AN EVALUATION OF JAPAN'S FINANCIAL SYSTEMS FOR ROAD CONSTRUCTION
- CONSIDERING THEIR CONTRIBUTION TO ECONOMIC GROWTH -

Tadashi ITOH
Research Associate
Department of Civil Engineering
Wakayama National College of Technology
Nada-cho, Gobo, Wakayama, 644-0023 Japan
Fax: +81-738-29-8469
E-mail: tito@civ.wakayama-nct.ac.jp

Yoshitaka AOYAMA
Professor
Department of Civil Engineering Systems
Kyoto University
Sakyo-ku, Kyoto, 606-8501 Japan
Fax: +81-75-753-5759
E-mail: aoyama@utel.kuciv.kyoto-u.ac.jp

Dai NAKAGAWA
Associate Professor
Department of Civil Engineering Systems
Kyoto University
Sakyo-ku, Kyoto, 606-8501 Japan
Fax: +81-75-753-5759
E-mail:nakagawa@utel.kuciv.kyoto-u.ac.jp

Ryoji MATSUNAKA
Research Associate
Department of Civil Engineering Systems
Kyoto University
Sakyo-ku Kyoto, 606-8501 Japan
Fax: +81-75-753-5759
E-mail: matsu@utel.kuciv.kyoto-u.ac.jp

Abstract: This study evaluates the effect of Japan's financial systems for road construction by utilizing a macro economic model. The model describes a relation between GDP and road capital investments, considering the interactive role of general public capital and private capital in addition to road capital. After the performance of the model was tested, it is applied to some case studies that evaluate the role of the main features of Japan's financial systems called "special purpose taxation" and the "toll road system."
As a result of these applications, a significant contribution of these systems to economic growth has been shown. However, the results of future estimation have shown that future revenue for road construction will reduce, and the effect of road capital on GDP will gradually diminish. The main reason is that the conventional financial systems are highly dependent on the increasing use of automobiles and additional investment for roads no longer creates increasing automobile demands.

1. INTRODUCTION

Japan's economic growth in the latter half of this century has been partly due to improvements in the country's infrastructure. Road construction in particular, accelerated by two characteristic financial systems called "special purpose taxation" and the "toll road system," has had a significant influence on growth.

This study evaluates the effect of those financial systems by utilizing a macro economic model that consists of four sub-models: the "road capital stock sub-model", the "social capital stock sub-model", the "private capital stock sub-model", and the "GDP sub-model." Outputs of the model includes the following data: the influence on the GDP of past political decisions on the application of the financial systems that have controlled investment amounts; the influence of subsidies and debts for road construction; and estimations of the influence of future political decisions.

2. SURVEY OF CONVENTIONAL STUDIES

Several previous studies have analyzed the influence of capital investment. Aschauer(1989), for example, calculated the effect of infrastructure investment on social productivity using Cobb-Douglas style production functions, in which the public capital stock by government sector was included as an element of production. He showed that a lack of infrastructure was one of the main causes of the USA's declining rate of productivity increase in the 1970's.

This sort of calculation has been done in Japan as well. Iwamoto(1990) showed that the marginal elasticity of social infrastructure investment to GNP was higher than that of private investment. Both Asako *et al.* (1994) and Kamada *et al.* (1994) calculated the effect of infrastructure investment on social productivity; the former using data analyses, the latter simulation analyses. Ota (1996), an example of studies that calculate the effect of transportation investment, showed the effect of road investment by estimating macro production functions. In this study, the capital stock of roads was used as a representative indicator of the quantity of infrastructure.

Although previous studies have calculated the effect of investment in infrastructure, what they have evaluated is the amount of capital investments; the evaluation of financial systems is not considered.

There are a few examples of studies that directly treat the effect of financial systems. Hayashi *et al.* (1996) calculated the effect of financial systems for road constructions and showed the significant contribution of these systems to Japan's economic growth. The purpose of our present study is similar to this study, and the main difference is that the interactive role of general public capital and private capital, in addition to road capital, is considered in this model.

3. STRUCTURE OF THE MACRO ECONOMIC MODEL

3.1 Framework

In order to evaluate the influence of the financial systems for road construction, it is important to analyze the following: cyclic relations among changes of capital investment amount caused by economic growth, increase of stock by the capital investment, and economic growth caused by the increase of stock.

This paper describes these relations by using a macro economic model consisting of four sub-models. As Figure 1 shows, three of the sub-models, the road capital stock sub-model, the social capital stock sub-model, and the private capital stock sub-model, work to describe the relation between GDP and capital investments. The fourth, the GDP sub-model, shows the outputs of the model, including results from the preceding sub-models.

The model is built under the following conditions.
1) Authorities that construct roads are divided into two types. One, the government, consists of national and local governments; the other, the toll road authority, represents all toll road constructors and operators.
2) Prices are deflated to that of 1990 using the deflator of gross domestic expenditure

shown in Annual Report on the National Account.
3) The model describes the period from 1955 to 1994, considering the introduction of special purpose taxation in 1956.

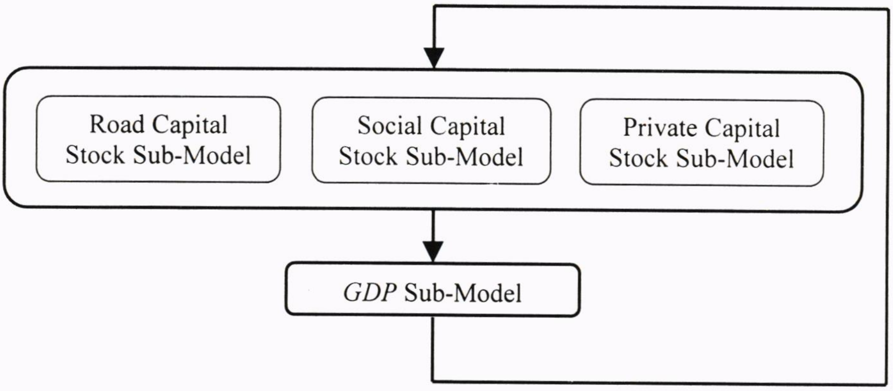

Figure 1. Framework of The Model

3.2 The Road Capital Stock Sub-Model

According to the process shown in Figure 2, the road capital stock sub-model determines the aggregate stock of road capital at the end of each year.

(a) General tax revenue

General tax revenue, which is defined here as revenue from general taxes except automobile user taxes, is considered to be calculated as

$$\tau_g(t) = a_1 \cdot GDP(t-1)^{b_1} \cdot \exp(c_1 \cdot Dummy), \qquad (1)$$

where $\tau_g(t)$= general tax revenue, $GDP(t-1)$= Gross Domestic Product, $Dummy$= a dummy variable representing bubble economy(1986-1991=1), a_1, b_1, c_1 = parameters and (t) and $(t-1)$ show the year whose value is adopted for the variables.

The main characteristic of this equation is the introduction of the dummy variable that describes the influence of the bubble economy.

(b) Automobile users taxes

Automobile users taxes can be divided into two types. One is constituted of taxes based on the use of automobiles represented by fuel taxes, the other is constituted of taxes on the possession of automobiles. The revenue of the former is considered to be calculated, as equation 4, from the tax rate on fuel retails, the total number of automobiles in ownership, and fuel consumption; and the latter, as equation 5, from the total number of automobiles in ownership.

We can obtain, by using these equations, quantified data on how the change of road stock influences tax revenues by analyzing the changes of the amount of automobile use and possession.

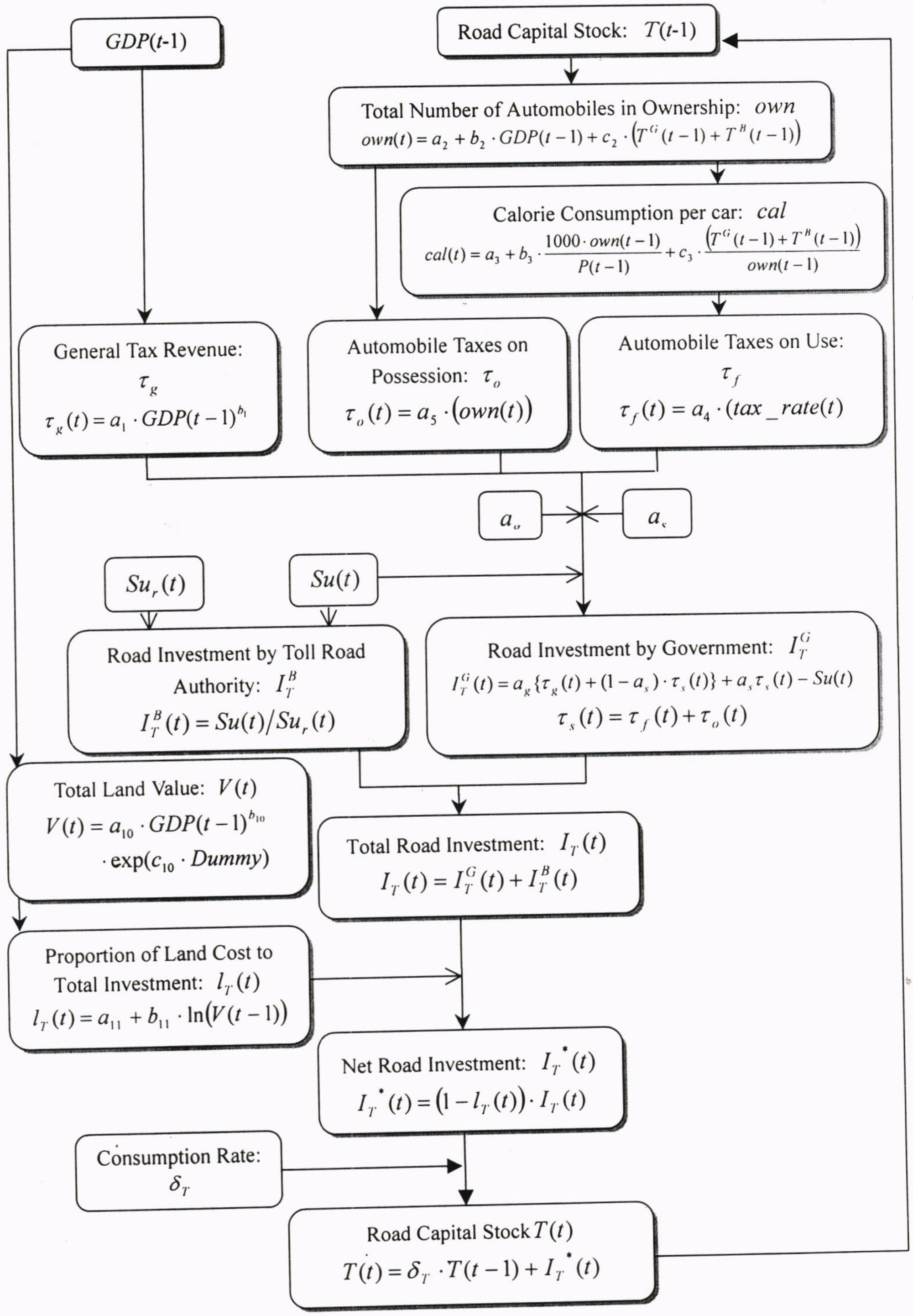

Figure 2. Road Capital Stock Sub-Model

The total number of automobiles in ownership and fuel consumption per car are considered to be calculated as

$$own(t) = a_2 + b_2 \cdot GDP(t-1) + c_2 \cdot \left(T^G(t-1) + T^B(t-1)\right), \qquad (2)$$

where $own(t)$ = the total number of automobiles in ownership, $T^G(t)$ = aggregate stock of general road capital, $T^B(t)$ = aggregate stock of toll road capital and a_2, b_2, c_2 = parameters, and

$$cal(t) = a_3 + b_3 \cdot \frac{1000 \cdot own(t-1)}{P(t-1)} + c_3 \cdot \frac{\left(T^G(t-1) + T^B(t-1)\right)}{own(t-1)}, \qquad (3)$$

where $cal(t)$ = calorie consumption per car, $P(t)$ = population, and a_3, b_3, c_3 = parameters.

Then automobile taxes on use $\tau_f(t)$ is given as

$$\tau_f(t) = a_4 \cdot \left(tax\_rate(t) \cdot cal(t) \cdot own(t)\right), \qquad (4)$$

where tax_rate = tax rate on fuel retails, and a_4 = parameter.

Automobile taxes on possession $\tau_o(t)$ is given as

$$\tau_o(t) = a_5 \cdot \left(own(t)\right), \qquad (5)$$

where a_5 = parameter.

Consequently automobile users taxes $\tau_s(t)$ is obtained as

$$\tau_s(t) = \tau_f(t) + \tau_o(t). \qquad (6)$$

(c) Total road investment

Total road investment consists of road investment by government and by toll road authorities.

Road investment by government $I_T^G(t)$ is given as

$$I_T^G(t) = a_g\{\tau_g(t) + (1-a_s)\cdot\tau_s(t)\} + a_s\tau_s(t) - Su(t), \qquad (7)$$

where a_g = the rate of amounts that are allocated to road investment in the revenue from general taxes, a_s = the rate of amounts that are allocated to road investment in the revenue from automobile users taxes, $\tau_s(t)$ = revenue from automobile users taxes, $Su(t)$ = subsidies to toll road authorities.

Road investment by toll road authorities $I_T^B(t)$ is given as

$$I_T^B(t) = {Su(t)}/{Su_r(t)}, \qquad (8)$$

where $Su_r(t)$ = subsidy rate.

Then the total road investment $I_T(t)$ is obtained as

$$I_T(t) = I_T^G(t) + I_T^B(t). \qquad (9)$$

(d) Net road investment

In order to calculate net road investment, cost for purchasing land should be subtracted from total road investment. The cost is calculated from total land value that is estimated as equation 10 utilizing a dummy variable.

$$V(t) = a_{10} \cdot GDP(t-1)^{b_{10}} \cdot \exp(c_{10} \cdot Dummy), \qquad (10)$$

where $V(t)$ = total land value, $Dummy$ = a dummy variable representing bubble economy(1987-1992=1), and a_{10}, b_{10}, c_{10} = parameters.

The proportion of land cost to total investment $l_T(t)$ is described by total land value.

$$l_T(t) = a_{11} + b_{11} \cdot \ln(V(t-1)), \qquad (11)$$

where a_{11}, b_{11} = parameters.

Then net road investment $I_T^{\bullet}(t)$ is obtained as

$$I_T^{\bullet}(t) = (1 - l_T(t)) \cdot I_T(t). \qquad (12)$$

(e) Aggregate stock of road capital

Aggregate stock of road capital $T(t)$ is calculated from net road investment considering consumption of stock.

$$T(t) = \delta_T \cdot T(t-1) + I_T^{\bullet}(t), \qquad (13)$$

where δ_T = consumption rate of road capital stock (assumed 4% per year).

3.3 The Social Capital Stock Sub-Model

The social capital stock sub-model describes the relation between GDP and social infrastructure investment that excludes road investment. The process of determining social infrastructure investment is shown in Figure 3.

(a) Consumption expenditure of government

Consumption expenditure of government $Ce_G(t)$ is assumed as

$$Ce_G(t) = a_{14} \cdot (GDP(t-1))^{b_{14}}, \qquad (14)$$

where a_{12}, b_{12} = parameters.

(b) Subsidies

Subsidies by government to industries are assumed to be calculated from the amount of general tax revenue. Considering 1984 a turning point, after which the subsidies stopped increasing, we introduced a variable describing the time trend.

$$Sub(t) = a_{15} \cdot \exp(b_{15} \cdot Max[0, t-1983]) \cdot \{\tau_g(t) + (1 - a_s) \cdot \tau_s(t)\}^{c_{15}}, \qquad (15)$$

where $Sub(t)$ = subsidies and a_{15}, b_{15}, c_{15} = parameters.

(c) Consumption of governmental fixed capital

Consumption of governmental fixed capital is calculated from the aggregate stock of social capital and road capital.

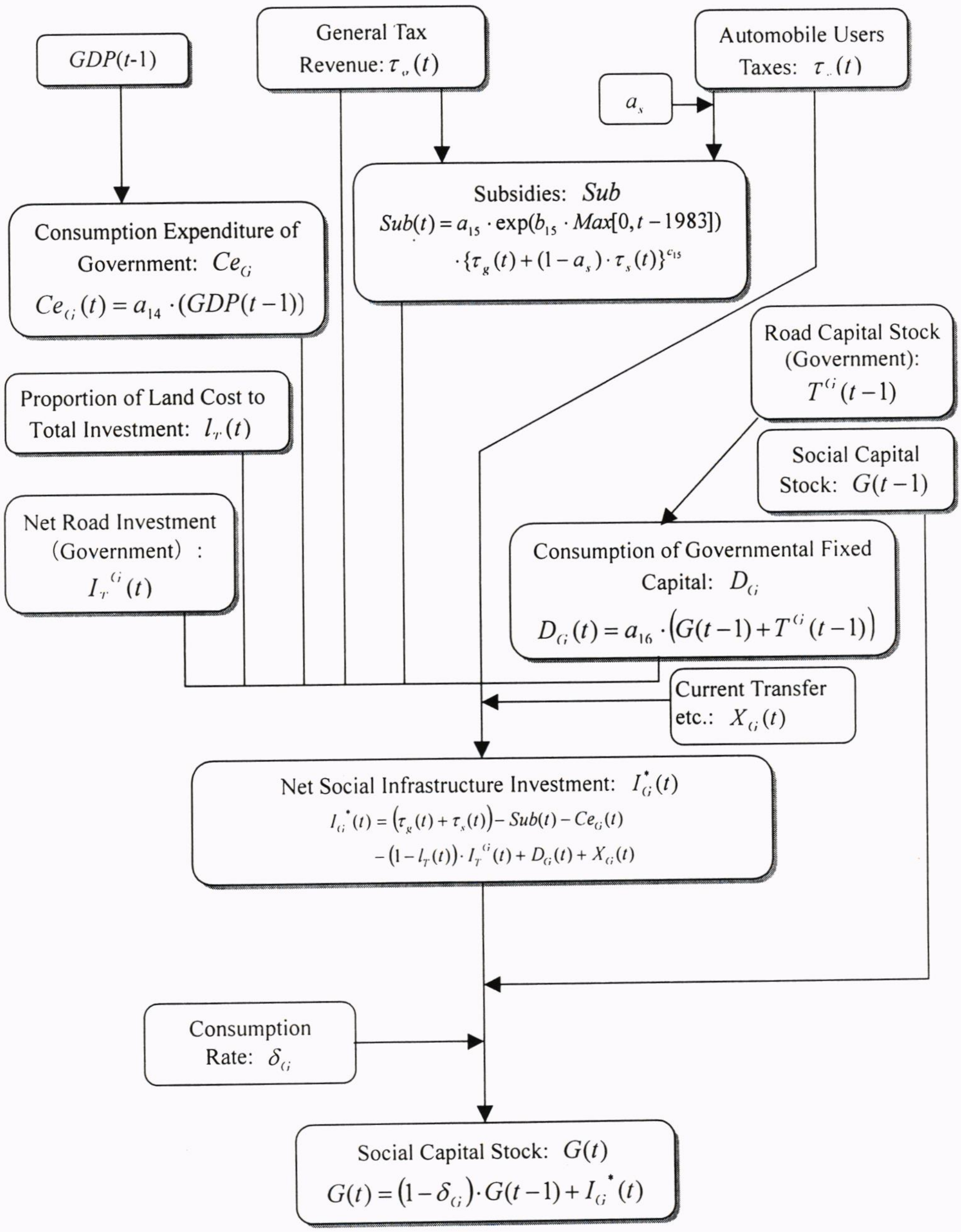

Figure 3. Social Capital Stock Sub-Model

$$D_{Gi}(t) = a_{16} \cdot \left(G(t-1) + T^{Gi}(t-1)\right)^{b_{16}}, \quad (16)$$

where $D_{Gi}(t)$ = Consumption of governmental fixed capital, $G(t-1)$ = aggregate stock of social infrastructure, $T^{Gi}(t-1)$ = aggregate stock of general road capital, = $\delta_T \cdot T^{Gi}(t-2) + (1 - l_T(t-1)) \cdot I_{Gi}^{T}(t-1)$, and a_{16}, b_{16} = parameters.

(d) Net social infrastructure investment

Net social infrastructure investment $I_{Gi}^{*}(t)$ is given as

$$I_{Gi}^{*}(t) = \left(\tau_g(t) + \tau_s(t)\right) - Sub(t) - Ce_{Gi}(t) - \left(1 - l_T(t)\right) \cdot I_T^{Gi}(t) + D_{Gi}(t) + X_{Gi}(t), \quad (17)$$

where $l_T(t)$ = proportion of land cost to total road investment, $I_T^{Gi}(t)$ = total road investment by government, $X_{Gi}(t)$ = current transfer etc. (include purchase of land).

(e) Aggregate stock of social infrastructure

Social infrastructure stock $G(t)$ is calculated from net social infrastructure investment considering consumption of stock.

$$G(t) = \left(1 - \delta_{Gi}\right) \cdot G(t-1) + I_{Gi}^{*}(t), \quad (18)$$

where δ_{Gi} = consumption rate of social infrastructure stock (assumed 4% per year).

3.4 The Private Capital Stock Sub-Model

The private capital stock sub-model describes the relation between *GDP* and private capital investment. The process of determining the private capital stock is shown in Figure 4.

(a) Saving

Saving $Sv(t)$ is described as the following saving function.

$$Sv(t) = a_{19} \cdot \left(GDP(t-1) - \left(\tau_g(t) + \tau_s(t)\right)\right)^{b_{19}}, \quad (19)$$

where a_{19}, b_{19} are parameters.

(b) Consumption of fixed capital

$$D(t) = a_{20} \cdot \left(GDP(t-1)\right)^{b_{20}}, \quad (20)$$

where $D(t)$ = consumption of fixed capital and a_{20}, b_{20} = parameters.

(c) Net private capital investment

Net private capital investment I_K^{*} can be defined from the following relations:

$$Sv(t) = GDP(t) - Ce_P(t) - Ce_{Gi}(t) - D(t) - X_K(t),$$

$$GDP(t) = Ce_{Gi}(t) + Ce_P(t) + I_{Gi}^{*}(t) + I_K^{*}(t) + I_T^{*}(t).$$

Then,

$$I_K^{*}(t) = Sv(t) + D(t) - I_{Gi}^{*}(t) - I_T^{*}(t) + X_K(t), \quad (21)$$

where $X_K(t)$ = miscellaneous investment.

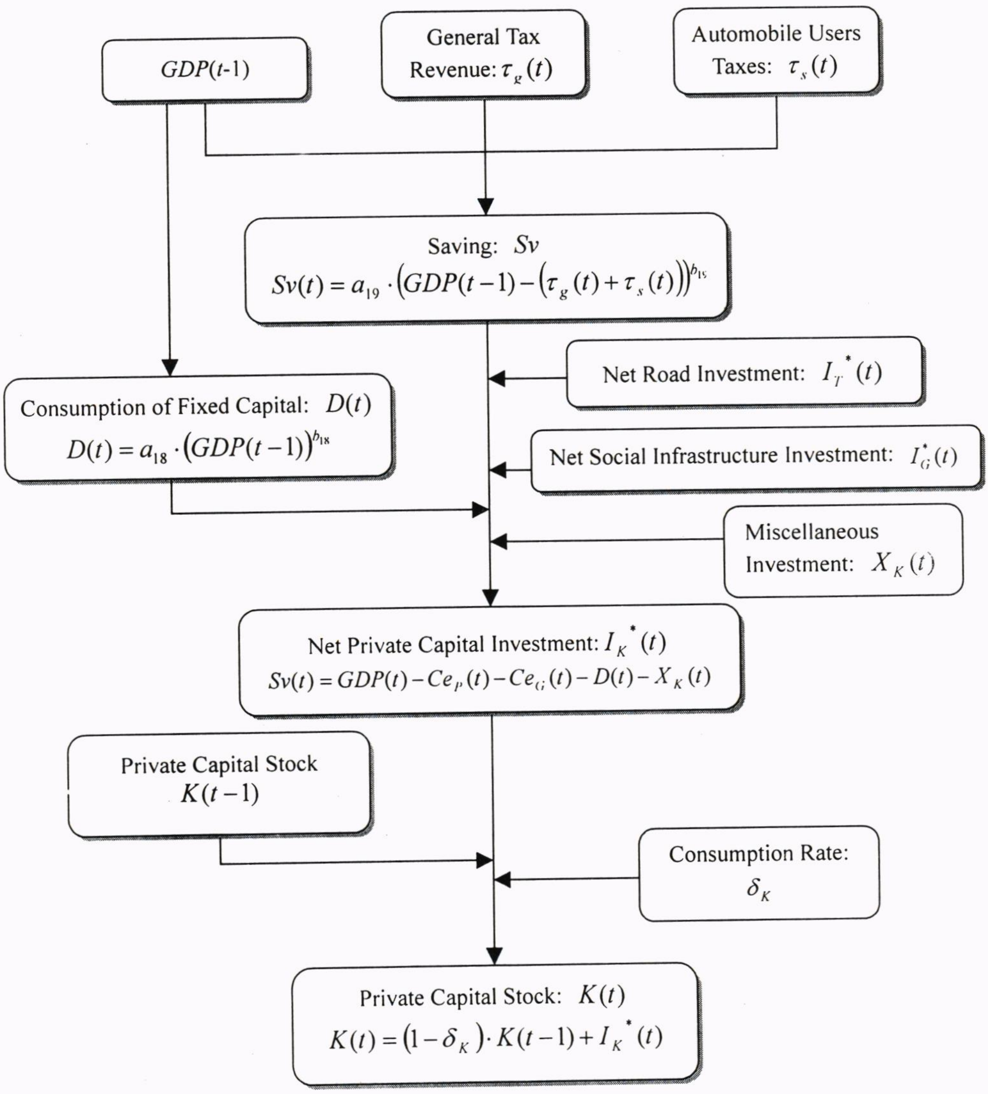

Figure 4. Private Capital Stock Sub-Model

(d) Aggregate stock of private capital

Aggregate stock of private capital $K(t)$ is calculated from net private capital investment considering consumption of stock.

$$K(t) = (1-\delta_K)\cdot K(t-1) + I_K^{*}(t), \tag{22}$$

where δ_K = consumption rate of private capital stock (assumed 4% per year).

3.5 The GDP Sub-Model

As the influence of the financial systems results in aggregate stocks of road capital, social capital and private capital, and GDP can be obtained using following production function.

$$GDP(t) = A(t)\cdot L(t)^{\beta_1}\cdot (k\cdot K(t))^{\beta_2}\cdot T(t)^{\beta_3}\cdot G(t)^{\beta_4}, \tag{23}$$

where $A(t)$ = the technical coefficient, $L(t)$ = labor (working population x index of working hours), k = net operation rate of private capital, $\beta_1, \beta_2, \beta_3, \beta_4$ = parameters.

The technical coefficient $A(t)$ in equation 23 is determined as equation 24, considering 1971 a turning point at which rapid growth ended.

$$A(t) = \exp\{\alpha_0 + \alpha_1 \frac{(Max[0, t-1959])^{3.5}}{t} + \alpha_2 (Max[0, t-1970])^{1.5} + \alpha_3 Dummy\}, \tag{24}$$

where $Dummy$ = a dummy variable for bubble economy(1987-1992=1).

Using this determination of the coefficient, the logarithmic version of equation 23 is yielded as

$$\begin{aligned}\ln GDP(t) = {} & \alpha_0 + \alpha_1 \frac{(Max[0, t-1959])^{3.5}}{t} + \alpha_2 (Max[0, t-1970])^{1.5} + \alpha_3 Dummy \\ & + \beta_1 \ln L(t) + \beta_2 \ln(k\cdot K(t)) + \beta_3 \ln T(t) + \beta_4 \ln G(t)\ .\end{aligned} \tag{25}$$

3.6. The Calibration of the Model

Parameters in the above equations are estimated. Data sources used for these estimations are listed at the end of this paper in alphabetical order according to the variables.

Given the values of 1954 as inputs, GDP and the aggregate stocks of each year are estimated as outputs. Both Figure 5, that demonstrates the comparison of estimated GDP and actual data, and Figure 6 regarding aggregate stock of road capitals show the degree of accuracy of results derived from the model.

4. APPLICATION OF THE MODEL FOR EVALUATING POLITICAL DECISION

Most important features of Japan's road investment adopted thus far are the government's use of a significant amount of automobile users taxes and subsidies to toll road authorities. In order to evaluate those financial systems, we investigated what change would have occurred if different policies had been adopted.

4.1 Allocation of Automobile Users Taxes to Road Investment

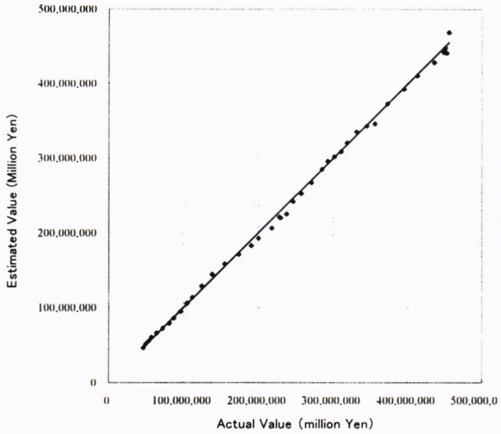

Figure 5. Comparison of Estimated GDP and Actual Data

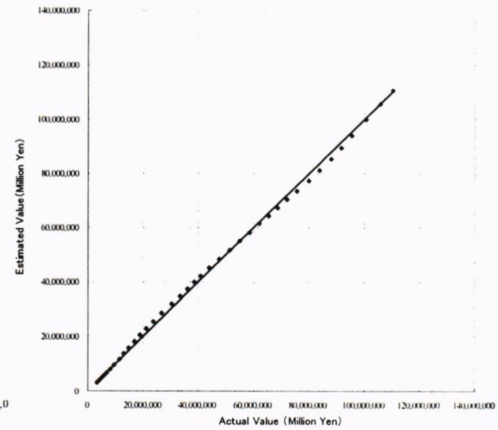

Figure 6. Comparison of Estimated Road Capitals and Actual Data

Approximately 80% of revenues from automobile users taxes have been continuously allocated to road construction thus far, and road investment has progressed according to the growth of the number of automobiles. The comparative analysis made here concerns how GDP changes under a different rate of the allocation, given the following three scenarios.

In the analysis, the remainder of revenue from automobile users taxes, which is not allocated to road investment, is considered to be used as general tax.

(Scenario 1-1) The rate of the allocation is 0%(SF=0%)
(Scenario 1-2) The rate of the allocation is 50%(SF=50%)
(Scenario 1-3) The rate of the allocation is 100%(SF=100%)

The results are shown in Figure 7(1). The case of scenario 1-1 and scenario 1-2 have got lower GDP than the case of actual data (SF=80%), while the case of scenario 1-3 have got higher.

The difference is more clear in Figure 7(2) which illustrated the growth of GDP as ratios to actual data. GDP in the case of scenario 1-1 reached 75% of the actual data and in scenario 1-2, 90%. On the other hand, in the case of scenario 1-3 the ratio is 105%.

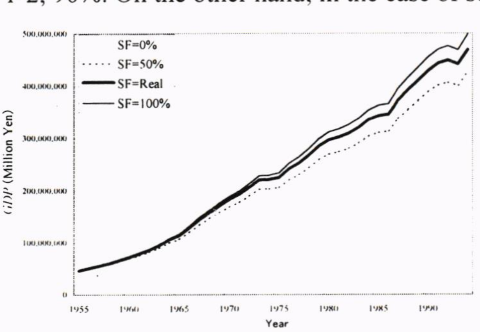

Figure 7(1). The Results of GDP in Each Case

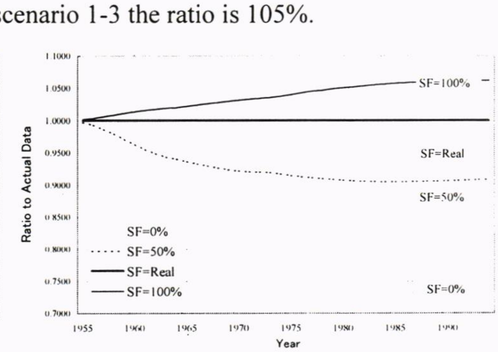

Figure 7(2). The Growth of GDP as Ratio to Actual Data

We may sum up that the result shows use of high percentage of revenue from automobile users taxes has raised the GDP.

4.2. Subsidies to toll road authorities by government

A change of policy regarding subsidies to toll road authorities by government creates a change of financial resources for toll road construction. Since toll roads are mostly invested with revenue from debts and subsidies, an increase/decrease of subsidies causes a decrease/increase of debts, respectively. At the same time, an increase/decrease of subsidies causes a decrease/increase of general investment by government. On the other hand, an increase/decrease of private investment will be also brought about by an increase/decrease of subsidies, because of the corresponding decrease/increase of debts of toll road authorities.

In order to estimate the influence of these changes on GDP, six scenarios are considered. In this analysis, the increase of subsidies is derived from the general fund, and the decrease of subsidies is put into the general fund, which means that those changes do not have any effects on the investment of general road by government.

(Scenario 2-1) Total toll road investment is the same as that in actual data, but subsidies are twice those in actual data, which means the subsidy rate is twice that in actual data. (Su×2,Sur×2)
(Scenario 2-2) Total toll road investment is the same as that in actual data, but subsidies are half those in actual data, which means the subsidy rate is half that in actual data. (Su/2, Sur/2)
(Scenario 2-3) Total toll road investment is twice that in actual data, and subsidies are twice those in actual data, which means the subsidy rate is equal to that in actual data. (Su×2)
(Scenario 2-4) Total toll road investment is twice that in actual data, and subsidies are equal to those in actual data, which means the subsidy rate is half that in actual data. (Sur/2)
(Scenario 2-5) Total toll road investment is three times that in actual data, and subsidies are three times those in actual data, which means the subsidy rate is equal to that in actual data. (Su×3)
(Scenario 2-6) Total toll road investment is three times that in actual data, and subsidies are equal to those in actual data, which means the subsidy rate is one-third that in actual data. (Sur/3)

The estimated GDP is shown in Figure 8(1) and its ratio to the case of actual data in Figure 8(2). The figures generally demonstrate that the scenarios, except scenario 2-1, have a higher GDP than the case of actual data. A more interesting result is that the fewer subsidy amounts gain the higher GDP. This result can be seen in such cases as scenario 2-1 vs. scenario 2-2; scenario 2-3 vs. scenario 2-4; and scenario 2-5 vs. scenario 2-6. These findings are caused by the difference in the elasticity of productivity and the amount of stocks between social capital and private capital. That is, the elasticity of social stock is greater than that of private capital.

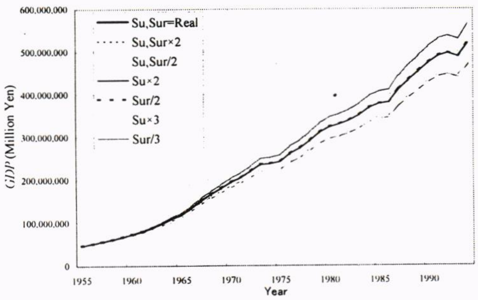

Figure 8(1). The Results of GDP in Each Case

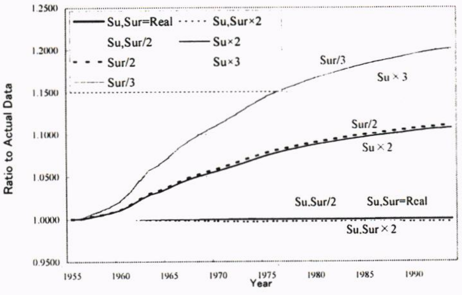

Figure 8(2). The Growth of GDP as Ratio to Actual Data

5. APPLICATION OF THE MODEL FOR THE ESTIMATION OF ECONOMIC GROWTH IN THE FUTURE

Although we have shown that the past policy for road construction has contributed to Japan's economic growth, there is no evidence that the trend will be continued in the future. In fact, as the efficiency of road investment is declining according to the increase in land prices, sustainability of the conventional systems that highly depends on users threatens to be unstable. In order to evaluate these problems, we estimated future economic growth by applying the model.

5.1 Conditions for the Estimation

The time period of the calculation is from 1995 to 2010, and the following values are used for inputs.

(a) Population is quoted from a population estimation calculated by the Ministry of Health and Welfare. Labor is calculated from the same estimated data.
(b) Values of a_g, a_s, Su_r Su, X_K, k and the time trend in equation 15 are assumed such that the values in 1994 will proceed from 1995 to 2010.
(c) The time trend in equation 24 is obtained by regression analysis using the data of GDP from 1975 to 1994.

5.2 Result of the Future Estimation

Figure 9(1) shows the growth of GDP and Figure 9(2) illustrates the rate of growth of each year. Although GDP is increasing, the rate of growth is declining. Comparing this result with the growth of aggregate stock of road capital, which is shown in Figure 10(1) and 10(2), the declining trends of both data with respect to rate of growth show similar features. They were growing prior to the early 1960's, after which they began declining.

The elasticity of aggregate stock of road capital to growth of GDP illustrated in Figure 11 also shows that the influence of road investment would diminish. These results are affected by the fact that the marginal investment to road construction hardly produces additional use of automobiles (see Figure 12), which suggests that the conventional financial systems highly dependent on the increasing use of automobiles have those limitations.

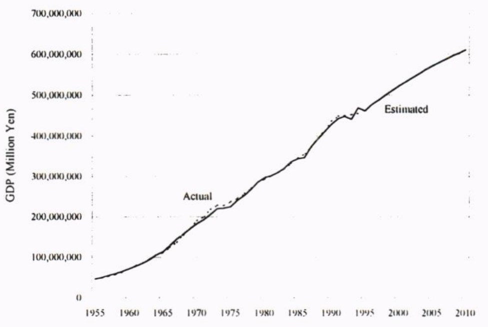

Figure 9(1). Estimated Growth of GDP

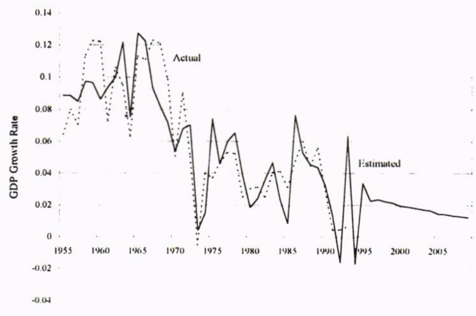

Figure 9(2). Estimated Growth Rate of GDP

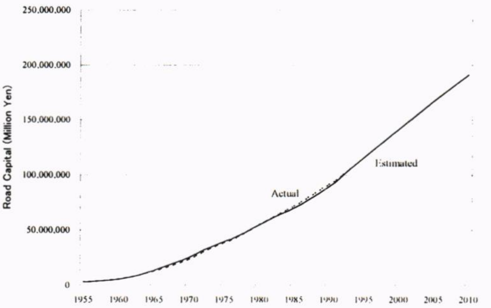

Figure 10(1). Estimated Growth of Road Capital

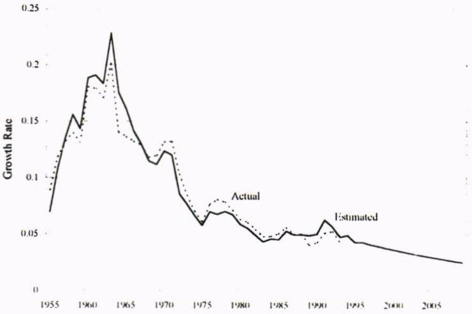

Figure 10(2). Estimated Growth Rate of Road Capital

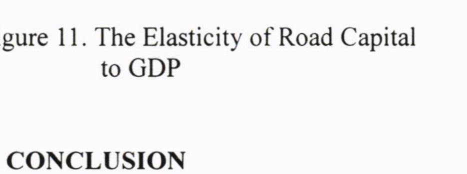

Figure 11. The Elasticity of Road Capital to GDP

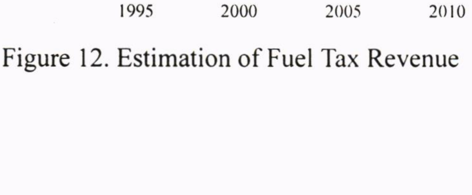

Figure 12. Estimation of Fuel Tax Revenue

6. CONCLUSION

In order to evaluate the influence of financial systems for road construction, we have formulated a macro economic model which describes the relation between the GDP and capital investments. The performance of this model has been tested by comparing data derived from its application to case studies with actual data of the GDP.

As a result of this application, the facts listed below have been established.

(1) The increase in road stock has influenced the GDP, through the interdependent mechanism between social and private capitals.
(2) It can be said that the special taxation for road construction has contributed to the economic growth of Japan, because the model shows that a high rate of road investment of the revenue from the automobile users taxes will bring high growth of GDP.
(3) Toll road construction invested by both debts and subsidies has also contributed to the growth of GDP.
(4) On the other hand, the results of future estimation have shown that future revenue, if the conventional system is continued, will reduce, and the elasticity of road capital to GDP will gradually diminish.

From these results, it can be said that Japan's economic growth and the successful contribution of road investment to that growth have been mutually dependent. However, now that the main network has almost been completed and the cost for construction per mile remains high, additional investment for road construction no longer creates increasing automobile demands. Under such circumstances, a new direction, one no longer dependent on demand, one showing concern for coming needs including the environment and disabilities, etc., should be introduced to replace conventional financial systems.

A foreseeable extension of this study would be to consider the repayment of debts, because the balance of debts for construction of toll roads has reached a significant amount and is likely to bring more influence to sustainability of the systems than previously.

REFERENCES

Asako K., et al.(1994) Productivity of Government Capital and the Welfare Evaluation of Government Investment Policy, **The Keizai Bunseki (The Economic Analysis) 135**, Economic Planning Agency, Tokyo, in Japanese.

Aschauer, D.A. (1989) Is Public Expenditure Productive? **Journal of Monetary Economics 23**, 177-200.

Hayashi Y, Kim K. and Okuda T. (1996) A Study on the Balance between Economic Growth and Transportation Infrastructure Investment, **Infrastructure Planning Review 13**, 67-74, in Japanese.

Iwamoto Y. (1990) An Estimation of Public Investment Policy in Postwar Japan, **The Economic Review 41(3)**, 250-261, in Japanese.

Kamada K., et al. (1994) Public Investment and Full-employment Surplus, **The Economic Review 45(1)**, 31-40, in Japanese.

Ota K. (1996) Measurement of Effects of Social Infrastructure Investment Using Macro Production Functions, **Expressway and Automobiles 39(10)**, 22-27, in Japanese.

APPENDIX

Data sources for inputs, alphabetically ordered by the name of variables. (All these sources are annually published in Japan.)

Automobile taxes, "Local Finance Statistical Annual Report", "Reference Calculation Data for Local Taxes", "Financial Statistics" and "Settlement Statistics."
Automobile tonnage transferred tax, "Reference Calculation Data for Local Taxes."
Consumption expenditure of government, "Annual Report on National Account."
Consumption of fixed capital, "Annual Report on National Account."
Current transfer etc. (including purchase of land), "Annual Report on National Account."
General tax revenue (exclude automobile users taxes), "Financial Statistics" and "Reference Calculation Data for Local Taxes."
Gross Domestic Product, "Annual Report on National Account."
Labor (index of working hours), "Monthly Labor statistical Abstract."
Labor (working population), "Labor Investigation Annual Report."
Net increase of liabilities, "Annual Report on National Account."
Net increase of financial assets, "Annual Report on National Account."
Net private capital investment, "Annual Report on National Account."
Net operation rate of private capital, "International Trade and Industry Statistics"
Private capital stock, "Private Enterprise Capital Stock"
Savings, "Annual Report on National Account."
Social infrastructure stock, "Social Infrastructure in Japan –from flow to stock."
Subsidies, "Annual Report on National Account."
Subsidies to toll road authorities, "Japan Highway Public Corporation Yearbook", "Japan Highway Public Corporation Data", "Metropolitan Expressway Public Corporation Yearbook", "Hanshin Expressway Public Corporation Yearbook", "Honshu-Shikoku Bridge Authority Data" and "Road Statistics."
Total road investment by toll road authorities, the same data as subsidies to toll road authorities.
Total social infrastructure investment, "Annual Report on National Account."
Total values of land, "Annual Report on National Account."