A STUDY ON THE BALANCE BETWEEN ECONOMIC GROWTH AND TRANSPORTATION INFRASTRUCTURE INVESTMENT

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Abstract: Road capital stock in Japan was formed within a short period after World War II. This study examines the financial system for road investment implemented in Japan, through which high supply of road infrastructure could be maintained. The study also proposes a macro socio-economic model for analyzing the impacts of this system on economic growth. Using this model, the extent this financial system contributed to Japanese economic growth is evaluated. The results of this study may provide general guidelines for road investment policies for some Asian developing countries which are now under rapid economic growth.

1. INTRODUCTION

Presently, many countries with rapid economic growth, such as Asian developing countries, face many problems. One of these crucial problems is how to develop infrastructure to cope with the rapid economic growth. Contrary to the ordinal private capital, transport infrastructure cannot be accumulated as internal activities of the market economy. Therefore, a system in which the public sector would be able to raise the appropriate financial resources and use them for infrastructure investment is necessary.

After World War II, investment in road infrastructure in Japan has kept a high share of the public investment. As a result, the Japanese road capital stock was formed within a short period after the war and this supported economic growth.

However, to what extent did road investment in Japan after World War II support economic growth? Clarification of this question is an important issue when considering alternative road investment policies in developing countries.

This study aims at first reviewing the characteristics of road investment in Japan after World War II. A macro socio-economic model is also developed to measure and analyze the level of contribution to economic growth made by an implemented financial system for road investment.

This paper is comprised of five chapters. Following the introduction, Chapter 2 describes the characteristics of Japanese road investment after World War II. Chapter 3 discusses the analytical framework of the proposed model and then model development is described. In Chapter 4, using the developed model, Japanese road investment level and the financial system are evaluated. Finally, the findings and conclusions of the study are summarized in Chapter 5.

2. DEVELOPMENT OF ROAD INVESTMENT IN JAPAN AFTER WORLD WAR II

Japan achieved a unique trend of economic growth; a rapid growth accompanied by a rapid capital stock formation in both public and private sectors. Among these stocks, road capital stock formation was remarkable. The road investment level required to meet created demand at each economic growth stage was secured by the establishment of a suitable financial system. Examples of such systems are: the special financial system established in 1953, and the 5-year plan of road development from the 1st (in 1954) to the 11th (Hayashi (1995)).

The recommendations regarding road development policies provided by the World Bank Investigation Team headed by Ralph J. Watkins in 1956 and the financial system developed in the light of these recommendations played an essential role in achieving the above mentioned trend. Therefore, this chapter describes the characteristics of Japanese road investment after World War II within the context of Watkins' recommendations. The discussion focuses on the level of investment in road, and the implemented financial system.

2.1 Establishment of Road Investment System

a) Before the Watkins Investigation Team (- 1956)

The postwar Japanese road policy started in 1948 when the "5-year Plan for Road and Street Networks Maintenance and Improvement" which was set up by "Mac Arthur's Memorandum" was submitted to the Japanese Government by GHQ of the Allied Forces. However, because of the bad financial situation at that time, the actual start of road investment began in 1950 with the road improvement projects financed by the " Fund of U.S. Assistance Incentive Goods to Japan". More road improvement projects took place around US occupation army bases according to the Japan-US Security Treaty in 1952. Since then, the road development system has improved gradually. In 1953 a special financial system based on resources from gasoline tax was established, followed by the first 5-year plan for road development in 1954. However, the resulting level of road improvement was not sufficient to catch up with demand.

b) Recommendations Regarding Road Development Policies in Japan Provided by the World Bank Investigation Team (1956)

It can be said that Japanese road investment after World War II actually started after recommendations regarding Japanese road development policies were provided by Watkins in 1956. The World Bank Investigation Team visited Japan at the request of the Japanese Ministry of Construction to carry out investigations for the construction of the Nagoya-Kobe expressway (Meishin). The team issued the so-called "Watkins Report", which provided some analyses and recommendations for Japanese road transport policies beyond the issues of the Meishin Expressway. Since this analysis was conducted objectively, review of this report can reflect the condition of road development policies of those days. The most important investigation results and recommendations in this report can be summarized as follows.

1) There are no roads in Japan. There exist only the land for road construction.

2) The condition of roads in Japan is very bad. Japan is the only industrial country that has neglected road networks completely. Seventy seven percent of the first level national roads, the most important roads, are not paved. Moreover, more than half of this network has not been improved at all. Also more than 90% of the second level national roads and municipal roads, which form the majority of the road network, are unpaved with more than 75% of it unimproved. However, the real condition of the network was much worse than what these statistical figures might indicate.

3) The neglect of road network development imposes a heavy burden on the economy.

4) The current 5-year plan of road improvement is very poor and is not enough to cover the lack of road network infrastructure.

5) The current road investment level is only 0.7% of the Gross National Product. However, based on the US experience, to achieve a minimum road construction and maintenance standards, 2% of GNP is necessary.

Since the recommendations by the Watkins Team were provided, the 5-year plan for road improvement has been regarded as an important component of the national economic plan which promoted rapid road investment.

c) Since the Watkins Recommendations (1958 -)

Receiving the Watkins recommendations, the "Urgent Law for Road Improvement" was established in 1958 and the structure of the road investment was completed. This law has the following three regulations:

1) The Ministry of Construction is responsible for establishing a 5-year plan for road improvement and for getting it approved by cabinet council.
2) The objectives and work volume for road improvement has to be indicated in the plan.
3) Revenues from fuel tax are allocated as financial resources for road improvement.

Based on the above, the road investment system in Japan has had the following two important components, 1) a 5-year plan for road improvement that assumes the role of planning and maintenance and 2) a road financing system that assumes the role of resource acquisition.

2.2 Trends of Road Investment

Japan has used policies to secure financial resources for road investment since the Watkins recommendations in 1956. In this section, road investment level, fund acquisition policies, and the characteristics of construction cost are analyzed.

a) Road Investment Level

Road investment levels before and after the oil crises in 1973 and 1979 for several developed countries are compared with the minimum 2% level recommended by a Watkins (Figure 1). This comparison shows that since World War II Japan has continued a higher investment level than other countries.

b) Acquisition of Financial Resources

High road investment level has been supported by the stable financial system for road investment. This system is based on three main sources 1) a special financial system with major resources raised from automobile related tax such as fuel tax, 2) a general financial system with resources raised from general tax such as income tax, and 3) a fiscal investment and loan system with resources, in the form of loans for profit making infrastructures, raised from postal savings.

The function of this financial system and the trend of the road investment level are shown in Figure 2. Since the Watkins recommendations were provided in 1956, a fiscal investment and loan system has been introduced and the special and general financial resources have increased not only at the rate of economic growth but even at a higher rate which has followed the aggressively increasing car traffic demand. Although the general resources fluctuated because of the two oil shocks, stable resources could still be ensured through the

mobile weight tax revenues and the increase of the general and special tax rates, etc. In this way, high road investment level has been maintained.

c) Road Construction Cost

As described above, road investment in Japan after World War II has been developed at a high level compared with other countries. However, in the assessment of actual construction volume, it cannot be said that high capital accumulation was achieved. The main reason may be the higher road construction costs in Japan compared with other countries. Figure 3 shows a comparison of average total cost per kilometer for recent construction of expressways in Five developed countries. As shown, both construction and land acquisition costs in Japan are much higher than those in other developed countries.

2.3 Characteristics of Road Investment in Japan

From the above, the characteristics of road investment in Japan can be summarized as follows:

- Higher level of investment compared with other countries,
- Resource supply through a financial system with stable revenue level, and
- High total construction cost compared with other countries.

As a result, it can be said that compared with other countries, postwar Japan could secure appropriate financial resources during its rapid economic growth and use them for road investment. Then, to what extent did road investment support economic growth? To clarify this issue, a macro analysis method to analyze the effects of road investment on the economy is developed. Using this method the following analysis is carried out: 1) How effective was road investment in Japan? and 2) To what extent did each financial resource contribute to economic growth?
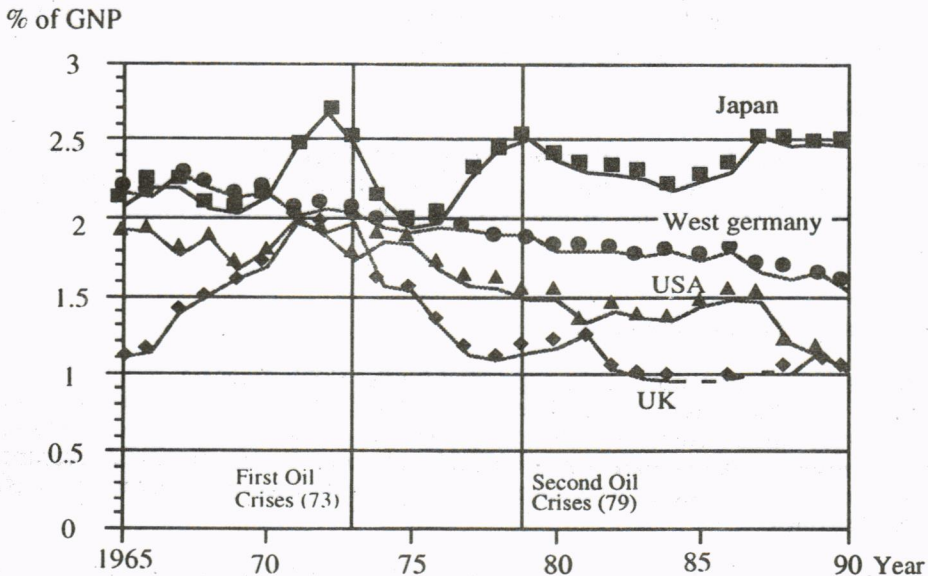

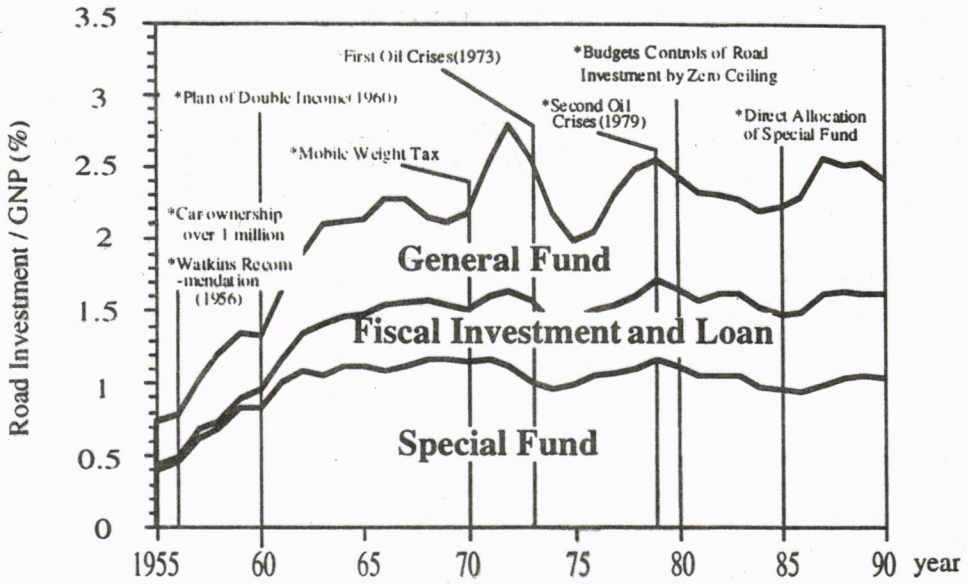Figure 1: Road Investment as % of GNP in Four Developed Countries

Figure 2: Trend and Breakdown of Road Investment by Source
Sources: Economic Planning Agency (1980,87,88,89,92,94),
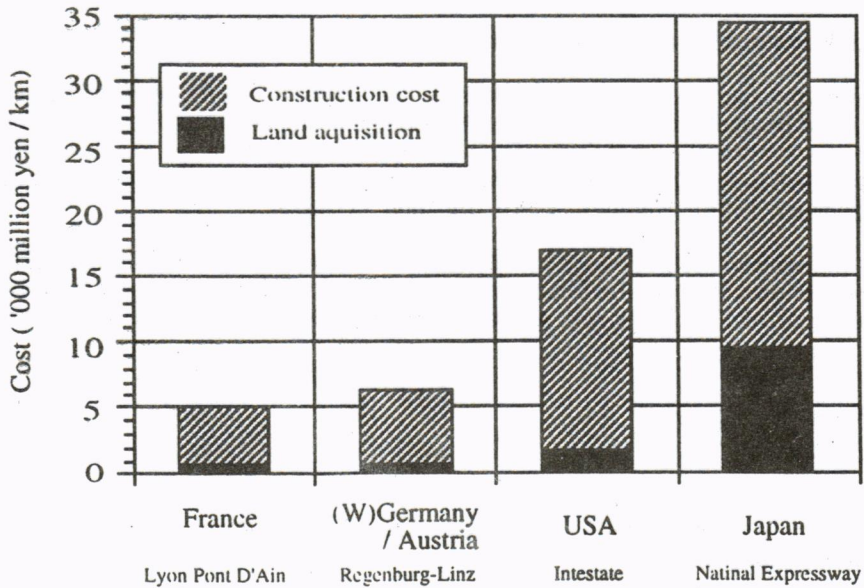Ministry of Construction (1991)

Figure 3: Comparision of Road Construction Cost in Developed Countries
Source: Economic Planning Agency (1991)

3. DEVELOPMENT OF A MACRO SOCIO-ECONOMIC MODEL

3.1 Framework

To analyze how the financial system for road investment contributes to economic growth, two points have to be considered. The first point is how funds are supplied and road capital stock is formed. The other point is how much road stock formation contributes to economic growth (see Figure 4).

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┌─────────────────────┐   a) ──────▶ ┌─────────────────────┐
│ Economic Growth     │ ═══          │ The Formation of    │
│ (Development)       │ ◀────── b)   │ Road Capital Stock  │
└─────────────────────┘              └─────────────────────┘
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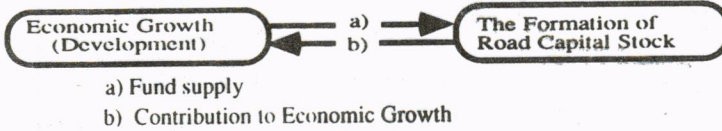a) Fund supply

b) Contribution to Economic Growth

Figure 4: The Study Approach

Based on the above, the proposed model consists of two sub-models: a macro economic growth sub-model and a road capital stock formation sub-model (see Figure 5). The macro economic growth sub-model tries to explain the economic impact of road stock formation, while the road capital stock formation sub-model tries to explain the mechanism of road stock formation as a result of economic growth.
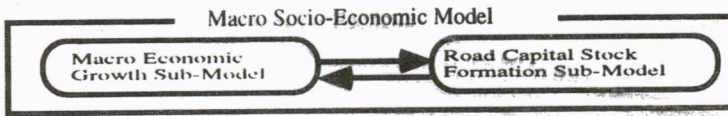
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 ───────── Macro Socio-Economic Model ─────────
┌─────────────────────────────────────────────┐
│ ┌──────────────────┐       ┌──────────────────┐ │
│ │ Macro Economic   │ ───▶  │ Road Capital Stock│ │
│ │ Growth Sub-Model │ ◀───  │ Formation Sub-Model│ │
│ └──────────────────┘       └──────────────────┘ │
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Figure 5: Framework of Macro Socio-Economic Model

3.2 Macro Economic Growth Sub-model

Economic growth depends not only on labor force level, but also on the formation level of capital stock and production technology level. Besides private sector stock, such as factories and machines, social capital stock in the form of roads, harbors, railways, etc. is essential. Social capital stock is an important productive factor and therefore it contributes to economic growth (Aschauer (1989) , Nemoto, (1990) , Iwamoto (1988)).

To explain the interrelation between productive factors, we use a Cobb-Douglas macro production function based on three factors of production, i.e. labor force stock, private capital stock and road capital stock, to estimate GDP. This function can be written as follows:

$$GDP_t = A_t \cdot L_t^{\beta_1} \cdot K_t^{\beta_2} \cdot G_t^{\beta_3} \tag{1}$$

where,

GDP_t : gross domestic product at year t,

L : labor force (total number of employees * index of labor hours),

K : private capital stock,

G : road capital stock,

A : coefficient for technology level, and

$\beta_1, \beta_2, \beta_3$: model parameters.

In Equation (1), when considering the national economy level, private capital stock (K) can be estimated as a yearly accumulation of a part of the after tax national income. On the other hand, road capital stock (G) can be estimated as an accumulation of every year's road investment excluding an assumed yearly depreciation rate. As for the coefficient for the technology level here, it can be estimated as a function of time. The parameters $\beta_1, \beta_2, \beta_3$ are

elasticities of production growth. For example, $\beta_3 = 0.4$ is a value which means that a 1% increase in road capital stock level would bring a 0.4% increase in GDP (assuming no relation between road stock and other productive factors).

Model parameters were estimated using statistical data on the history (1955-90) of the three productive factors included in the model. The estimated parameters are as follows: $\beta_1 = 0.544$ (t = 4.60), $\beta_2 = 0.153$ (t = 2.06), $\beta_3 = 0.450$ (t = 9.33) and $R^2 = 0.999$. Here, the values of $\beta_1 + \beta_2 + \beta_3 = 1.147 > 1$ which indicates the existence of economy of scale through out the economic growth in Japan (including road stock).

Using this function, it is possible to explain the sensitivities of GDP to productive factors in Japan during the period 1955–90. For example, a low level of road capital stock results in a bottleneck in economic growth even though growth of private capital stock might be high. It is also true that a high level of road investment does not effectively contribute to economic growth when formation of private capital stock is not satisfactory.

3.3 Road Capital Stock Formation Sub-model

The purpose of this sub-model is to explain the mechanism of the road stock formation. To do so, it is essential to model each of the three main sources for road investment in Japan, namely, special financial funds, general funds, and fiscal investment and loan funds. Figure 6 shows the framework of this sub-model. An explanation of each part is included in the following sections.
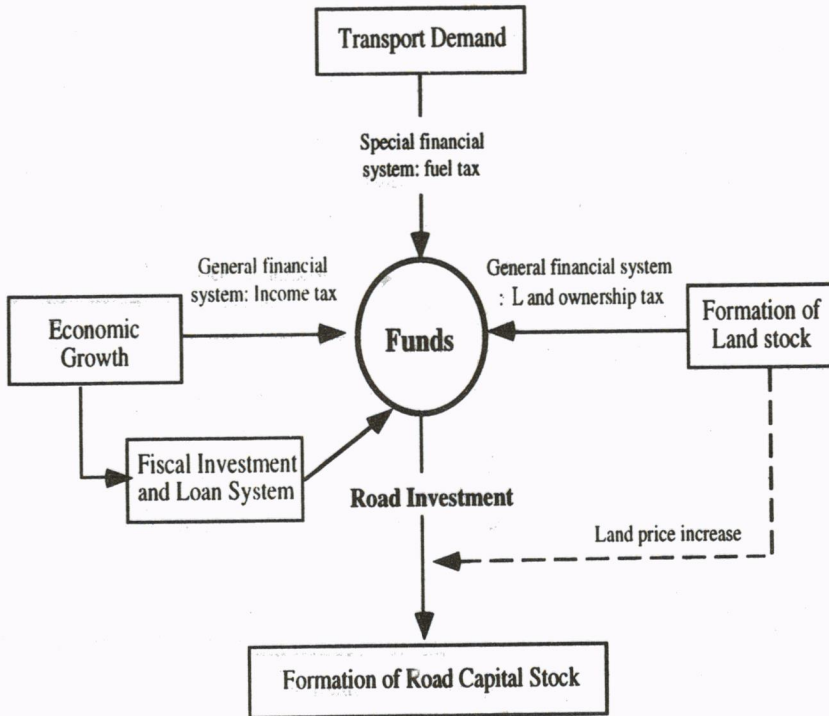

Figure 6 Framework of The Road Capital stock Formation Sub-model

a) Funds Raised Through the Special Financial System (special fund)

This is a system in which a special tax is collected in proportion to fuel consumption such as gasoline tax and oil-gas tax. This proportional relation is clearly shown in Figure 7 in which a strong correlation between special fund revenues and total vehicle kilometers is depicted. Figure 8 shows that total vehicle kilometers also strongly correlates with GDP. Therefore, the amount of collected revenues throughout this system can be said to depend on GDP throughout its influence on automobile use.
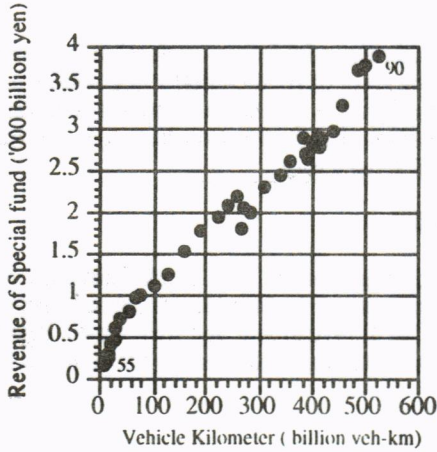
Figure 7: Relationship between Revenue of Special Fund and Vehicle Kilometers (1955-90)
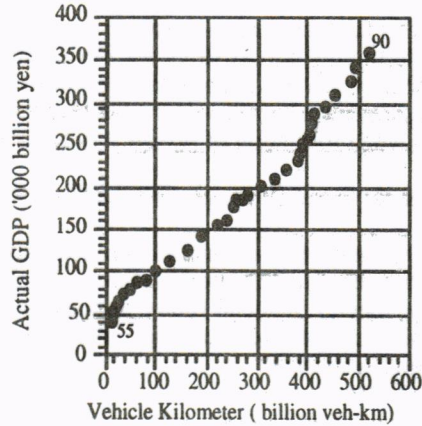Sources: Ministry of Construction (1991), and Transport (1960-93)

Figure 8: Relationship between Economic Growth and Vehicle Kilometers (1955-90)
Sources: Economic Planning Agency (1980,87,88,89, 92,94) , Ministry of Transport (1960-93)

Therefore, the amount of the special fund raised and used for road investment at a certain year can be expressed as a function of total vehicle kilometers for the previous year. On the other hand, total vehicle kilometers can be expressed as a function of GDP. This can be given by the following empirical equations:

$$I_{1t} = \alpha_{1f} \cdot Q_{t-1} \tag{2}$$

$$Q_{t-1} = \exp(a_1 \cdot GDP_{t-1} + b_1) \tag{3}$$

where,

I_{1t} : special fund used for road investment at year t,

Q_t : total vehicle kilometers at year t-1,

α_{1t} : unit value of special fund per vehicle kilometer (exogenous variable), and

a_1, b_1 : model parameters.

Result of parameter estimation for this model is given in Table 1. Also actual and estimated special fund levels are compared in Figure 9. In general, the above equations are satisfactory in explaining the special fund level.

Table 1: Estimated Parameters of
Special Fund Model

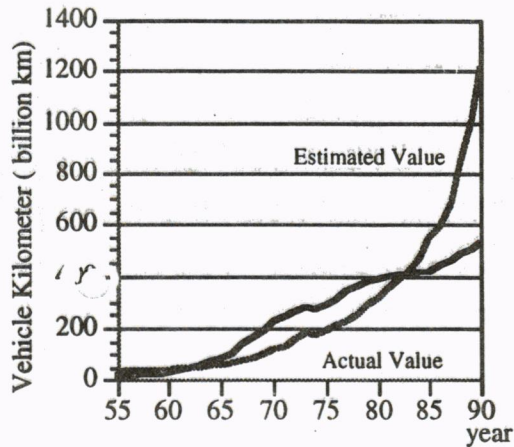| parameters.	estimated value	(t value)	R^2 Value
a_1	16.8980	(96.77)	0.825
b_1	0.0113	(12.72)	

Figure 9: Comparision of Actual and Estimated
Values of Special Fund
Source: Ministry of Transport (1960-93)

b) Funds Raised Through the General Financial System (general fund)

The funds in this system can be classified into two categories based on their sources. The first is funds raised through specific tax, such as income tax, corporate tax, and etc. but excluding fuel tax. The other is raised through land ownership tax. The total amount of the fund is the simple summation of these two sources. The amount of funds raised through specific tax can be directly related to GDP while the other part can be related to land price. This can be empirically expressed by the following equations:

$$I_{2t} = \alpha_{2t} \cdot (S_{1t} + S_{2t}) \tag{4}$$

$$S_{1t} = a_2 \cdot GDP_t^{b_2} \tag{5}$$

$$S_{2t} = \tau_t \cdot V_t \tag{6}$$

where,

I_{2t} : general fund used for road investment at year t,

S_{1t} : total specific tax revenues at year t-1,

S_{2t} : total land ownership tax revenues at year t-1,

τ_t : rate of land ownership tax (exogenous variable),

V_t : total land value,

α_{2t} : ratio of specific and land ownership tax revenues used as general fund (exogenous variable), and

a_2, b_2 : model parameters.

The result of parameter estimation for this model is given in Table 2. Also actual and estimated general fund levels are compared in Figure 10. From the figure, it might be said that the model is enough to catch the trend of general fund usage for road investment.

Table 2: Estimated Parameters of General Fund Model

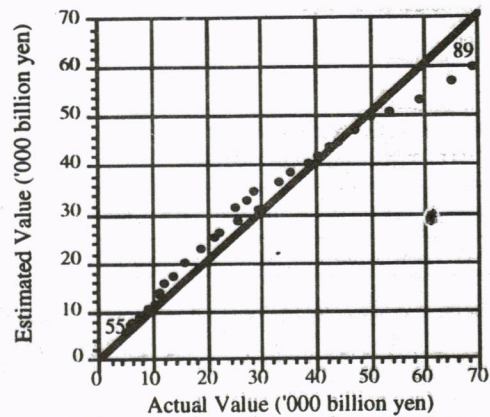| parameters	estimated value	(t value)	R^2 Value
a_2	1.128	(46.41)	0.984
b_2	-2.494	(-20.56)	

Figure 10: Comparision of Actual and Estimated Values of General Fund (1955-90)

Source: National Tax Agency (1955-93)

c) Funds Raised Through Fiscal Investment and Loan System (fiscal loan fund)

At the current stage of model development, the fund from the fiscal investment and loan system (I_3) is treated as exogenous. It is, however, intended to model it in a similar way like the other two fund sources, i.e. relate the fund amount to other economic indicators such as GDP. However, it should be noticed that with the current model framework, it is can still be applied to analyze the case in other developing countries (given appropriate parameters). That is true because the fiscal investment and loan system is peculiar to Japan.

d) Formation of Road Capital Stock

Total investment in road infrastructure at any year can be derived by summing up the funds raised from the above discussed sources. To convert this into added stock, the part of the investment which will be used for land acquisition has to be deducted. This can be expressed as follows:

$$I_{gt} = \frac{I_{1t} + I_{2t} + I_{3t}}{1 + B_t} \qquad (7)$$

where,

I_{gt}: real road investment to be added to the stock at year t, and

B_t: ratio of land acquisition cost to total road construction cost (exogenous).

To compute the total road capital stock at any year, the "Benchmark Year Method" is used. In this method, the new investment value is added to the depreciated value of existing stock. Therefore, road capital stock at any year can be given as follows:

$$G_t = I_{gt} + (1 - \mu_g) \cdot G_{t-1} \qquad (8)$$

where,

μ_g: road stock depreciation rate (assumed to be 0.04).

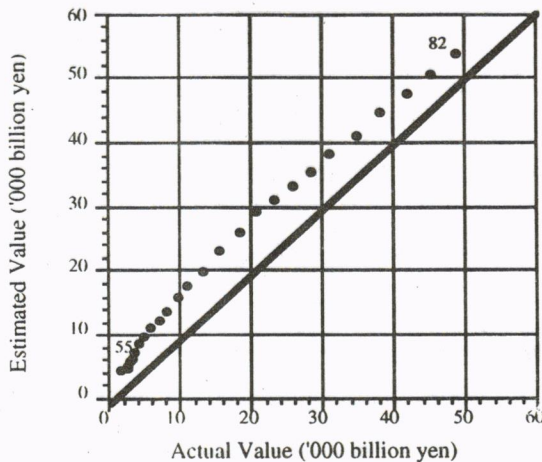Comparison of the actual and estimated formation of road capital stock is shown in Figure 11.

Figure 11: Comparison of Actual and Estimated
Value of Road Capital Stock (1955-82)
Source: Economic Planning Agency (1986)

4. EVALUATION OF JAPANESE ROAD INVESTMENT AND FINANCIAL SYSTEM

In this chapter, we try to evaluate the impact of road investment on the growth of the economy. Also the contribution to economic growth from each of the three sources for road finance is evaluated. This analysis is carried out using the macro economic model developed above.

4.1 Collection of Data and Assumptions for Analysis

In our simulation, data sources and assumptions are as follows;

1) Basic socio economic data were obtained from the Economic Planning Agency, National Tax Agency, Treasury, Bank of Japan, Ministry of Construction, Transport and International Trade and Industry, and other public institutions.
2) Whenever complete time serial data was not available, estimated values were used.
3) All monetary values are standardized using 1980 as a base year.
4) Labor, private stock and technology level are assumed to be independent of road stock formation level.

4.2 Analysis of the Impact of Road Investment

As discussed in Chapter 2, road investment level in postwar Japan was relatively high and stable. Then, how much did this investment level contribute to Japanese economic growth? One indicator which can reflect the level of contribution is the gross rate of return on road capital stock. This is an indicator which gives the increase in GDP brought by a unit increase in road stock capital. The value of this indicator can be computed as follows:

$$r_{gt} = \beta_3 \cdot \frac{\hat{GDP}_t}{G_t} \tag{9}$$

where,

r_{gt} : gross rate of return on road capital stock at year t, and

$\hat{GDP}_t$: estimated value of gross domestic product.

Using this indicator, Figure 12 shows the gross rate of return over the period 1955 — 1990. When considering the entire period, the computed gross rates of return generally reflect a high rate indicating the vital role of road investment for economic growth. The decreasing rate of return with time is an evidence of the lack of road capital stock in the 1950's and a high potential demand at that time, or in other words, a bottleneck.

All things considered, Japanese road investment has contributed to economic growth effectively.
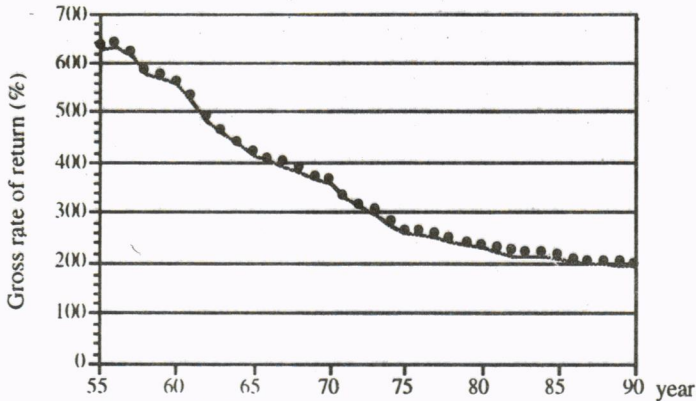

Figure 12: Estimated Gross Rate of Return on
Road Capital Stock (1955-90)

4.3 Analysis of the Financial System

The objective of this analysis is to show how much each of the three fund sources used to finance road investment in Japan contributed to economic growth. To do this, we estimated a GDP using a developed model assuming hypothetical investment scenarios as follows:

Scenario 1: Road investment depends only on general and fiscal funds. Revenues raised
           from fuel tax are all directed to consumption.
Scenario 2: Road investment depends only on general and special funds. The fiscal
           investment and loan system is not implemented.

A third scenario in which the general fund resource is not available is impractical and therefore not considered in the analysis.

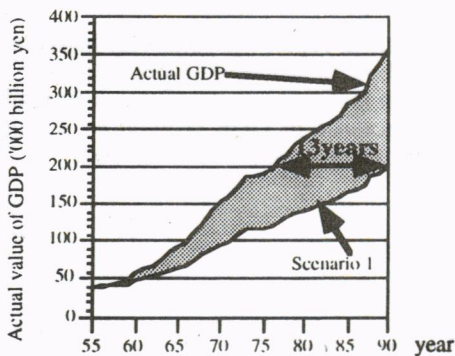The estimation results of the two scenarios are shown in Figures 13 and 14.

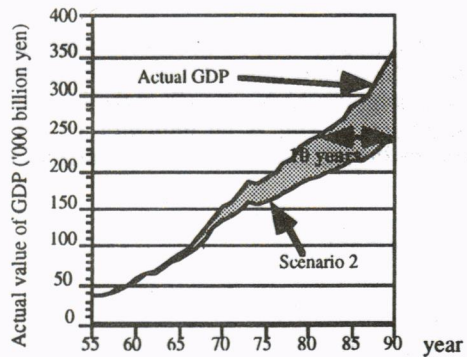Figure 13: The Effect of Special Fund on
the Growth of the Economy

Figure 14: The Effect Fiscal Fund on the
Growth the Economy

From the figures, we may infer the following;
1) Without the special financial system, the Japanese economy would have lagged by 13 years behind the actual level achieved in 1990.
2) Without the fiscal investment and loan system, the economy would have lagged by 10 years behind the actual 1990 level.

From these results, we may conclude that each source of funds used for road investment has played an important role in economic growth in Japan.

5. SUMMARY AND CONCLUSIONS

In this paper, a framework for an analysis method for road capital stock formation and its impact on economic growth is proposed. Within this framework, a macro economic model is developed and used to analyze the Japanese financial system for road investment. Through a simplified case study, it was shown that road investment in Japan had a relatively high rate of return. This was specially true at the early stages of road stock formation which indicates that at that time lack of road infrastructure hindered economic growth. The case study also showed that if the Japanese financial system for road investment had less sources for funds than what was actually made available in the last 40 years, the economy would have lagged by more than 10 years behind the actual level achieved by the year 1990. In general, this case study amplifies the vital role of road stock for economic growth.

Beyond analyzing the Japanese road investment case, the developed methodology can be implemented to study alternative policies for road investment levels and/or financial systems in developing countries.

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