario

The basic task of this scenario is to identify technological improvements that would be effective to reduce emissions under the assumption of certain levels of transport activity in the BAU scenario.

The assumptions are as follows:

Factors	Assumptions
Technical improvement of efficiency of energy consumption regarding each mode of transport	Reduction in fuel expenses (Reducing by 20% of 1995 year for 2010 regarding gasoline automobiles).
	Economic policy to promote to own low emission vehicles, e.g. favorable treatment of tax policy.
	Improvement of efficiency of energy consumption in using automobile, railway, shipping and aviation.
Development and diffusion of clean energy or low emission vehicle	Such clean energy or low emission vehicle as Electric Vehicle, Hybrid Vehicle and CNG Vehicle will be widespread.

(3) Assumptions for the Capacity-Constraint Scenario

This scenario indicates that the reduction in passenger car use would be to some extent compensated by increase in the use of public transport, and that the reduction in truck use would be compensated by increase in the use of rail freight. The summary of assumptions are as follows:

Factors	Assumptions
Improvement of efficiency of freight movement	Rail and shipping freight facilities will be improved
	Efficiency of freight loading on trucks will be improved
	Size of trucks will be enlarged
	Logistic system will be widespread in freight movement
Public transport use (Modal shift from auto-mobile to public transport)	Service level of such public transport as buses and railways will be improved so as to achieve higher level of public transport use
Traffic demand management	Promotion of off-peak commuting will become effective
	Occupancy of vehicle will become much higher
ITS	Traffic flow will become smoother
Traffic flow management	Road traffic flow will be more smoothly controlled by such means as traffic signalizing

3.4 Results

According to the study done by the Japanese government, taking the several scenarios stated above into consideration, reduction in emission of carbon dioxide for 2010 in Japan was estimated as follows;

The Scenario	Expected Amount of Reduction in 2010 million ton-C
(1) The High Technology Scenario	4.6
(2) The Capacity Constraint Scenario	8.1
(3) Combined scenarios of (1) and (2)	12.7

Table 1. **Estimated Reduction in CO₂ in each Sector**

[million ton-C]

Sector	1990	2010 (BAU scenario)	Reduction of CO ₂	2010□ ((2)+(3) scenario)	2010 /1990 growth rate
TOTAL	287	347	▲60	287	0%
Industrial	135	142	▲16	126	▲7%
Domestic	72	99	▲27	72	0%
Energy Conversion	21	25	▲3	22	5%
Transport	58	81	▲13	68	17%

Note: The values of basic indicators were assumed for COP3 goals of carbon dioxide reduction for Japan. These are calculated by AIM model.

4. Backcasting Approach for Reduction in Nationwide Emission

In this Chapter, we discuss future environmental load caused by transportation under the assumption of current trend of demand for each mode.

Through this study, we apply the backcasting approach, which has been discussed in chapter 2, to quantify effects on the reduction in environmental load.

In the following discussion of the procedure, we will derive a target share of demand for each mode of transportation to meet criterion drawn by the backcasting approach.

4.1 Procedure of Analysis

The general features of the procedure are as follows:

(1) Basic Assumptions

Basic assumptions adopted here are as follows.

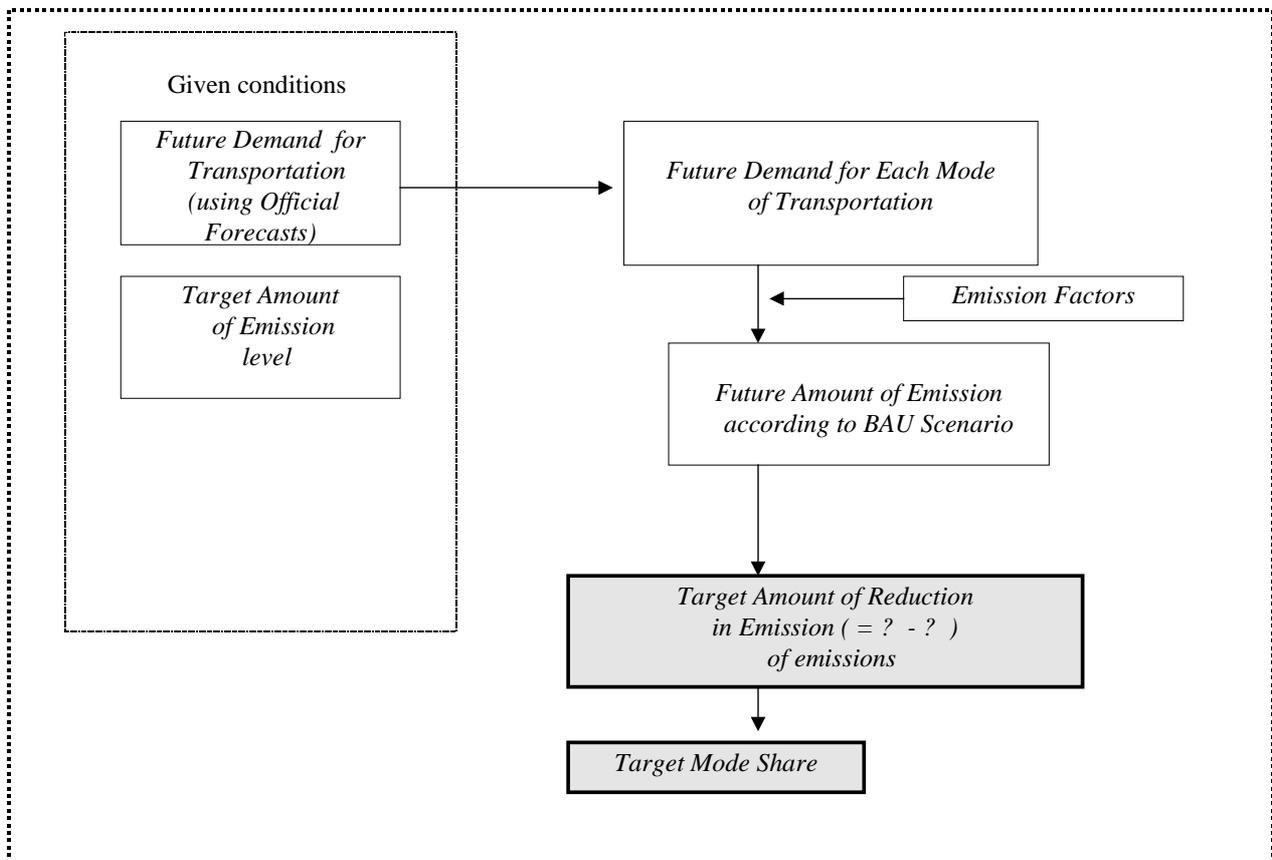
- | | |
|--------------------------------------|---|
| a) Emission concerned | : CO ₂ |
| b) Study Area | : Japan |
| c) Modes of Transportation concerned | : Railways, Road traffic, Aviation and Shipping |
| d) Year concerned | : 2000, 2010, and 2020 |

(2) The Study Flow

The study flow can be shown as follows.

Backcasting Approach for The Estimation of Desirable Level of Policy Implementation

Figure 1. The Study Flow of the Backcasting Approach



4.2 Transport Demand Forecasts

As for transport demand forecasts, we adopt some official forecasts instead of making our own forecasts through this study.

(1) Overview of existing official forecasts

Here we look over existing official demand forecasts being studied and published in Japan. The research reports that we referred in our own study are as follows:

- a) The Council for Transport Policy, "Basic tasks for problems to be solved in the transport policy in 1990s moving forward the 21st century", July, 1992.
- b) Japan Transport Economic Research Center, "Future Demand for Transportation in the 21st Century in Japan", March, 1992.
- c) National Land Agency's interim report on future demand for transportation, 1997.

- a) The Council for Transport Policy, "Basic tasks for problems to be solved in the transport policy in 1990s moving forward the 21st century", July, 1992.

The Basic Concept

Viewing future social and economic trend toward 21st century, several assumptions were set in 2000, which involve such figures as future economic growth or future population. Then taking these figures into account, future transport demand was forecasted.

Forecasting was done based on several substitutable future economic growths. On that account, the several predicted values were supposed in this study.

Future Economic Trend

As for the growth rate of the real GNP of Japan, several values are proposed. One is the value proposed in the 4th National Comprehensive Development Plan being published in 1987, i.e., average annual growth rate from that year through the year 2000 was predicted as□□. Another value is five- year average economic growth rate of 3.75% defined in the five-year Economic Plan published in 1988. Moreover they have two values i.e. the one is the 4% annual economic growth rate that is consistent with the 4th National Comprehensive Development Plan, the other value is the 3% economic growth rate that is consistent with the lower growth economy scenario in Japan.

Future Population

The Population in Japan in 2000 was set as 131, 192, 000 people. This value was defined being based on the middle estimate procedure published by Laboratory of Population Affairs of Ministry of Welfare, under the assumption of annual average growth rate of 0.5% from 1995 through the year 2000.

Future Regional Figures Concerning Social and Economic Aspects

As for future social and economic figures in regional scale, every 10 regional block has predicted value of shares concerning personal and freight transport generation and attribution in the year 2000. The each share was set as two values i.e. the one is consistent with the decentralizing scenario, and the other value is consistent with the business-as-usual scenario.

Future Transportation

Officially authorized transportation networks being employed as the assumptions.

Car ownership

Future car ownership was forecasted as the original value in this study. They forecasted by making use of the methodology of logistic curve estimation. Scenarios were adopted. One is the business-as-usual scenario that gives the upper limit as same as the all Japan average. The other is the large city constraint scenario which gives the upper limit of the approximately 80% of all Japan value.

- b) Japan Transport Economic Research Centre, "Future Demand for Transportation in the 21st Century in Japan", March, 1992.

Basic concept

In this study, the future passenger demand in person-kilometre and future freight demand in ton-kilometre in 2000 were forecasted.

Firstly, average passenger travel distance is estimated in terms of kilometre referring to past transport statistics from 1976 through 1988. And maximum and minimum predicted demand of transport in 2000 is shown in this report.

Secondly, a regression model to estimate passenger transport demand by GNP is given in this report. Then passenger demand forecasts in 2010 is obtained in terms of person-kilometre.

As for the freight demand forecasting, firstly average freight travel distance is estimated in terms of kilometre referring to past transport statistics in 1988. And predicted value of transport demand in 2000 is shown in this report. Secondly GNP elasticity is estimated by using of the outputs of the existing research reports. Then future freight demand forecasts in 2010 is obtained in terms of ton-kilometre.

Outcomes

Passenger Transport

Mode of Transportation		Transport Demand in 2010 million person-kilometre
Aviation		97,000 ~ 119,600
Railways	Shinkansen	92,500 ~ 105,300
	Ordinary Lines	388,600 ~ 414,300
	Sub-total	481,100 ~ 519,600
Cars	Buses	96,600 ~ 107,700
	Passenger cars	769,400 ~ 819,100
	Sub-total	866,000 ~ 926,800
Shipping		4,800
Total		1,441,700 ~ 1,520,500

Freight Transport:

Mode of Transportation	Transport Demand in 2010 million ton-kilometre		
Aviation	14.8	~	17.9
Railways	332	~	473
Trucks	2,850	~	3,520
Shipping	2,180	~	3,170
Total	5,460	~	7,050

c) National Land Agency's interim report on future demand for transport, 1997.

National Land Agency published official forecasts of transportation demand of passenger and freight by mode for 2000, 2010, 2020 and 2025 as shown below.

Table 2. Forecasts of the Demand for Passenger Transport

Mode of Transportation	100 million person-kilometre				
	1994 (present value)	2000	2010	2020	2025
Passenger Cars	8,968	10,355	12,158	13,633	14,106
Railways	3,963	4,428	5,019	5,467	5,576
Shipping	59	61	63	61	59
Aviation	613	766	971	1,161	1,227
Total	13,603	15,612	18,211	20,352	20,967

Source: National Land Agency.

Table 3. Forecasts of the Demand for Freight Transport

Mode of Transportation	100 million ton-kilometre				
	1994 (Present Value)	2000	2010	2020	2025
Trucks	2,806	3,039	3,364	3,627	3,706
Railways	245	254	269	279	283
Shipping	2,385	2,505	2,697	2,849	2,894
Aviation	9	10	13	15	15
Total	5,445	5,808	6,343	6,770	6,898

Source: National Land Agency

(2) Future Demand for Transportation adopted in this Study

Taking into account of the several official forecasts stated above, we decide to adopt the one that the Agency of Land Use Planning has estimated. The reasons why we adopt those outcomes are as follows:

- a) The period under study meets our scope of study
- b) The forecast is the latest estimation for the years far beyond 2000 in Japan
- c) The forecasted values are used as the basis for drawing up the New National Comprehensive Development Plan for which the National Land Agency is responsible

The types of modes corresponding to the demand forecasts published by the National Land Agency are less detailed than those corresponding to the emission factors. Therefore we have to disaggregate the modes for forecast to match the classifications for emission factors.

The correspondence of modes are shown in the following Table.

Table 4. Correspondence of the Mode Classifications

Modes for Demand Forecasts		Modes for Emission Factors *
Cars	<ul style="list-style-type: none"> • Passenger Cars (Including Buses) 	<ul style="list-style-type: none"> • Commercial Passenger Cars • Private Passenger Cars including mini-sized motor vehicles
		<ul style="list-style-type: none"> • Private Buses • Chartered Buses • Passenger Buses
	<ul style="list-style-type: none"> • Trucks 	<ul style="list-style-type: none"> • Large-sized Lorries of Common Carries • Small-sized Lorries of Common Carries • Large-sized Private Trucks • Small-sized Private Trucks
Railways	<ul style="list-style-type: none"> • Passenger Railways 	<ul style="list-style-type: none"> • Ordinary Lines
		<ul style="list-style-type: none"> • The Shinkansen
	<ul style="list-style-type: none"> • Freight Railways 	<ul style="list-style-type: none"> • JR Freight
Aviation	<ul style="list-style-type: none"> • Passenger Airways 	<ul style="list-style-type: none"> • Passenger Airways
	<ul style="list-style-type: none"> • Cargo Airways 	<ul style="list-style-type: none"> • Cargo Airways
Shipping	<ul style="list-style-type: none"> • Passenger Ship 	<ul style="list-style-type: none"> • Passenger Ship
	<ul style="list-style-type: none"> • Cargo Ship 	<ul style="list-style-type: none"> • Cargo Ship

*Source: Japan Transport Economic Research Center, "A Survey on the Environmentally Friendly Transportation", August 1995.

For the purpose of adjusting the 2 different types of modes stated above, we applied a simple idea of proportional distribution. The procedure is discussed in more detail as follows.

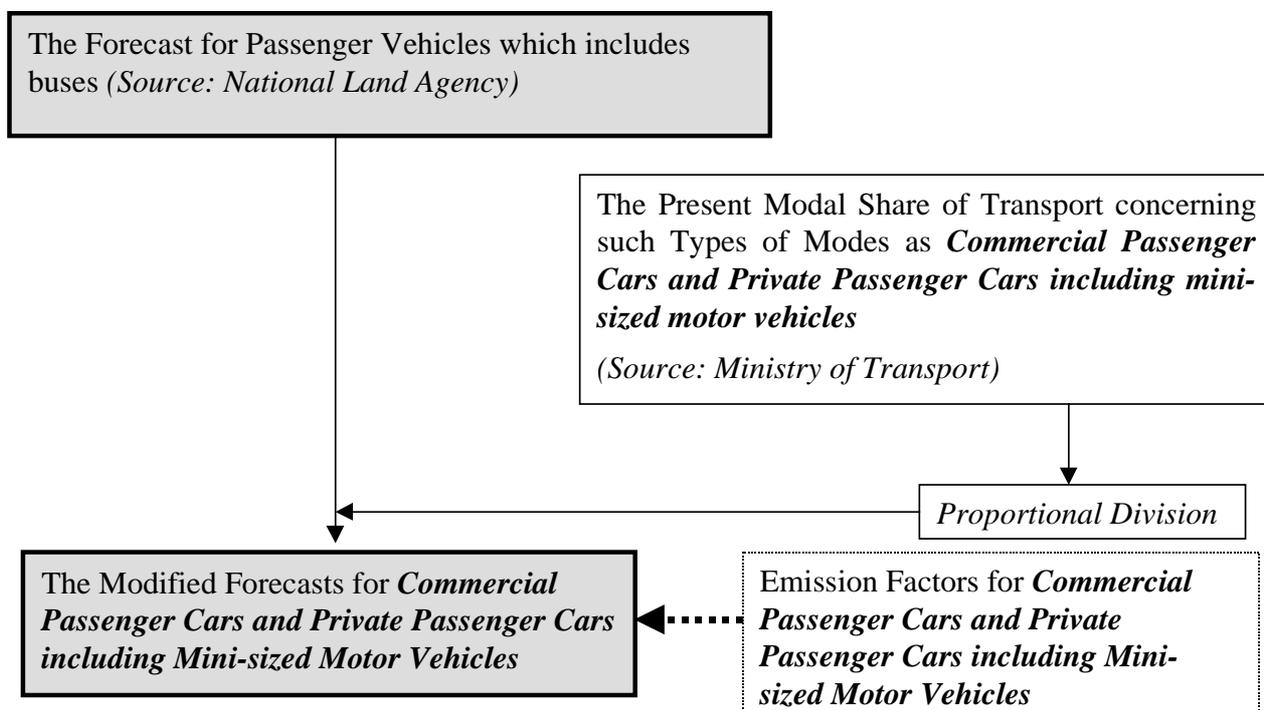
(3) Procedure for adjustment of different types of modes

In order to get future demand for transportation of which modes correspond to the classification of emission factors we divide the former forecasted volume proportion to the present mode share.

Procedures are shown as follows:

Example : Case of Passenger Vehicles

Figure 2. Procedure for getting Modified Forecasts corresponding to the Classification of Emission Factors (Case of Passenger Cars)



According to the procedure shown in the above figure, all the forecasts are adjusted. Then we can obtain the modified forecasts for each mode of transportation as follows.

Table 5. **Modified Forecasts for Passenger Transportation (100 million person-kilometre)**

Mode of Transportation	1990 (Present Value)	2000	2010	2020
Private Passenger Cars	7,270	9,101	10,686	12,008
Private Buses	330	264	310	348
Commercial Passenger Cars	156	155	182	205
Passenger Buses	337	346	406	456
Chartered Buses	436	489	574	646
Sub-total for Automobiles	8,530 (65.7%)	10,355 (66.2%)	12,158 (66.8%)	13,663 (67.1%)
Ordinary Lines	3,148	3,666	4,156	4,527
The Shinkansen	722	762	863	940
Sub-total for Railways	3,870 (29.8%)	4,428 (28.3%)	5,019 (27.6%)	5,467 (26.9%)
Passenger Ships	60 (0.5%)	61 (0.4%)	63 (0.3%)	61 (0.3%)
Passenger Airways	520 (4.0%)	800 (5.1%)	971 (5.3%)	1,161 (5.7%)
Total	12,980 (100.0%)	15,644 (100.0%)	18,211 (100.0%)	20,352 (100.0%)

Note: The percentage numbers shown in () mean share of transportation mode.

Table 6. **Modified Forecasts for Freight Transportation (100 million ton-kilometre)**

Mode of Transportation	1990 (Present Value)	2000	2010	2020
Large-sized Private Trucks	660	622	689	743
Small-sized Private Trucks	141	116	128	138
Large-sized Lorries of Common Carries	1,921	2,286	2,530	2,728
Small-sized Lorries of Common Carries	18	15	17	18
Sub-total for Trucks	2,740 (50.1%)	3,039 (52.6%)	3,364 (53.0%)	3,627 (53.6%)
Freight Railways	270 (4.9%)	254 (4.4%)	269 (4.2%)	279 (4.1%)
Cargo Ship	2,450 (44.8%)	2,470 (42.8%)	2,697 (42.5%)	2,849 (42.1%)
Cargo Airways	10 (0.2%)	10 (0.2%)	13 (0.2%)	15 (0.2%)
Total	5,470 (100.0%)	5,773 (100.0%)	6,343 (100.0%)	6,770 (100.0%)

Note: The percentage numbers shown in () mean share of transportation mode.

4.3 Emission Factors

We adopt the following emission factors proposed in the previous research:

Adopted CO₂ emission factors

Table 7. CO₂ emission factors regarding passenger transport

<i>Mode</i>	Energy consumption (kcal/person-kilometre)	CO ₂ emission factors (g-C/person-kilometre)
Private Passenger Cars	580	44.6 (949)
Commercial Passenger Cars	1,298	89.3 (1, 900)
Private Buses	124	9.7 (206)
Passenger Buses	247	19.4 (413)
Chartered Buses	106	8.3 (177)
Ordinary Railways	100	4.7 (100)
The Shinkansen	123	5.6 (119)
Passenger Ships	295	23.9 (509)
Passenger Airways	394	30.2 (643)

Source: Japan Transport Economic Research Center, "The Study on Environmentally Friendly Transport", 1995

Note: The percentage numbers shown in () mean share of transportation mode

Table 8. CO₂ emission factors regarding freight transport

<i>Mode</i>	Energy consumption (kcal/ton-kilometre)	CO ₂ emission factors (g-C/ton-kilometre)
Large-sized Lorries of Common Carries	616	48.3 (819)
Small-sized Lorries of Common Carries	2,303	180.4 (3, 058)
Large-sized Private Trucks	1,040	81.5 (1, 381)
Small-sized Private Trucks	7,705	599.0 (10, 153)
Freight Railways	114	5.9 (100)
Cargo ship	159	12.9 (219)
Cargo Airways	5,250	402.4 (6, 820)

Note: The percentage numbers shown in () mean share of transportation mode.

4.4 Target Amount of Reduction in Emission

(1) Forecasted CO₂ emission

CO₂ emissions in the future years are estimated by multiplying transport demand by emission rate, by mode, as follows;

Basic Equation

$$\begin{aligned} & (\text{CO}_2 \text{ emission for a specific mode } i) \\ & = [\text{Transport demand for a specific mode } i \text{ (person-kilometre or ton-kilometre)}] \\ & \quad \times [\text{Emission factors of CO}_2 \text{ for a specific mode } i \text{ (g-C/person-kilometre} \\ & \quad \text{or g-C/ton-kilometre)}] \end{aligned}$$

Results:

Table 9. Forecasted CO₂ Emission

(1, 000 ton/year)

	1990	2000	2010	2020
Passenger Transport	38,755	48,019	56,369	63,451
Freight Transport	27,150	27,068	29,970	32,266
Total	65,905	75,088	86,339	95,717

(2) Target Amount of Reduction in Emission

In order to get target amount of reduction, we set the target CO₂ emission in each year of 2000, 2010 and 2020. Then we simply subtract the target value from the forecasted value shown in the previous section.

The target CO₂ emission

We adopt the total emission level in 1990 as the target value.

The target amount of reduction in CO₂ emission

We get the target amount of reduction by subtracting the target emission from the forecasted emission.

$$\boxed{\text{The target reduction}} = \boxed{\text{The forecasted emission}} - \boxed{\text{The target emission}}$$

Results:

The target amount of reduction calculated in this study is stated in the following Table.

Table 10. **The target amount of reduction in CO₂ emission**

(1, 000 ton)

	1990	2000	2010	2020
Passenger Transport	38,755	48,019	56,369	63,451
Freight Transport	27,150	27,068	29,970	32,266
Total	65,905	75,088	86,339	95, 717
The rate of increase (%) (compared to the value in 1990)	0.0	13.9	31.0	45.2
The amount of increase (compared to the value in 1990)	0.0	9,183	20,434	29,812
This is regarded as the target amount of reduction				

4.5 Required Level for the Policy Implementation

Backcasting approach gives us the solution regarding what amount of counteracts may be enough to achieve the target reduction of emission.

In this section we discuss the desirable level for policy implementation that enable us to reach the target level of CO₂ emission.

In this study, we set the case that if we adopt the modal-shift policy leaving other policies intact, what amount of share of transport would be required. On that account we adopt the modal-shift policy as the study object.

(1) Target mode share

Basic Concepts:

In this study we consider the desirable share of transportation that achieves the target reduction. We define the share of transportation macroscopically i.e. we grasp the share of transportation in nationwide scale. The basic equation is denoted as follows.

$$\begin{aligned}
 & \text{[The demand of nationwide transport of} \\
 & \text{mode } i \text{ (in person-kilometre} \\
 & \text{or ton-kilometre)]} \\
 (\text{The share of transport of mode } i) = & \frac{\hspace{15em}}{\hspace{15em}} \\
 & \text{[The demand of nationwide transport of} \\
 & \text{all modes (in person-kilometre} \\
 & \text{or ton-kilometre)]}
 \end{aligned}$$

The simple scenarios regarding both passenger transport and freight transport are set as follows.

Scenario for Passenger Transport:

In estimating modal shift from private passenger vehicles to passenger railways, . Shinkansen is excluded because the number of long distance travellers who may shift from car to Shinkansen seem very few.

Scenario for Freight Transport:

Modal shift from trucks(large-sized lorries of common carries) to freight railways is assumed.

Results:

Numerical outputs and some considerations regarding these outputs are as follows.

The Sector of Passenger Transport:

Firstly we estimate the shares of passenger cars and passenger railways in 2000, 2010 and 2020 based on the assumption that the current trend of modal shift would go on as it is. As a result, the shares of passenger cars are estimated to be about 58% in 2000 and 59% in 2010 and 2020, while the shares of passenger railways are estimated to be about 23% in 2000 and 2010 and 22% in 2020, respectively.

Secondly we estimate the target shares of passenger cars and passenger railways taking account of the normative condition that enables us to reach the policy target of the future CO₂ emission to be equivalent to the level in 1990. The target modal shares of passenger cars are estimated to be about 43% in 2000, 34% in 2010 and 29% in 2020, while the target shares of passenger railways are estimated to be about 38% in 2000, 47% in 2010 and 52% in 2020, respectively.

According to the results stated above, a drastic change in modes between passenger cars and railways should be required. These results suggest us the difficulties in achieving of the policy target.

Table 11. **Estimated Shares of Modes (1000 billion person-kilometre)**

	1990	2000		2010		2020	
	Present	BAU	BCA	BAU	BCA	BAU	BCA
• Private Passenger Cars	7,271 (56.0%)	9,101 (58.2%)	6,779 (43.3%)	10,686 (58.7%)	6,272 (34.4%)	12,008 (59.0%)	5,819 (28.6%)
• Private Buses	330	264	264	310	310	348	348
• Commercial Passenger Cars	156	155	155	182	182	205	205
• Passenger Buses	337	346	346	406	406	456	456
• Chartered Buses	436	489	489	574	574	646	646
• Ordinary Railway Lines	3,148 (24.3%)	3,666 (23.4%)	5,988 (38.3%)	4,156 (22.8%)	8,570 (47.1%)	4,527 (22.2%)	10,716 (52.6%)
• The Shinkansen	722	762	762	863	863	940	940
• Passenger Ships	60	61	61	63	63	61	61
• Passenger Airways	520	800	800	971	971	1,161	1,161
Total	12,980	15,644	15,644	18,211	18,211	20,352	20,352

Note:

1: Percentage values within () show the share of transport.

2: BAU stands for Business As Usual scenario, . BCA stands for Back Casting Approach.

The Sector of Freight Transport:

Firstly we estimate the modal shares of trucks and freight railways for 2000, 2010 and 2020 based on the assumption that the current trend of modal shift will go on. As a result, the shares of trucks (large-sized lorries of common carries) are estimated to be about 40% from 2000 through 2020, while the shares of freight railways are estimated to be about 4% from 2000 through 2020.

Secondly we estimate the target shares of trucks and freight railways taking into account of the normative condition that enables us to reach the level of CO₂ emission in 1990. The target modal shares of trucks (large-sized lorries of common carries) are estimated to be about 30% in 2010 and 23% in 2020, while the shares of freight railways are about 15% in 2010 and 22% in 2020, respectively.

Looking at the gaps between the estimated shares according to BAU scenario and those to BCA, it looks quite difficult to achieve the targets only by modal shift.

Table 12. **Estimated Shares of Modes (1000 billion ton-kilometre)**

	1990	2000		2010		2020	
	Present	BAU	BCA	BAU	BCA	BAU	BCA
• Large-sized Private Trucks	660	622	622	689	689	743	743
• Small-sized Private Trucks	141	116	116	128	128	138	138
• Large-sized Lorries of Common Carries	1,921 (35.1%)	2,286 (39.6%)	2,286 (39.6%)	2,530 (39.3%)	1,865 (29.4%)	2,728 (40.3%)	1,521 (22.5%)
• Small-sized Lorries of Common Carries	18	15	15	17	17	18	18
Freight Railways	270 (4.9%)	254 (4.4%)	254 (4.4%)	269 (4.2%)	934 (14.7%)	279 (4.1%)	1,486 (21.9%)
Cargo Ships	2,450	2,470	2,470	2,697	2,697	2,849	2,849
Cargo Airways	10	10	10	13	13	15	15
Total	5,470	5,773	5,773	6,343	6,343	6,770	6,770

Note:

1: Percentage values within () show the share of transport for both trucks and freight railways.

2: BAU stands for Business As Usual scenario, . BCA stands for Back Casting Approach.

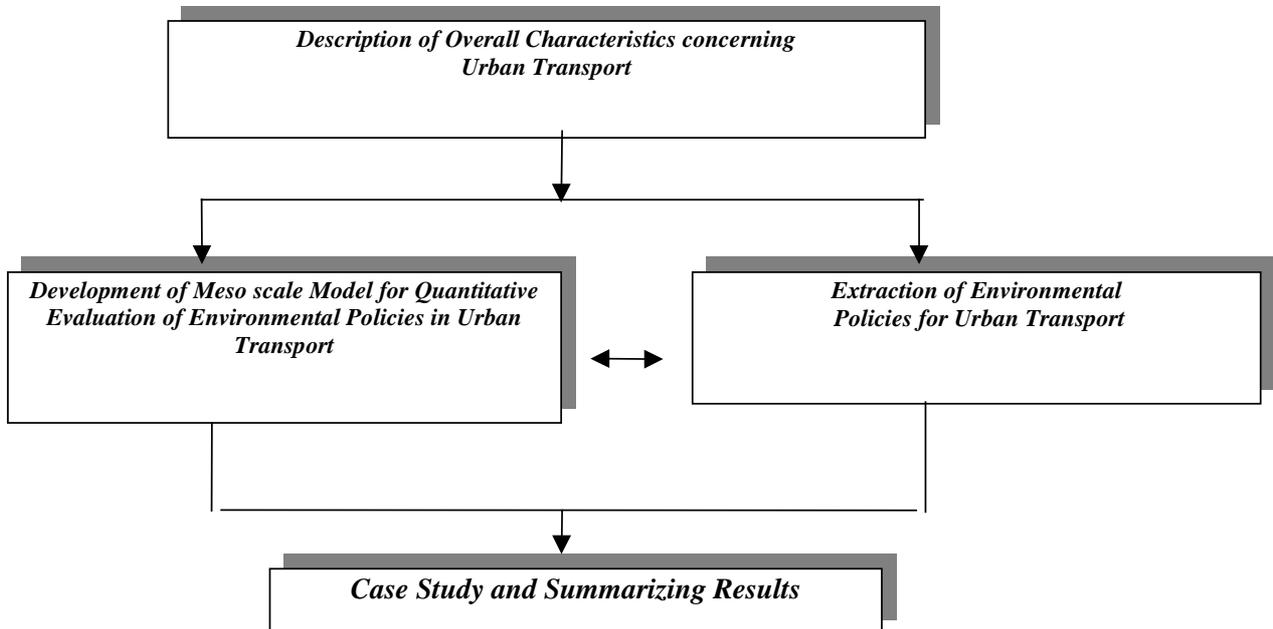
5. Examining Measures for Reduction in CO₂ Emission in Urban Transport

In this chapter, we examine possible effects of alternative countermeasures to reduce CO₂ emission caused by transport in urban level. A meso scale model is developed. to evaluate the effects of environmental countermeasures on urban transportation.

5.1 Procedure

(1) Study Flow

The purpose of this chapter is to characterize environmental policies considering characteristics of urban transport that would depend on urban structure , and to develop a new urban meso scale model for quantitative evaluation of effects of environmental countermeasures on urban transportation. General flow of the study can be described as follows:

Figure 3. **Flow of the Study**

(2) Scope of the study

Environmental issues regarding urban passenger transport may concern every day life of people. The share of urban passenger transport in CO₂ emission is about 59% in emission of whole passenger transport section in 1990 and is still similarly dominant.

The share of emission (CO₂) in passenger transport shows 65% while freight transport shows 35%. Taking such considerations stated above into account, we focus on the urban transport. In this chapter, we discuss the degree of the environmental issues concerning urban transport and give certain knowledge regarding effects of environmental countermeasures. This study involves development of our own model that provides a powerful tool for evaluation of environmental countermeasures that could be applied to urban transport.

5.2 Study Area

As for the cities which we pick up for our study, we extract cities as the objectives for our study referring to the report on The Nationwide Person Trip Survey in 1992, published by Ministry of Construction

5.3 Macroscopic Features of Urban Transport in Japan

According to the data of Nationwide Person Trip Survey , Ministry of Construction, in 1992, major characteristics of urban transport can be described as below, considering the size of population of cities.

a. Number of trips

The number of trips using public transport has been level off in most cities, while passenger car trips has increased substantially mainly in rural small cities.

b. The share of passenger car usage

The share of passenger car usage in rural cities , which have less than one hundred thousand population, is over 50%, while less than 30% in large cities which have more than five hundred thousand population including Tokyo, Osaka and Nagoya.

c. Average trip length of passenger car

The statistics shows that the average trip length by of passenger car is larger in smaller cities.

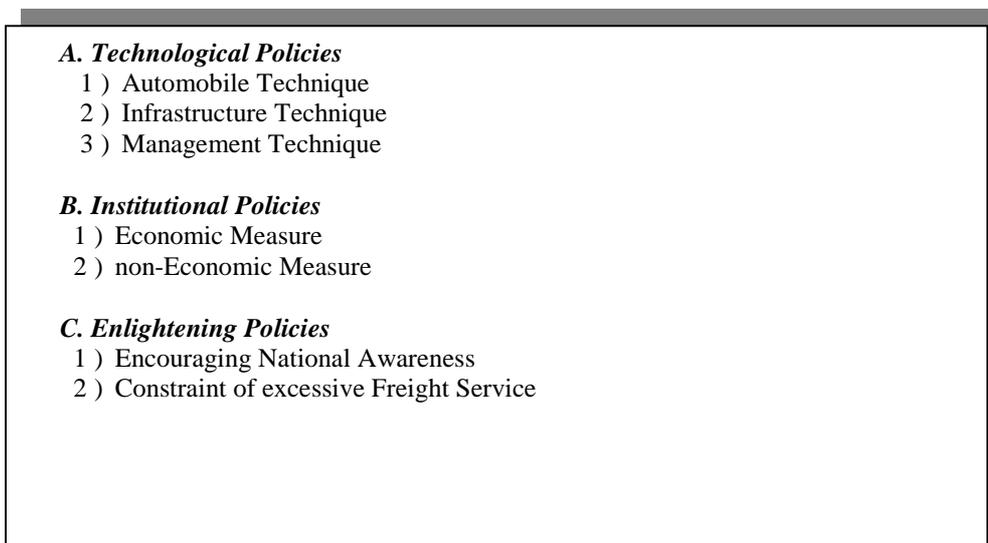
5.4 Classification of Countermeasures for Sustainable Urban Transport

Countermeasures for sustainable urban transport may be classified as shown in the following figure. [Hayashi (1997) see references in Chapter 7]

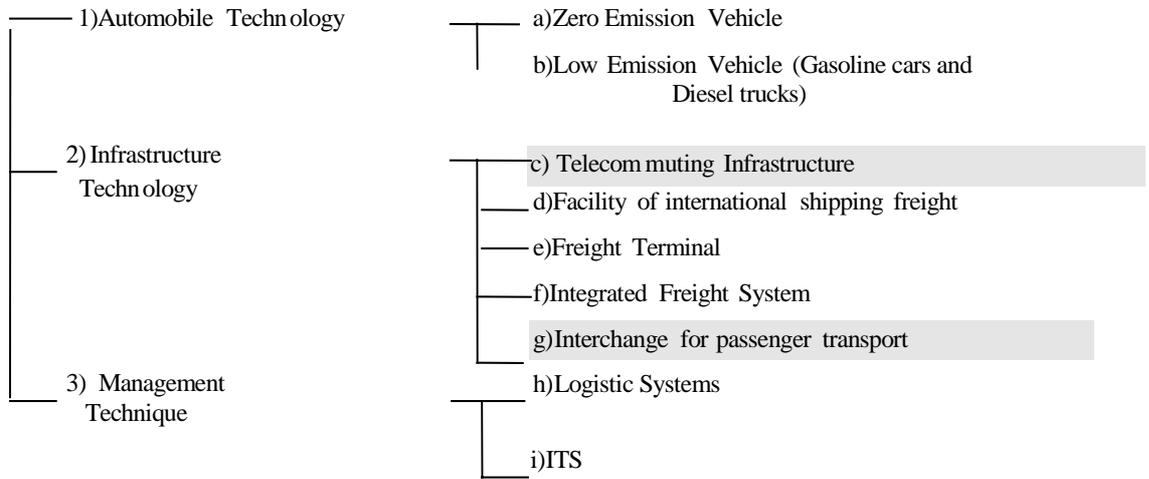
In this framework, the technological policies by and large corresponds to EST1 scenario while the institutional policies correspond to EST2 scenario. Other two kinds of policies such as the enlightening policies and the land use policies might be out of the EST policy categories.

Each group of policies stated above has more detailed countermeasures as follows:

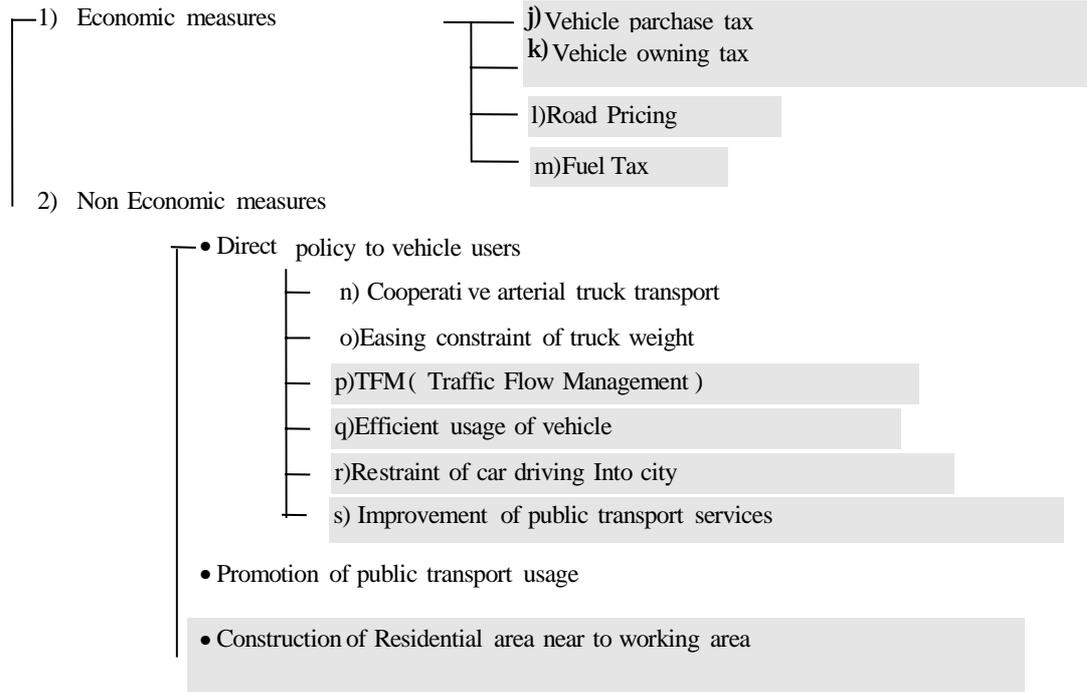
Figure 4. **Policy Framework**



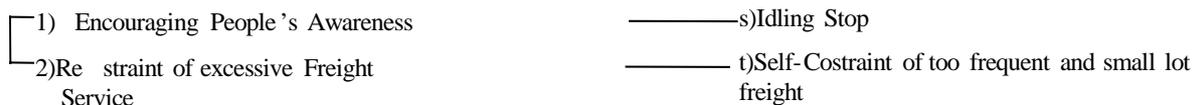
A. Technological Policies



B. Institutional Policy



C. Enlightening Policy



Note: Policies relevant to urban transport.

5.5 Model Building

Data used for building model:

We develop our own model by making use of data published by Ministry of Construction.(Source: The Nationwide Person Trip Survey in 1992) Besides we apply data of population census published by General Affairs Agency, car ownership statistics published by Ministry of Transportation.

As for the data from The Nationwide Person Trip Survey in 1992, the general contents of the data are as follows.

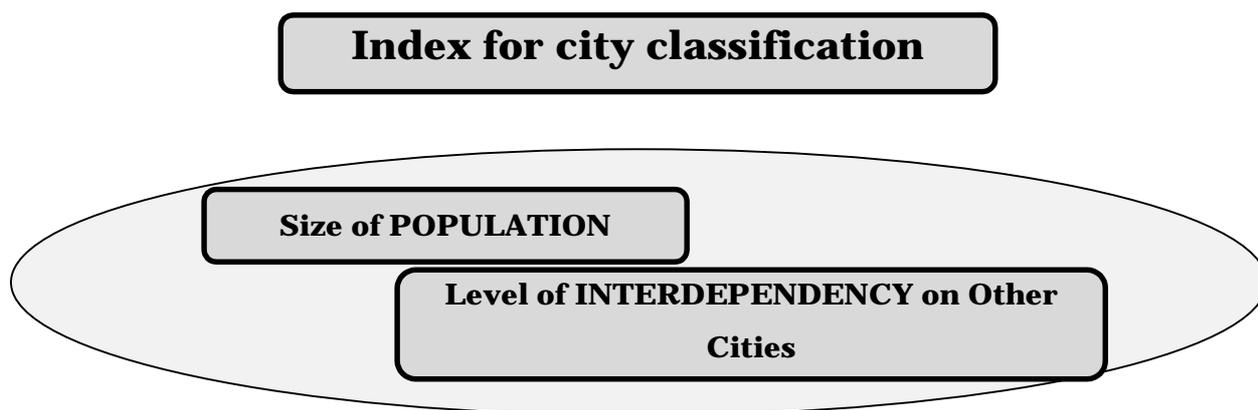
Table 13. General contents of the data

The year of survey	1991
Number of objective cities	78 cities
Number of objective households	360 households
Obtained statistics (weekends/holidays)	1) Trip generation unit (gross/net) 2) Frequency of going out from home 3) Shares of trip purpose commuting/school/business/going back home/others) 4) Shares of transport modes passenger car/railway/bus/motor bike/on foot) 5) Average trip time for each mode

Source: Ministry of Construction, "The Nationwide Person Trip Survey in 1992".

(1) Classification of Cities in Japan

Transport conditions may be very different between cities. Here, we classify the cities by population size and independency. Independency is defined as share of the number of people, who are working or attending to school within the cities where they live, in total number of living people in the city.



Taking 2 types of indices stated above into consideration, 62 cities in Japan under study were classified into 4 types of city categories, of which definitions are as follows.

- Metropolitan Core City (MCC)

A City defined as the core city of a metropolis which also involves surrounding cities (Population is more than 1 million and independence index is more than 80%)

- Metropolitan Suburban City (MSC)

A City located in outskirts of a Metropolis. Activities of residents strongly depend on Metropolis (Population is between 0.5 million and 1 million and independency index is less than 80%)

- Regional Core City (RCC)

A City defined as core of a region (Population is between 0.1 million and 0.5 million and independency index is more than 80%)

- Regional Suburban City (RSC)

A City defined as outskirts of a Regional Core City. Activities of residents strongly depend on the Regional Core City. (Population is between 0.1 million and 0.5 million and independency index is less than 80%)

- Independent Small City (ISC)

Defined as rural city of which population is less than 0.1 million.

Summary of classification of cities can be described as follows;

Table 14. Summary of Classification of Cities

		Interdependence Index	
		more than 80% (Highly independent)	less than 80% (Less independent)
Population	More than 1 million	Metropolis	none
	Between 0.5 ~ 1 million	none	Metropolitan Suburb
	Between 0.1 ~ 0.5 million	Regional Core City	Regional Suburban City
	less than 0.1 million	Independent Small City	

(2) Description of Newly Developed Meso-Scale Model

Basic Structure of the Model can be stated as follows:

$$E_i = e_i \times L_i$$

- E_i : emitted from automobiles in region i [g]
- e : emission factors of CO₂- [g-C/ persontrip-kilometre]
- L_i : Demand of automobile transport in region i [persontrip-kilometre]
 $= a_i$ (Unit of automobile trip generation in region i. [persontrip/person • day])
- xP_i (Population in region i [persons])
- xC_i (Share of automobile transport in region i)
- xl_i (Average trip length of automobile in region i [km])

Table 15. Model Structure

$E_i = e_i \times L_i$		<i>Modeling</i>
An Emission factor	e_i	Exogenous variable
Automobile transportation L_i $= a_i \times P_i \times c_i \times l_i$	a_i : Unit of trip generation	Exogenous variable
	P_i : Future population	Exogenous variable
	c_i : A Share of automobile transport	= f (car ownership, density of spatial railway station ↓ (Car ownership) = g (population density individual income road area per person)
	l_i : Average trip length of automobile	= h (population density inner city rate of commuting and attending to school)

Policies corresponding to variables in the model stated above can be shown as follows:

Table 16. Model variables and corresponding policies

Model variables	Corresponding Policies (See Table-)
a_i (Unit of trip generation in city i)	<ul style="list-style-type: none"> • Infrastructure technology c) Introduction of Telecommuting systems
l_{ij} (Average trip length of mode j in city i)	<ul style="list-style-type: none"> • Land use policy v) Residential development near working place
c_{ij} (Share of mode j in city i)	<ul style="list-style-type: none"> • Infrastructure technology g) Implementation of terminal for passenger transport • Economic measure j) Vehicle purchase tax k) Vehicle owning tax l) Road pricing policy m) Fuel Tax • Non-Economic measure s) Improvement of public transport services (e.g. Increasing number of new railway stations)

(3) Model parametre estimates

The results of parametre estimates and goodness of fit between actual statistics and model outputs are as follows.

Model for prediction of share of automobile transport

Share of automobile transport in region i

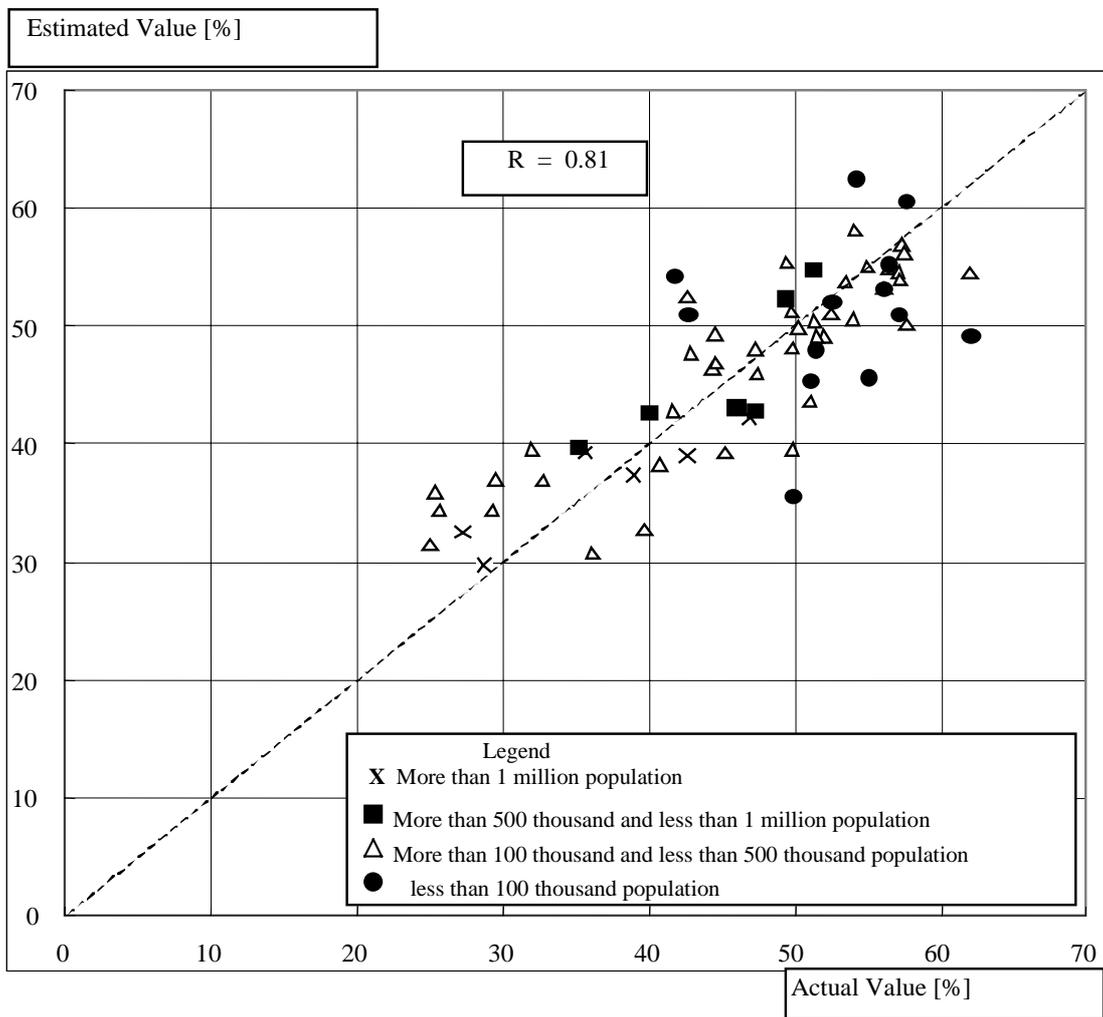
$RAIL_i$: Spatial density of railway stations in region i (stations/km²),

CAR_i : Car ownership in region i (cars/1, 000persons)

$$C_i = \frac{100.0}{1.0 + \exp(0.46 \cdot RAIL_i - 4.23 \cdot CAR_i + 1.88)}$$

(t-value : 1.83) (t-value : -8.67) (t-value : 8.16)
(Multiple Correlation Coefficient : R = 0.81)

Figure 5. Goodness of Fit of Estimation of Share of Automobile Transport



Model for prediction of car ownership:**CAR_i** Car ownership in region i*DL_i* : Road area per residential person in region i (km²/person)*p_i* : Population density in region i (persons/km²)*d_i* : Dummy variable in region i : 0 or 1*x_i* : Income normalized by car price in region i (= income/lowest price of a new car)

$$CAR_i = 0.036 \cdot \log_e DL_i - 0.02 p_i + d_i (A_i / (1.0 + \exp(-x_i)) + 0.23)$$

(*t*-value : 3.63) (*t*-value : 4.45) (*t*-value : 2.17)

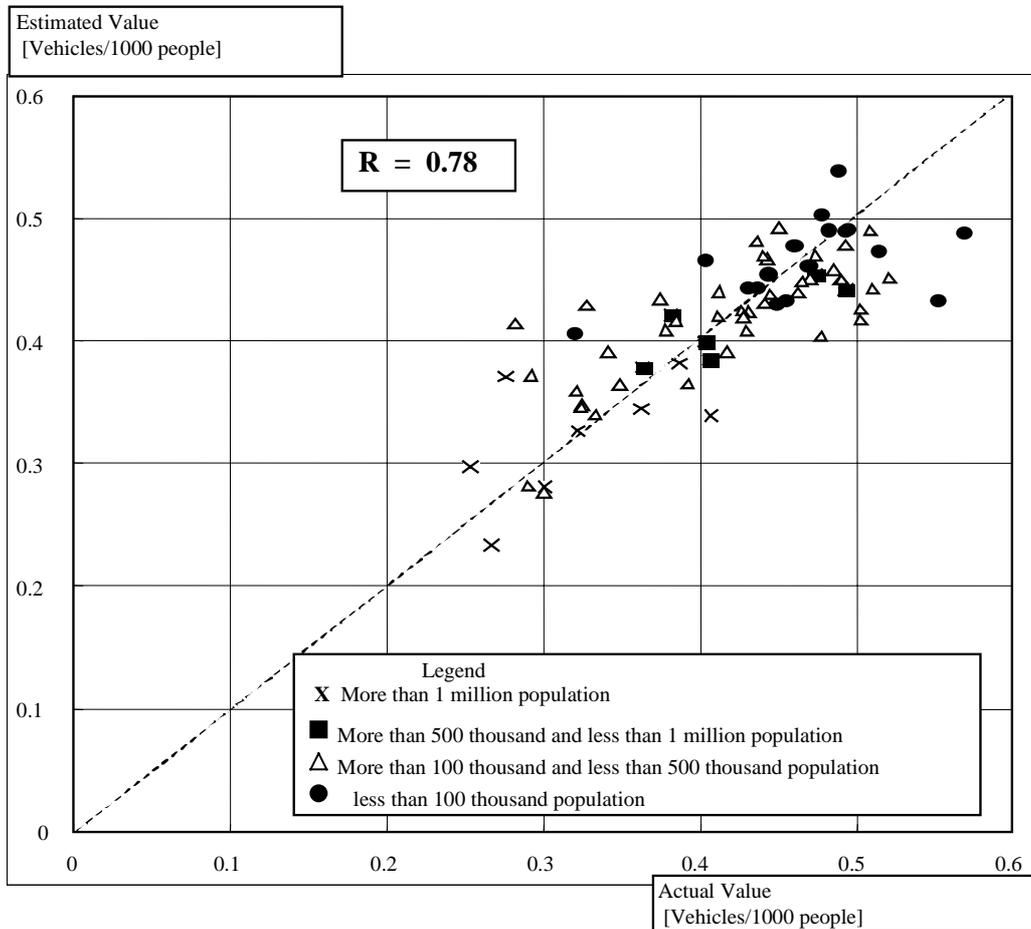
$$A_1 = 0.21 \text{ (t-value: 1.54)}$$

$$A_2 = 0.23 \text{ (t-value: 1.71)}$$

$$A_3 = 0.24 \text{ (t-value: 1.67)}$$

(Multiple Correlation Coefficient: *R* = 0.78)

Figure 6. Goodness of Fit of Estimation of Car Ownership Model



Model for prediction of Average trip length of automobile:

Average Trip Length of Automobile in region i

$p_{rail\ i}$: Density of station per person in region i (station/person)
 r_i : Inner city ratio in travels for commuting and attending school

$$l_i = \exp(-12.25 p_{rail\ i} - 9.22 \cdot r_i + 21.0)$$

(t-value: -2.01) (t-value: -5.06) (t-value: 14.76)

(Multiple Correlation Coefficient: $R = 0.55$)

Figure 7. Goodness of Fit of Estimation of Car Trip Length Model

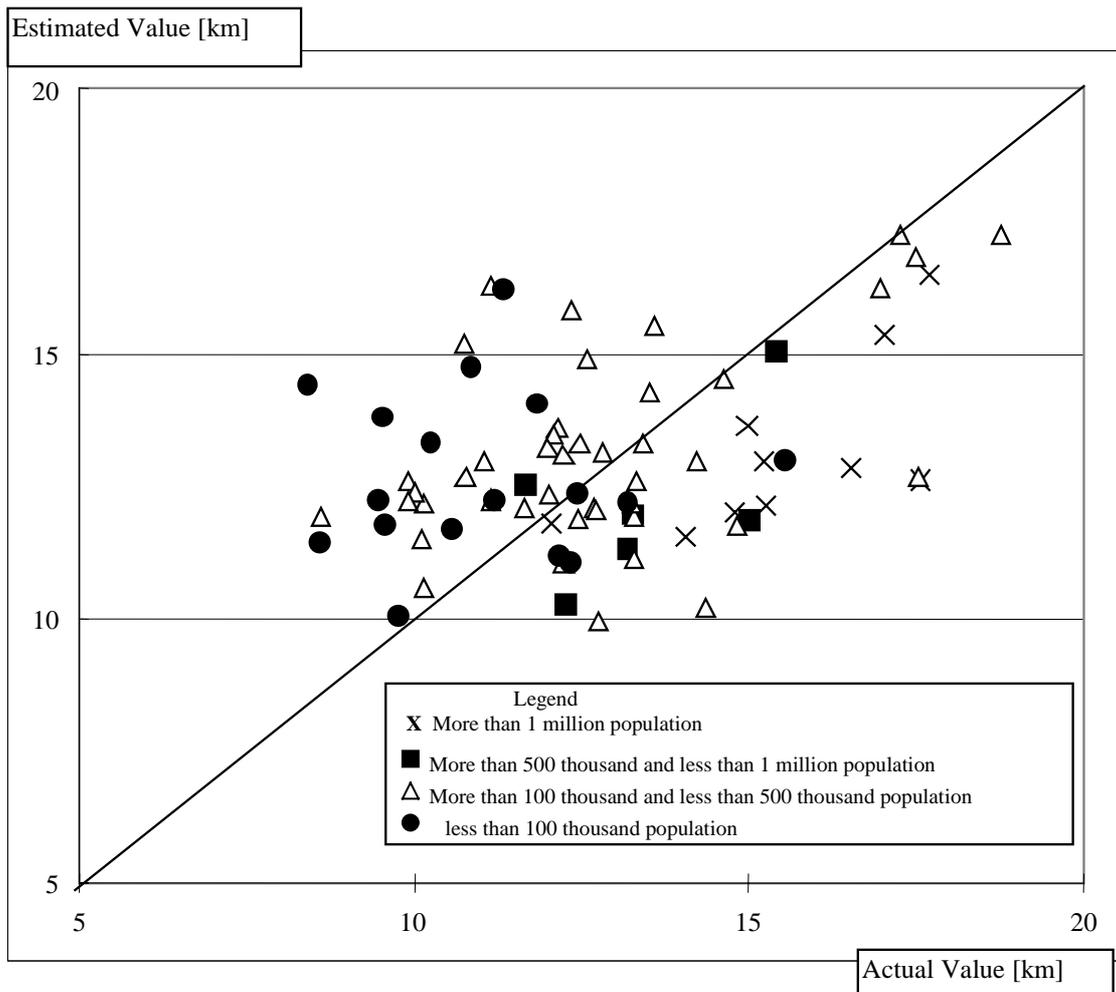
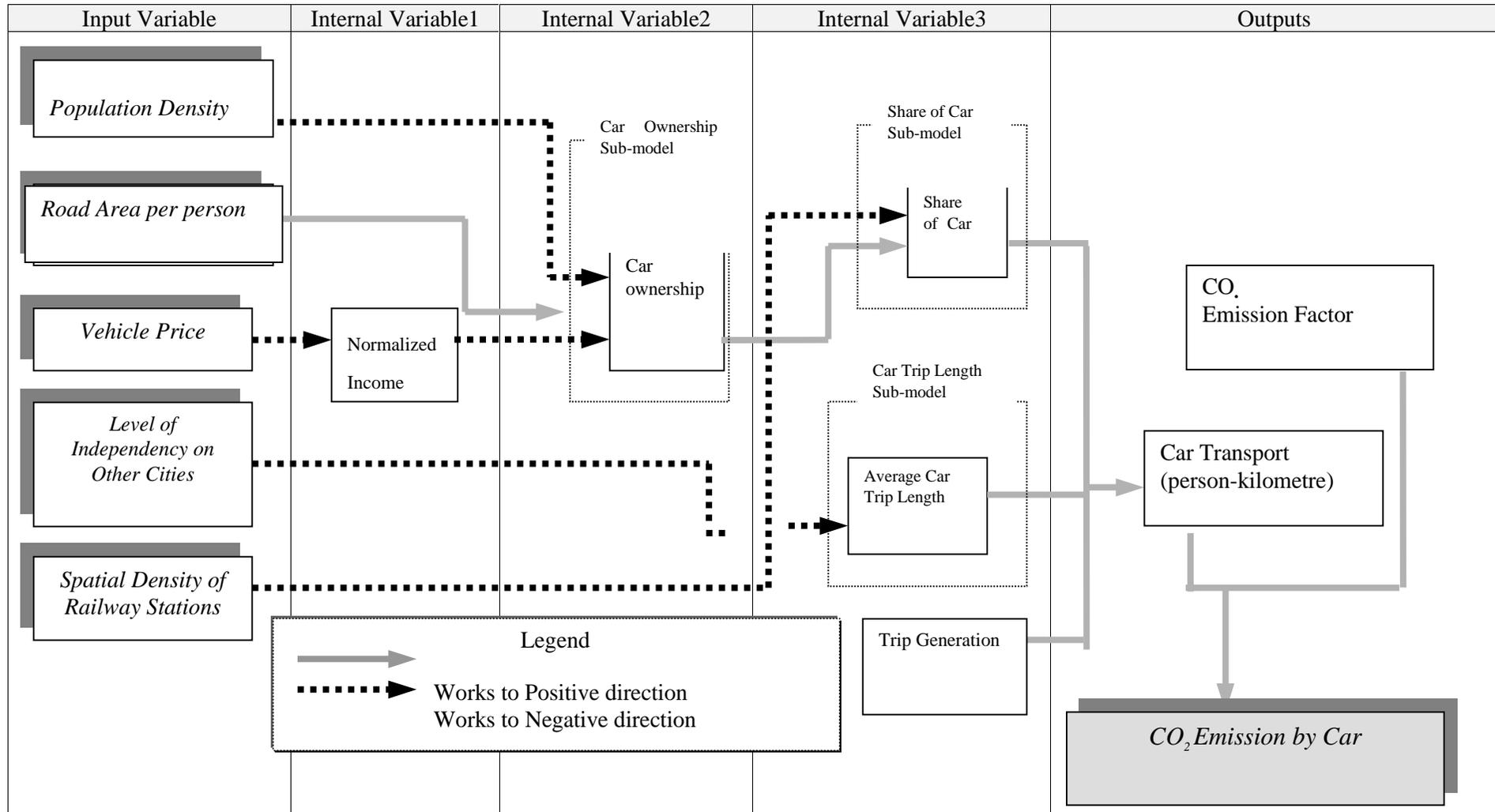


Figure 8. Relationship among Model Variables



5.6 Sensitivity Analysis on the Effects of Countermeasures

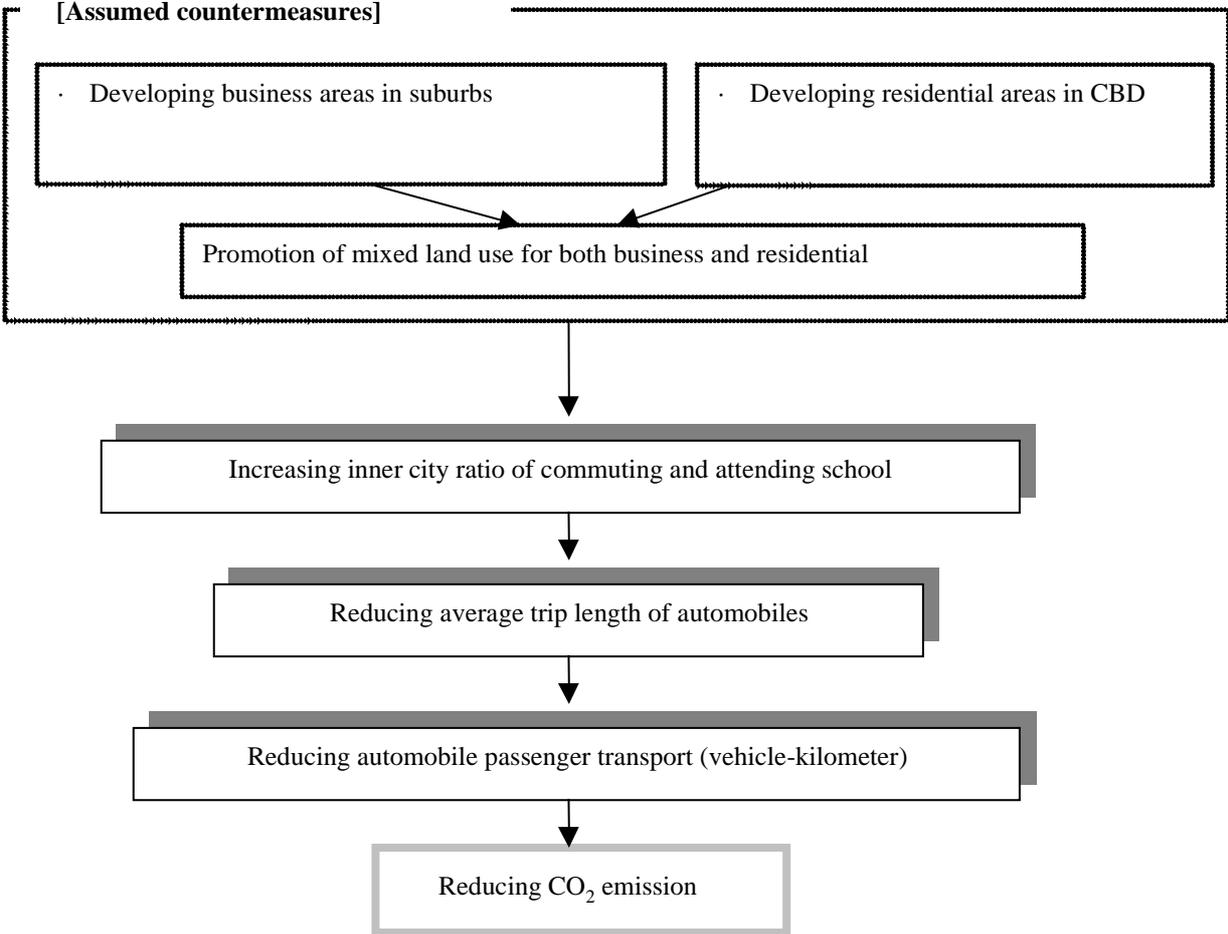
In this chapter we apply our model to evaluate the effects of some countermeasures.

(1) Case Study

Sensitivity analysis of land use policy of residential development near working places-

To develop residential area near working places could reduce the average trip length of automobiles in the region. Basic idea for causes and effects are as follows.

Figure 9. Flow of effects of land use policy

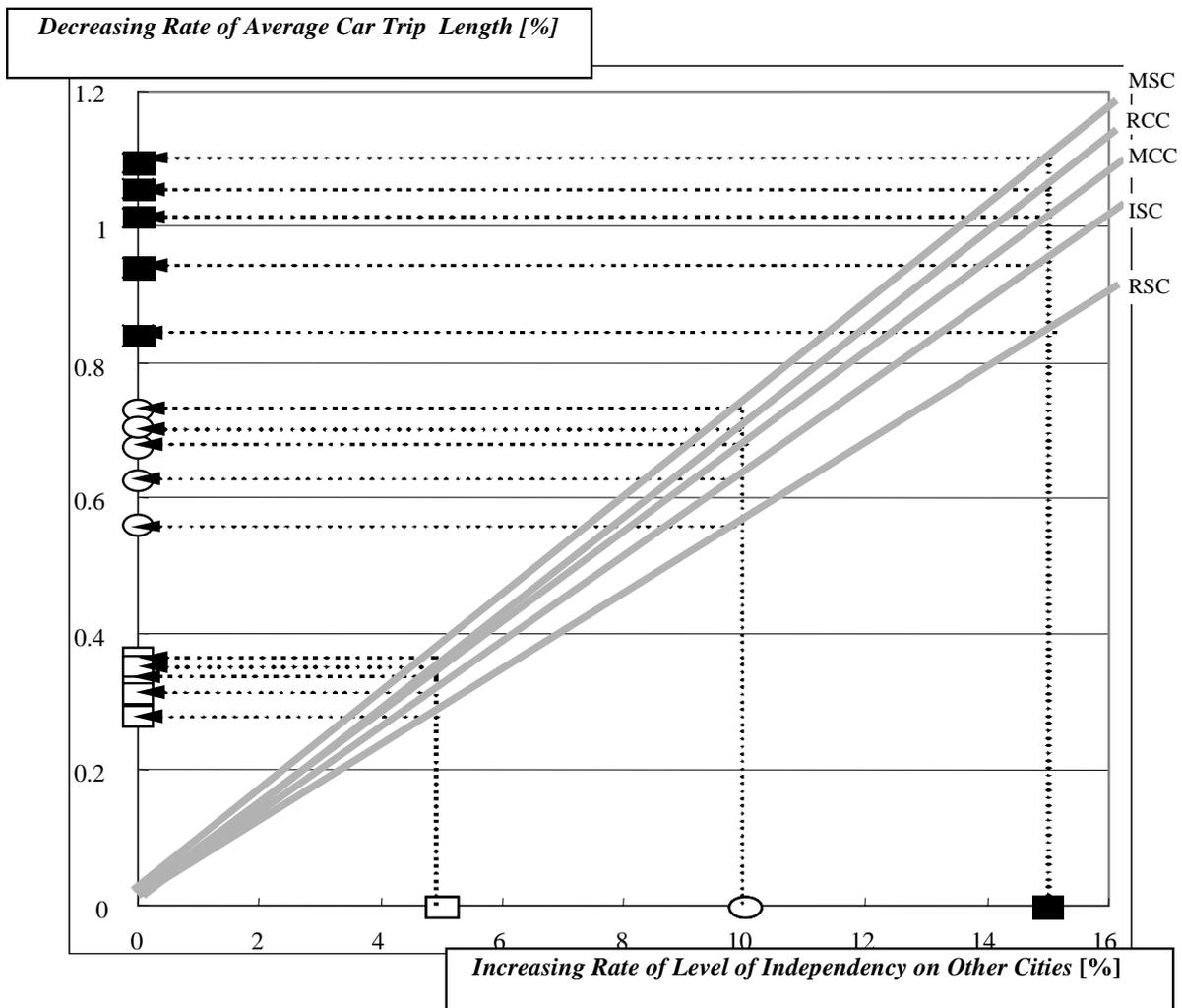


Results and interpretations

The figure below shows the relationship between rate of increase in inner city ratio of commuting and attending school and that of reduction in average trip length of automobiles. A line drawn in the following figure means the elasticity the increasing rate in average trip length of automobiles against the increasing rate in inner city ratio of commuting and attending school. In other words, this elasticity is equivalent to the sensitivity of the average trip length of automobiles to the inner city ratio of commuting and attending school.

The inner city ratio of commuting and attending school varies from 0% to 16%, while the average trip length of automobiles varies from 0% to 1.2%.

Figure 10. **Increasing Rate of Level of Independency on Other Cities and Decreasing Rate of Average Car Trip Length**



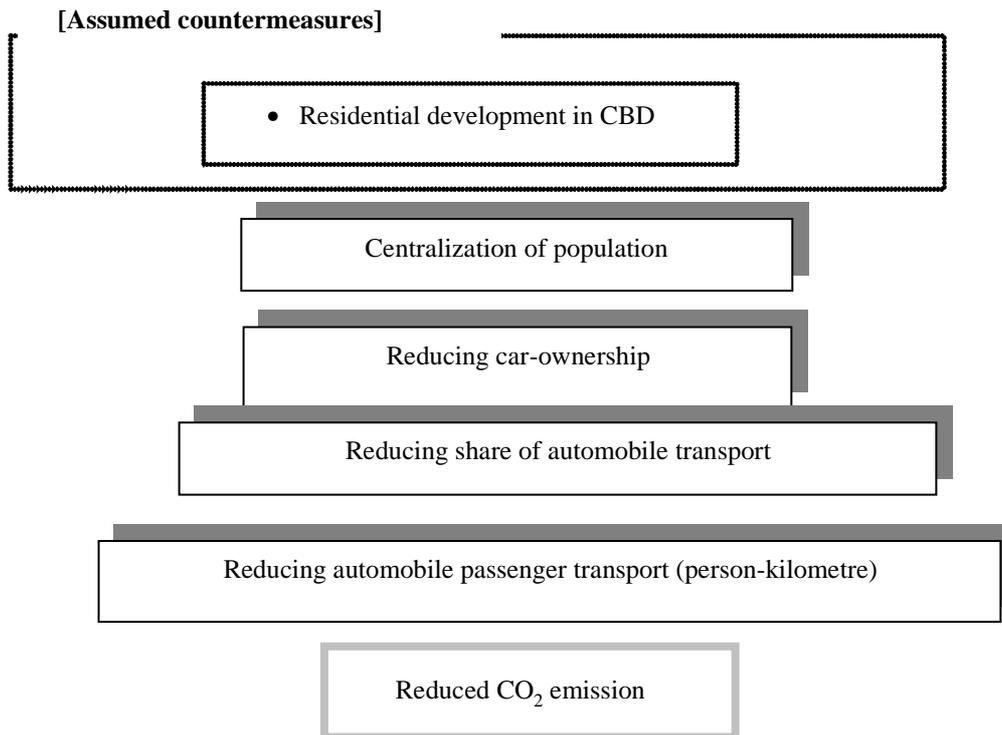
Comparing this elasticity among groups of cities in the figure shown as below, the city group that shows the highest elasticity is the group of metropolitan suburbs, which involves Chiba city and Sakai city. On the other hand, the city group that shows the lowest elasticity is the group of regional suburbs.

(2) Sensitivity analysis of land use policy of residential development to centralize the population

Residential development near work in CBD could contribute to centralize population to reduce the share of automobile transport.

The flow of causes and effects are as follows.

Figure 11. **Flow of effects of land use policy**



Results and interpretations

The right-hand side figure shows the relationship between rate of increase in population density and rate of reduction in car ownership, while the left-hand side figure shows the relationship between rate of reduction in car ownership and rate of reduction in share of automobile transport.

The population density varies from 0% to 16%, while the car ownership varies from 0% to 4.0% and the share of automobile transport varies from 0% to 4.0%.

The group of suburbs has the highest elasticity while the group of independent small cities is the lowest.

Figure 12 a and b

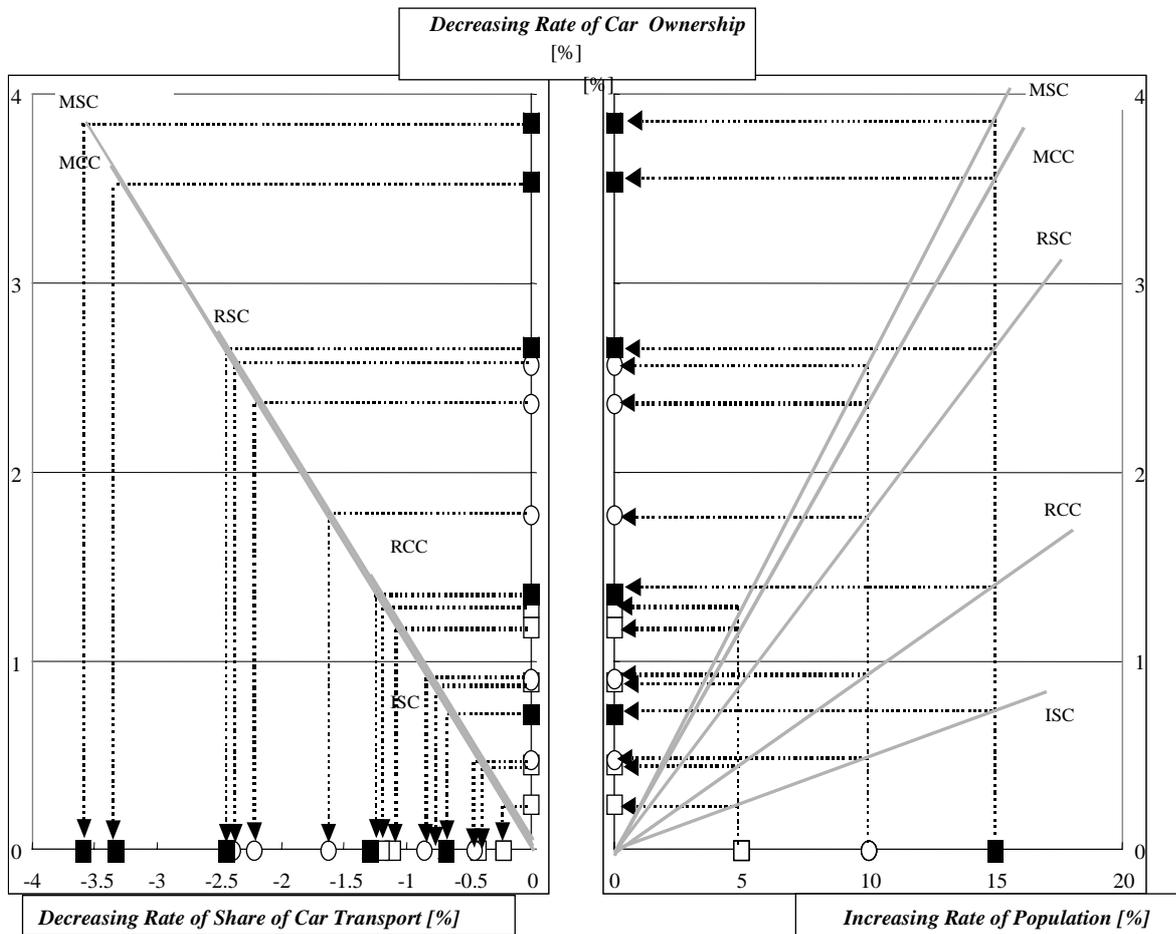


Fig. a) Decreasing Rate of Car Ownership and Decreasing Rate of a Share of Cars

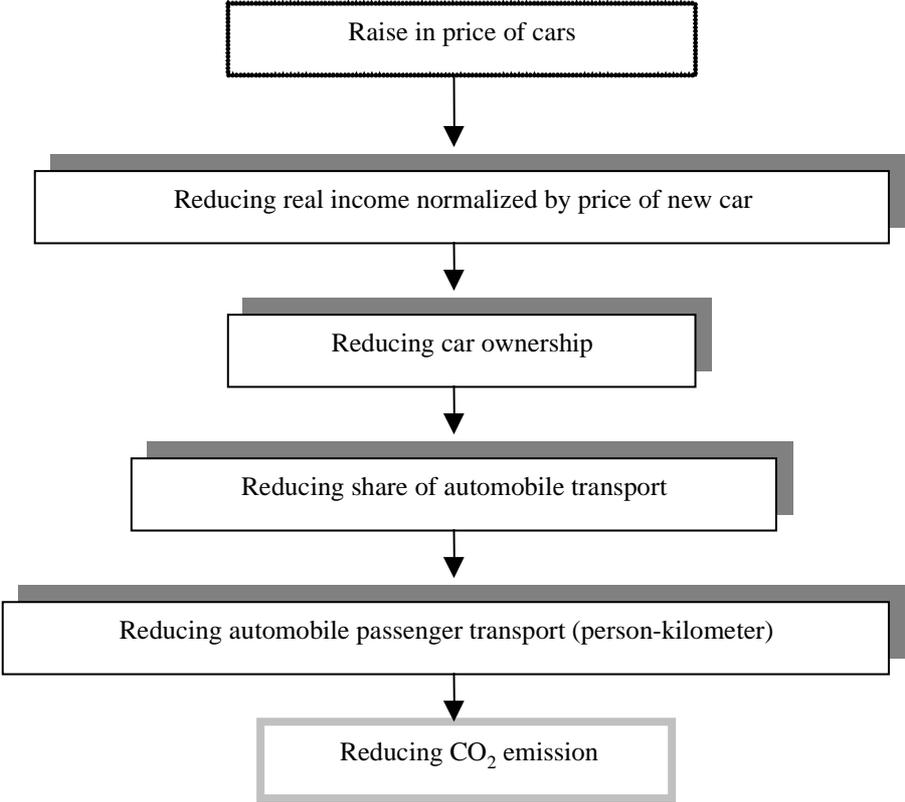
Fig. b) Increasing Rate of Population and Decreasing Rate of Car Ownership

(3) Sensitivity analysis of car-price increase

To raise price of cars could contribute to restrain the degree of car ownership. And thus the share of automobile transport could reduce.

Figure 13. Flow of effects of economic disincentive policy

[Assumed countermeasures]



Results and interpretations

Car price varies from 0% to 20%, while the car ownership varies from 0% to 2.5% and the share of automobile transport varies from 0% to 2.5%.

Comparing the elasticities among the group of cities, the group of metropolitan suburban cities has the highest while that of independent small cities has the lowest.

Figure 14 a and b

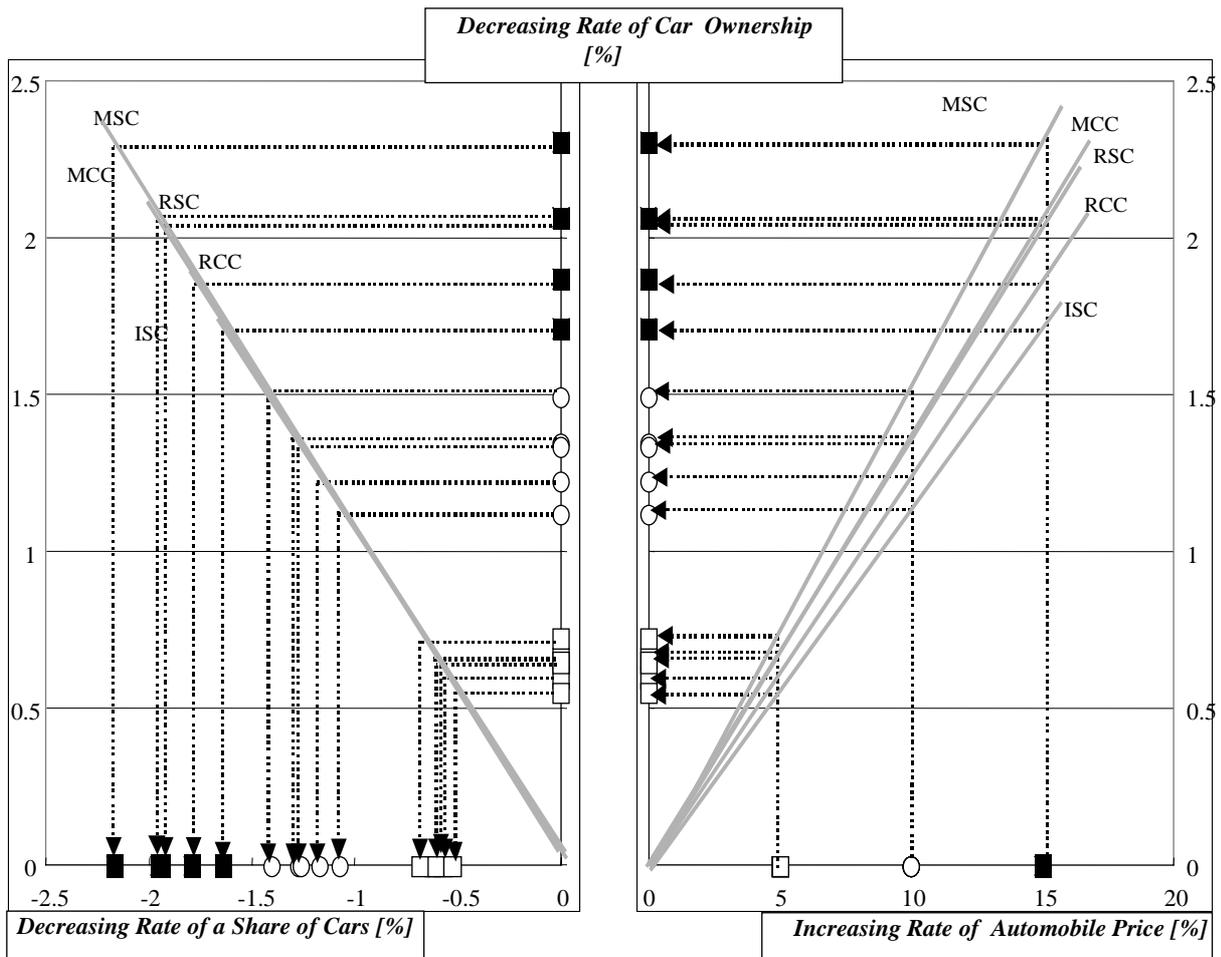


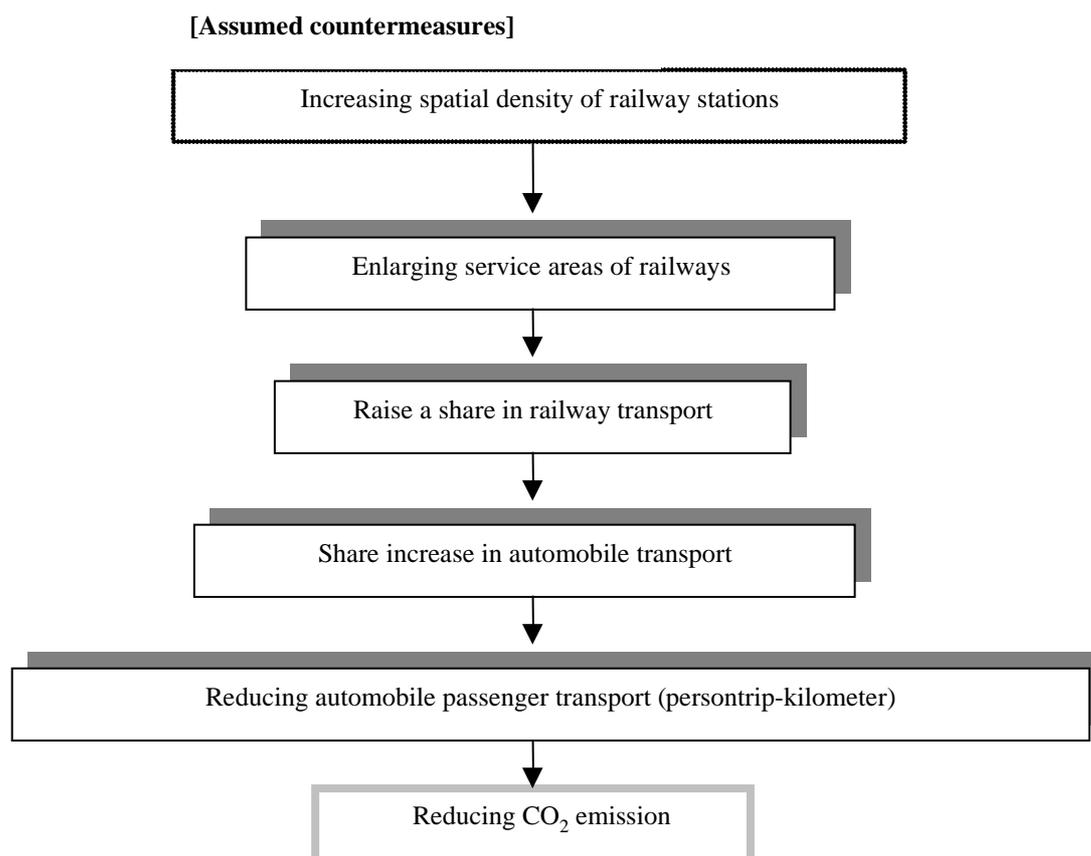
Fig a) Elasticity of Decreasing Rate of Car Ownership against Decreasing Rate of a Share of Cars *Fig b) Elasticity of Increasing Rate of Automobile Price against Decreasing Rate of Car Ownership*

(4) Sensitivity analysis of policy of raising railway stations density

To raise spatial density of railway stations could contribute to raise the share of railway transport, while a share of automobile transport should be reduced.

Basic idea for causes and effects are as follows.

Figure 15. **Flow of effects of rail infrastructure improvement policy**

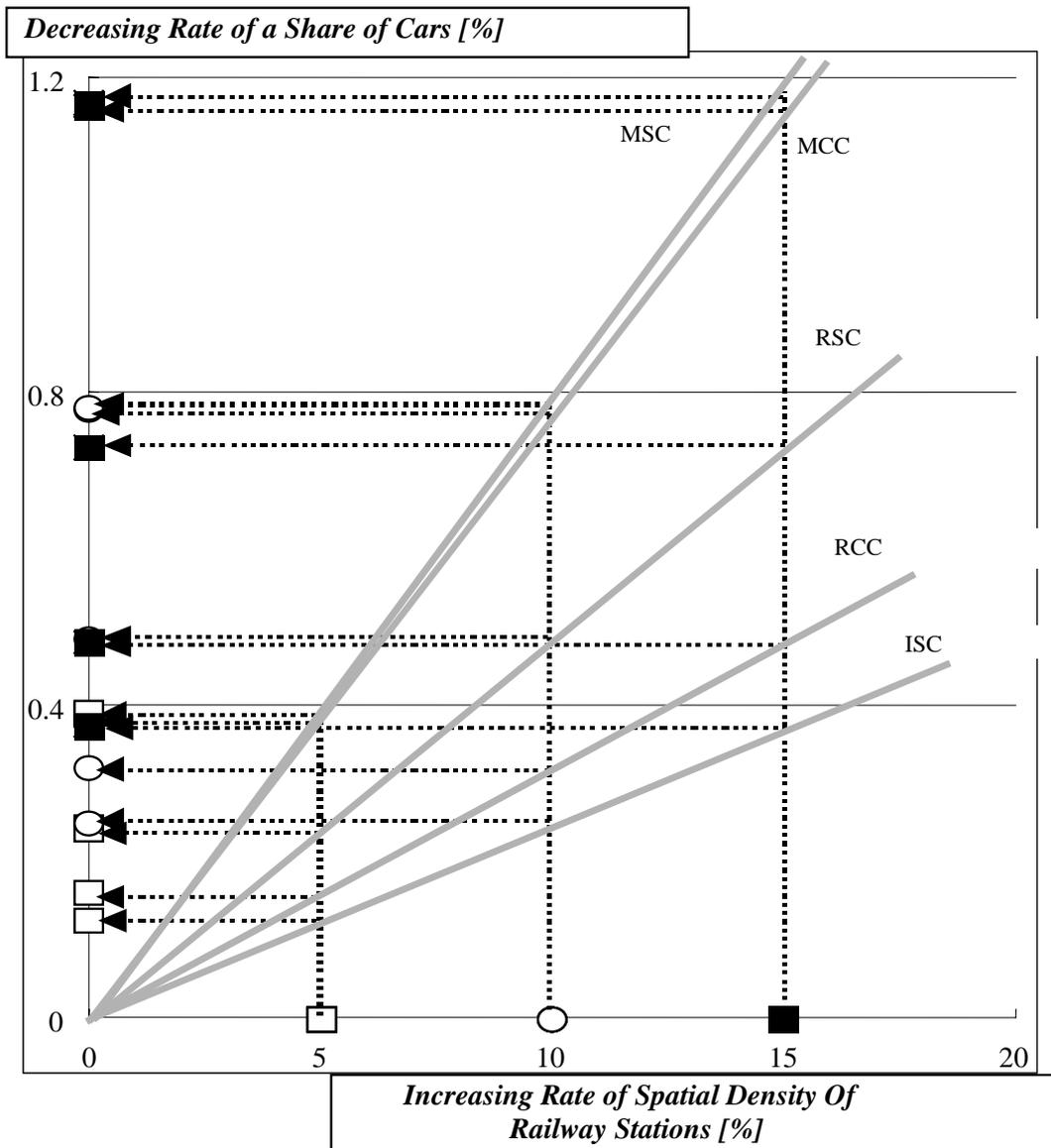


Results and interpretations

Railway station density varies from 0% to 20%, while the share of automobile transport varies from 0% to 1.2%.

Comparing the elasticity among the groups of cities, the group of metropolitan suburban cities has the highest while that of independent small cities has the lowest.

Figure 16. **Elasticity of increasing Rate of Spatial Density of Railway Stations against Decreasing Rate of a Share of Cars**



(5) Comparing elasticities of alternative countermeasures within the same city group

Within the same group of cities, we compare elasticities of alternative countermeasures such as increasing population density, car price and railway station density.

Comparing Metropolis with Suburbs in terms of elasticities which consists of share of automobile against population density, automobile price and spatial density of railway station

The elasticity of share of automobile against population density is three times as big as that of share of automobile against railway station density, while that of share of automobile against car price is two times as big as that of share of automobile against railway station density.

Figure 17. Elasticity of Share of Automobile against Exogenous Variables stated in Figure (Case for Metropolitan Core Cities: MCC)

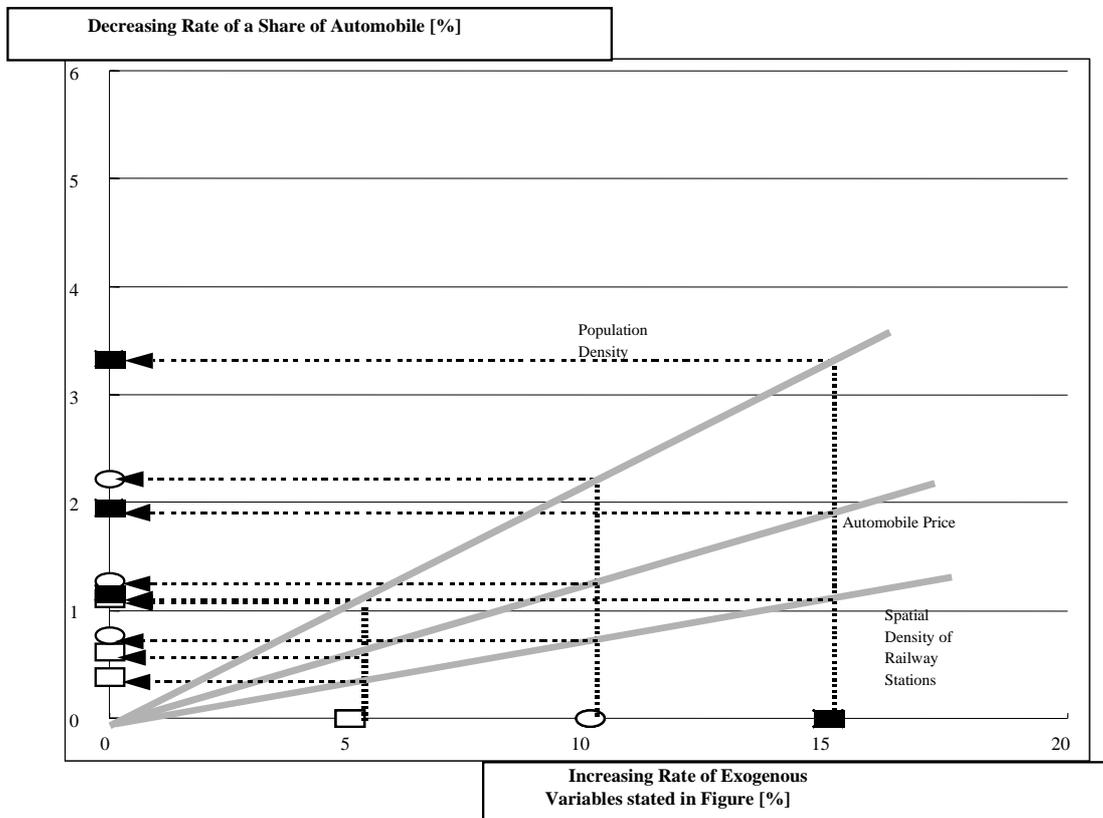
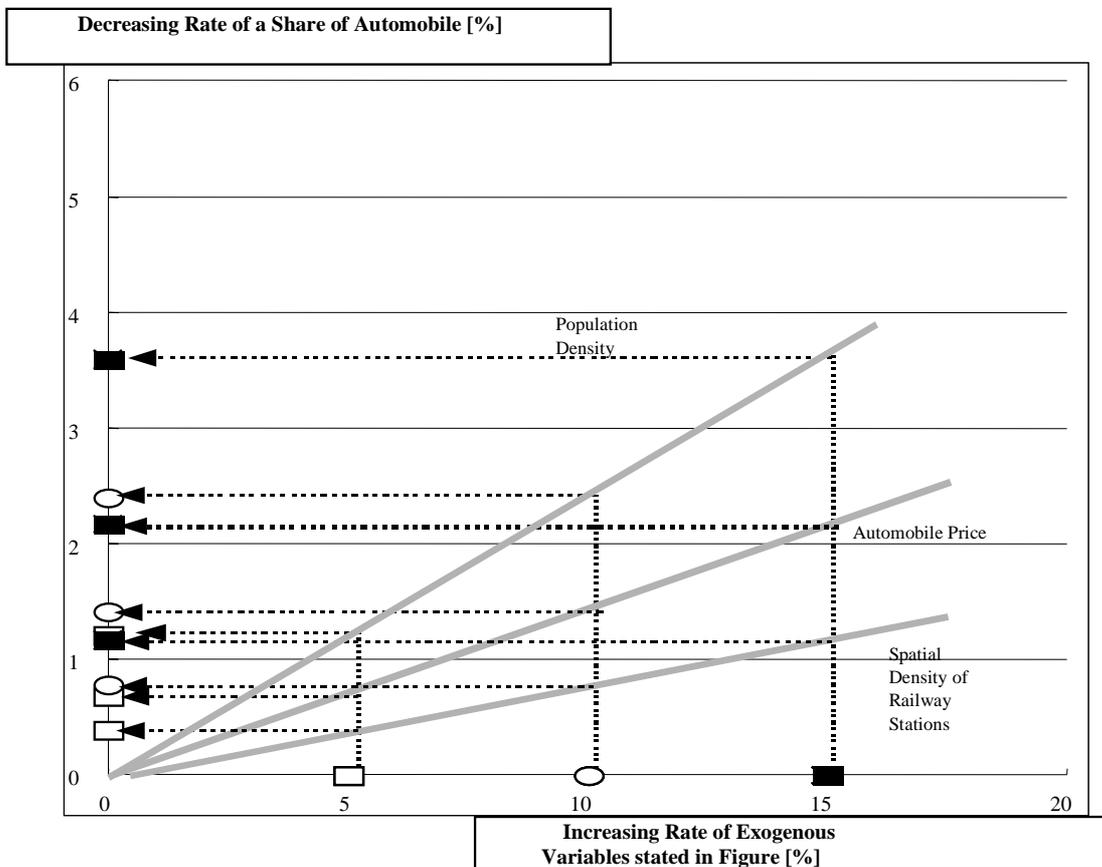


Figure 18. Elasticity of Share of Automobile against Exogenous Variables stated in Figure (Case for Metropolitan Suburban Cities: MSC)



Comparing Regional core cities with Regional suburban cities

Elasticity of population density in Regional suburbs shows higher value than that in Regional core city. As a whole, elasticity of countermeasures in these 2 city groups is low rather than Metropolis or Suburbs.

Figure 19. Elasticity of Share of Automobile against Exogenous Variables stated in Figure (Case for Regional Core Cities: RCC)

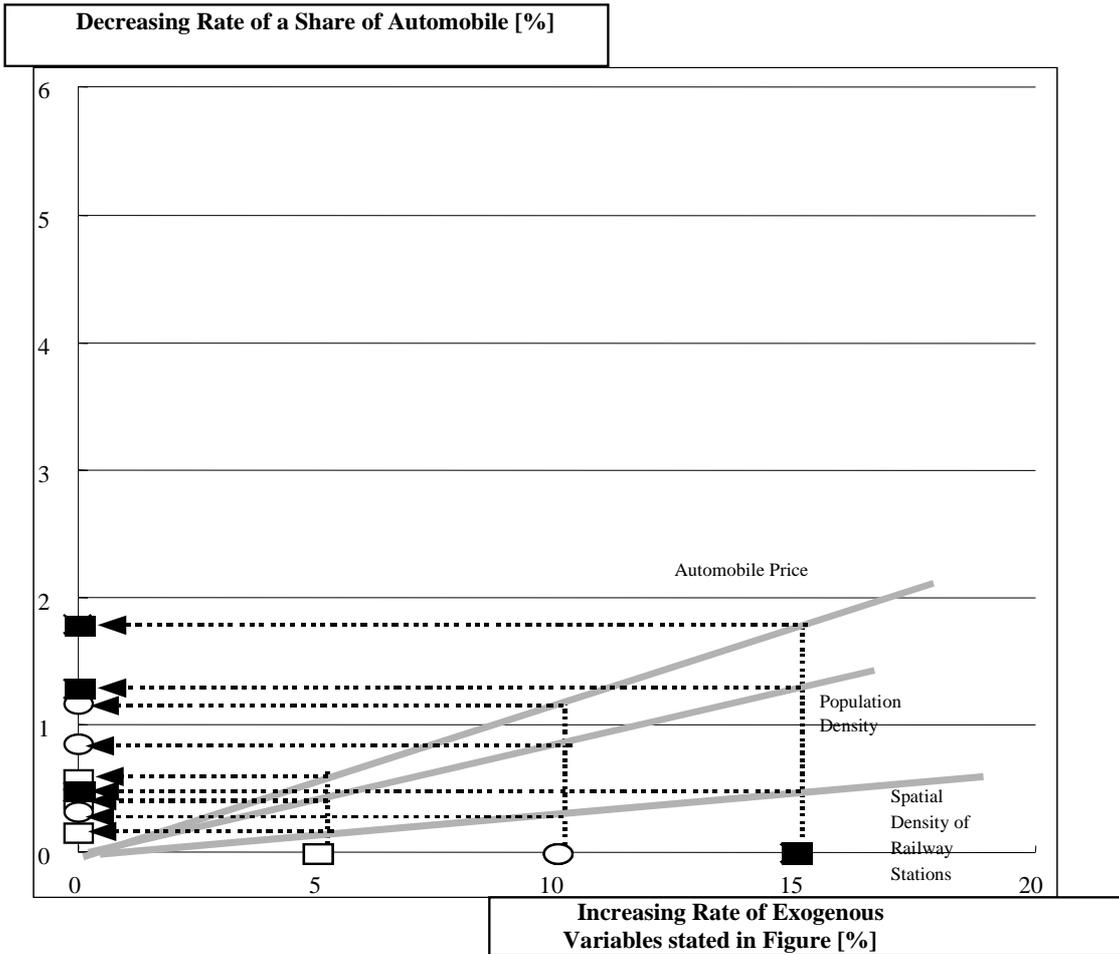
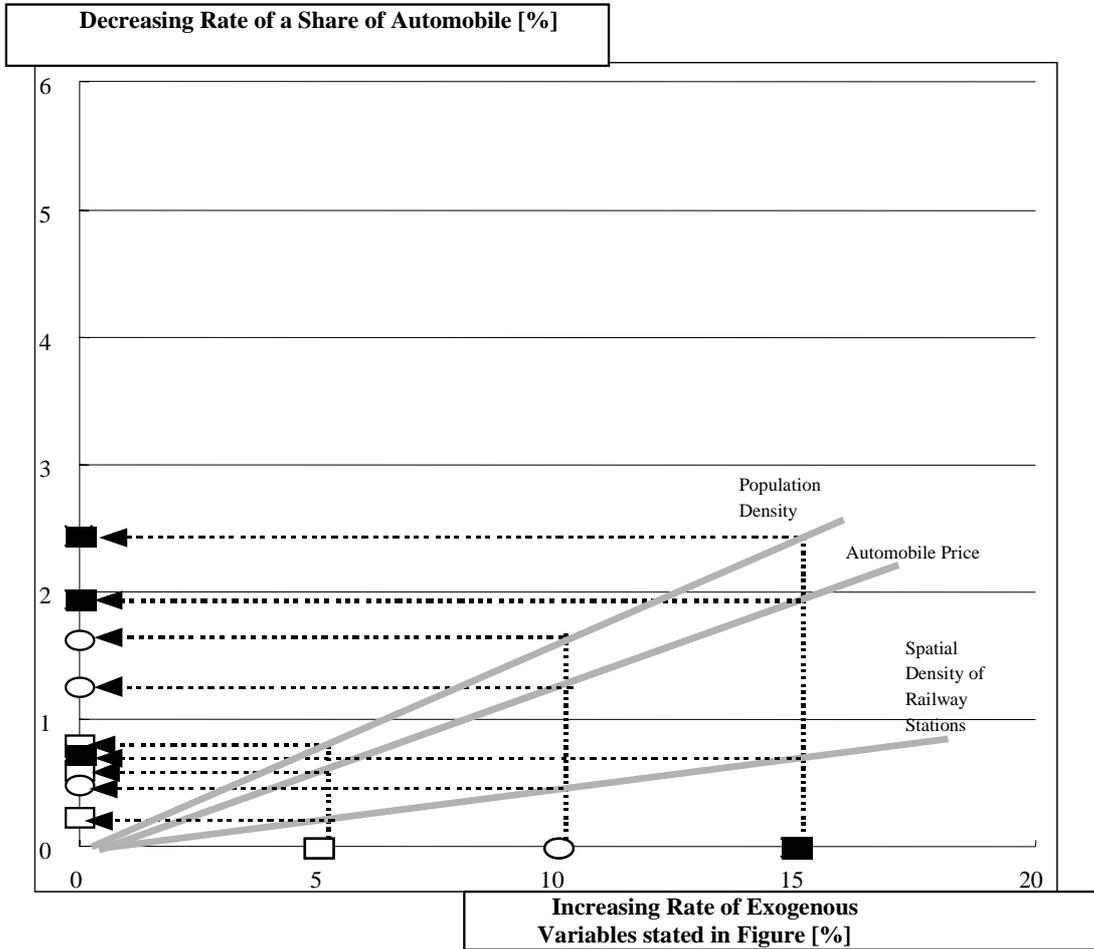


Figure 20. Elasticity of Share of Automobile against Exogenous Variables stated in Figure (Case for Regional Suburban Cities: RSC)

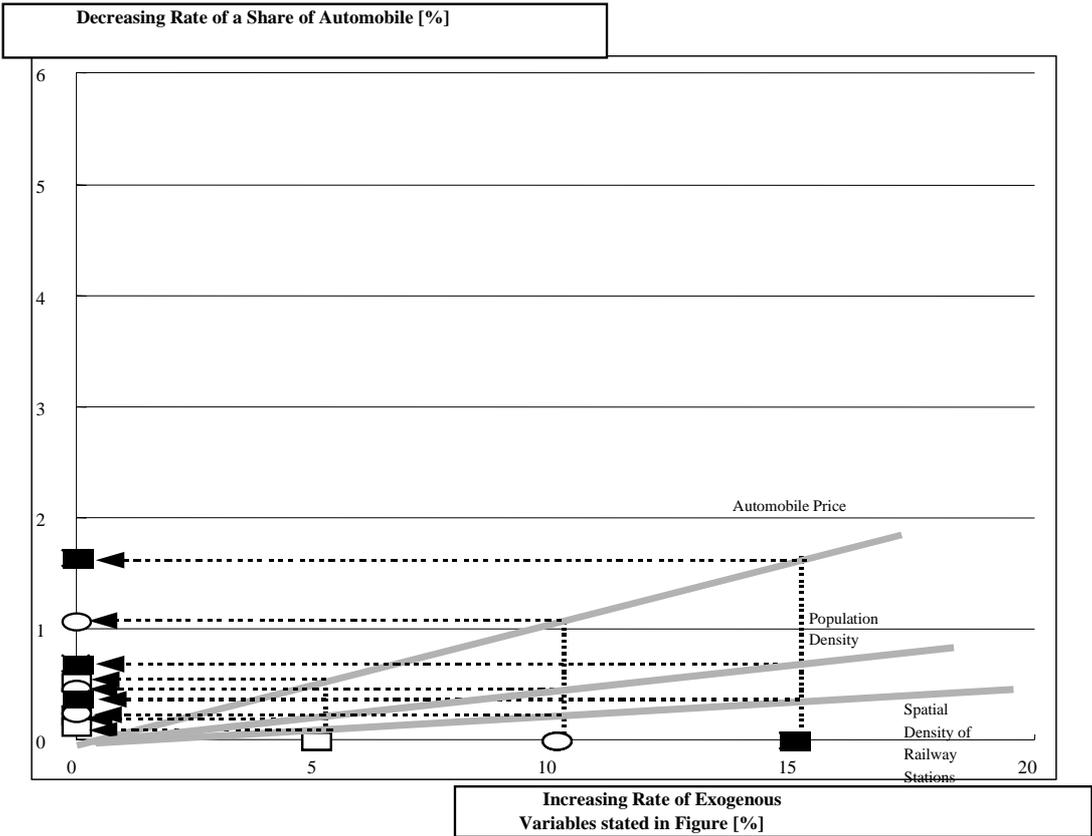


Independent small city

The elasticity of population density is lower than that of Regional core city.

Elasticity of countermeasures in Independent small city shows pretty low level compared with the other city groups.

Figure 21. Elasticity of Share of Automobile against Exogenous Variables state in Figure (Case for Independent Small Cities: ISC)



6. Conclusions

Summary of conclusions are follows:

1. We discussed future environmental load caused by transportation under the assumption of current trend of demand for each mode. Through this study, we applied the backcasting approach, which has been discussed in chapter 2, to quantify effects on the reduction in environmental load. According to the results discussed in the chapter 4, a drastic change in modes between passenger cars and railways should be required. These results suggest us the difficulties in achieving of the policy target. Also looking at the gaps between the estimated shares according to BAU scenario and those to BCA, it looks quite difficult to achieve the targets only by modal shift.
2. We examined possible effects of alternative countermeasures to reduce CO₂ emission caused by transport in urban level. In this study, a meso scale model was developed. to evaluate the effects of environmental countermeasures on urban transportation. As discussed in chapter 5, we could obtain good fit of estimation of the model. We are convinced that we can examine the effects of some alternative countermeasures in urban transport taking into account of different regional characteristics of cities.

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