FOREWORD

Koji Fujimoto*

At the dawn of the 21st century, international society is being confronted with poverty problems in developing countries. In order to alleviate poverty, it is essential for developing countries to achieve sustainable, pro-poor economic growth. To realize such economic growth, infrastructure must be developed at the national, regional and community levels in an appropriate manner corresponding to each stage of development.

Based on its own experiences which Japan went through after the Meiji era, Japan has provided comprehensive economic cooperation for infrastructure development in the developing world, especially in Asian countries. The Japan Bank for International Cooperation (JBIC) has provided ODA loans for a wide variety of infrastructure development projects: the development of the international transport infrastructure such as the Bangkok international airport; the construction of the key transport routes such as the Beijing-Kowlong railway passing through poor regions in China; a large-scale regional development, such as the Eastern Seaboard Development Program in Thailand; and the improvement of the living environment at community and municipal levels, including rural water supply projects in the Philippines and human settlement improvement projects in Indonesia. These projects have produced significant achievements.

Responding to the substantial needs of infrastructure development in developing countries, JBIC continues to provide financial and institutional assistance in this field. In so doing, the following three points need to be considered.

First, we have to grasp quantitatively the macroeconomic effect of infrastructure and its effect on poverty reduction. Economic analyses of infrastructure development have been conducted on an individual project basis with a view of the internal rate of return. However, the macroeconomic effect of the infrastructure projects and the extent of their contribution to poverty reduction have not been sufficiently analyzed due to data constraints and the limitations in methodology. While the World Bank and the Asian Development Bank are now addressing this issue, JBIC should also develop such an analytical methodology to provide more effective assistance for infrastructure development.

Second, we need to develop new approaches as well as institutional frameworks for building infrastructure. For example, in order to reduce the fiscal burden of governments, it has become increasingly popular to promote private sector participation in infrastructure development. To make this approach more effective, it is indispensable to develop institutional frameworks including relevant legal systems. In the urban sector of developing countries, where rapid population increase is expected, we have to create an innovative approach in building infrastructure to benefit the urban poor. Japan's experiences in the institutional aspects of infrastructure development will provide valuable lessons for developing countries. Thus, what is expected of us is to analyze these experiences and share them with those concerned with international development.

Third, it is necessary to develop new types of infrastructure, especially related to IT. At the Kyushu-Okinawa Summit, Japan announced to provide a total of 15 billion dollars over the next five years to assist in the development of the IT field. It is an urgent task for us to consider how to address IT related issues.

From the perspective described above, this *Special Issue: Infrastructure for Development in the 21st Century* provides a collection of papers, proposing a conceptual framework for this topic. The papers included are as follows.

With regard to the aforementioned first point, Naoyuki Yoshino (Keio University) analyzes the economic effect of infrastructure on the macroeconomic framework, referring to the post-World War II period of Japan. Yasuyuki Sawada (University of Tokyo) puts forward an analytical framework for the impact of infrastructure on poverty reduction, based on the concept of "transient poverty." As for the second point, Hirotaka Yamauchi (Hitotsubashi University) examines cost sharing and private sector par-

* Executive Director, Research Institute for Development and Finance

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ticipation in infrastructure development, primarily focusing on the transport sector. Tetsuo Kidokoro (University of Tokyo) addresses the implementation of and a methodology for infrastructure development in the poor urban areas. Tsuneaki Yoshida (Takushoku University) examines Japan's experiences in infrastructure development, comparing them with Korean experiences. Regarding the third point, Takeshi Shinohara (Senior Consultant, Nomura Research Institute) discusses IT related issues.

We hope that this *Special Issue* will contribute to future research and discussion on the roles of infrastructure in development.

ECONOMIC EFFECTS OF INFRASTRUCTURE – JAPAN'S EXPERIENCE AFTER WORLD WAR II* –

Naoyuki Yoshino**
Masaki Nakahigashi***

SUMMARY

Japan's public investment tends to particularly increase during a period of economic recession. During the period of extreme economic recession after the first oil crisis in 1974 and recently during the Heisei Recession after 1991, public investment was employed as a measure to expand aggregate demand. In addition to this aggregate demand effect, public investment also has the effect of contributing to the increase in productivity and economic welfare through accumulation of social capital stock. Especially in developing countries where infrastructure is still insufficient, public investment is expected to contribute to future economic growth as a key production factor.

The purpose of this paper is to demonstrate and clarify the relationship between social capital stock and economic growth by estimating the productivity effect of social capital stock in the post World War II period of Japan not only on the macro level but also by industries, sectors and regions. Major conclusions obtained from the results of these analyses are summarized as follows:

(i) the productivity effect of social capital stock of Japan (the effect of social capital stock which increases the potential productivity of the private sector) maintained a high standard during the high economic growth period, but it has been hovering at low levels since structural changes started in 1970.

(ii) Comparison of the productivity effect of social capital stock by industries, sectors and regions shows that the productivity effect of social capital stock is high in the tertiary industries, in the IT and environment-related sectors and in regions containing large urban areas such as Kanto, Kinki and Tokai, but low in Hokkaido and Southern Kyushu.

Lastly, suggestions for developing countries based on the results of these analyses are examined.

1. INTRODUCTION

Japan's public investment was actively implemented after World War II and during the subsequent high growth period. Even compared with other advanced countries, the ratio of public investment to GDP has constantly been at a very high level following the war. Although the ratio started to decline in the 1980s as a result of the tight fiscal policy, it increased again since 1990s (Figure 1). Public investment, as one means of fiscal policy that ranks along side with tax reduction policies, provides the effect of expanding aggregate demand[1]. Since the Heisei Recession that started in 1991, measures to stimulate the economy have been enacted several times, thus increasing the ratio of public investment to GDP. However, from a long-term point of view, public investment is accumulated as SHAKAI SHIHON[2] (social capital stock or infrastructure) and contributes to production activities and increases in economic welfare. The same is not true for fiscal policy measures such as social security and taxation.

Recognizing that Japan lacked social capital stock after World War II compared with other advanced countries, the government promoted the expansion of public investment through the New Long-term Economic Plan of 1957 (started in 1958) and the National Income Doubling Plan of 1960 (started in 1961) (Table 1). Empirically

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* This paper substantially modified and added contents to the editions of Yoshino and Nakajima (1999), Yoshino, Nakata and Nakahigashi (1999) and Yoshino and Nakahigashi (1999). Opinions and views described in this paper are solely those of the authors. The authors are also responsible for any errors that may be found in this paper.

** Ph.D. Professor of Economics, Keio University, Japan

*** Ph.D. candidate, Keio University, Japan

1 Yoshino and Nakajima (1999, Chapter 4 and on) and Yoshino, Kaji and Kameda (1998) can be cited regarding the short/mid-term impact of economic effects of public investment. Furthermore, Nakata (2000) can also be mentioned as one examining the impact that specifically refers to the finance sector.

2 SHAKAI SHIHON is translated into "social capital stock" or "infrastructure" in this paper.

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analyzing whether or not the development of infrastructure by the promotion of these economic plans has supported Japan's high economic growth is useful for examining the significance of infrastructure development with regard to the economic development of developing countries.

This paper analyzes the productivity effect of social capital stock, using data for the period from after World War II until 1990s. First, focusing on the macro effects of social capital stock, time-series changes are estimated. Next, the productivity effect of social capital stock is classified and estimated by (1) industries, (2) sectors and (3) regions. Through these empirical analyses, the productivity effect of social capital stock can be measured quantitatively and numeric comparison is made possible.

This paper is composed in the following manner:

In Section 2, changes in Japan's public investment after World War II is analyzed using time-series data. In Section 3, major past studies related to the economic effect of infrastructure are reviewed. In Section 4, the productivity effect of social capital stock is estimated. In Section 5 and Section 6 the data are classified by industries, sectors and regions, and the productivity effect of social capital stock is estimated. This paper is concluded in Section 7, in which the role of infrastructure in developing countries is discussed.

2. CHANGES IN POST-WAR PUBLIC INVESTMENT

When the effect of public investment is focused on a short-term aggregate demand effect, the government consumption expenditure and its economic effect can be considered as identical. However, in the long-term effects, public investment and government consumption, should be clearly classified. This is because public investment is accumulated as social capital stock and provides a direct influence on production activities, and at the same time it creates a spreading effect by indirectly promoting investment activity and employment in the private sector. Furthermore, parks, urban development, forest preservation and other such projects provide the effect of raising the welfare standard of an entire society. In this chapter, how the public investment after World War II has changed is examined, based on the fluctuations in time-series data and changes in the economic plans of the government.

First, changes in the post-war public investment viewed from data are shown in Figure 1. The changes in the ratio of public gross fixed capital formation to the GDP and in the real GDP growth rate. Typically, the real GDP growth rate and the ratio of public investment to GDP proceeded in the same direction, on average, until the high economic growth period of the early 1970s, while the ratio of public investment to GDP and the real GDP growth rate consistently moved in opposite directions after the first oil crisis. It is assumed that at that time, large-scale public investments were implemented to prevent economic recession due to stagnation. Also, movements of both variables have been similar since 1995. It is assumed that the dependency of Japan's economy on public demand has increased as a result of the expanded scale of public investment[3].

Next, changes in economic plans are examined to highlight the direction of long-term economic policy put forth by the government. Table 1 shows a list of economic plans after World War II (only plans after the establishment of the Economic Planning Agency in 1955). There were changes in the contents of public investment. The economic plans before the 1960s show that resources were distributed so as to maximize the economic growth as represented by concentration of infrastructure investment in the Pacific Belt area. On the other hand, the economic plans since the late 1960s were aimed at improving the regional disparity and deteriorating living environment using public investment.

The following two points are clarified through these analyses. First, very high economic growth was realized by promoting public investment centering on the improvement of economic infrastructure during the high economic growth period. Second, public investments since the 1970s included many public investments aimed at improving living environment, such as housing and environmental preservation, that are not considered to directly contribute to production activities.

It is necessary to empirically clarify these arguments. Thus, how the impact of infrastructure on production is related to public investment policies is clarified in the following chapters through the estimation of the macro productivity effect of social capital stock (Section 4) and the estimation of the productivity effect of social capital stock by industries and sectors (Section 5 and Section 6).

3 The influence of the large-scale economic measures to cope with the Heisei Recession, in particular, cannot be ignored. Refer to Yoshino and Nakajima (1999) and Nakata (2000) for details on economic measures.

3. PRECEDING STUDIES ON THE ECONOMIC EFFECT OF INFRASTRUCTURE

The level of infrastructure provision as a long-term impact of public investment is seen as providing a significant influence on the current state of economic growth. This can be inferred from the fact that many international organizations are actively promoting the improvement of infrastructure by providing various support programs to developing countries. For example, there is a close relationship between infrastructure and economic activities. This is seen in the lack of infrastructure development hindering the economic growth in China and in many case studies, such as those on the economic impact of infrastructure in farming areas in India[4]. This relationship is also shown in cross-section data analyses that indicate positive relations between the levels of infrastructure, such as the development of electricity, telecommunications, roads and other facilities and that of economy. Recent studies, which link infrastructure and economic development, are briefly discussed in the following section. Studies are classified into those that verified the productivity effect of social capital stock, namely the effect that the infrastructure raises potential productivity, and others on the economic effect of infrastructure in the framework of economic growth theory.

Many studies have been conducted on the productivity effect of social capital stock, triggered by the attention given to the infrastructure as a cause of the decline in productivity in USA. Such studies include those by Ratner (1983) and Aschauer (1989). Results on the effects are diverse depending on the estimation methods and scope of the analysis. These studies mostly examined advanced countries where data was well developed, and only a few studies analyzed the data on the developing countries. However, recently data development has been making progress thanks to Summers and Heston (1991) and the World Development Indicator (World Bank), and studies aimed at developing countries are also being conducted. For example, Canning (1999) clarified that infrastructure contributes to production through verification by a panel data and cross-section data of 82 countries (or 57 countries) collected from the 1960-1990 time-series data. Also, Canning and Pedroni (1999) estimated the effect by infrastructure on economic growth by sectors[5], using an approach similar to that of Canning (1999). According to this estimation, telephone and paved roads are generally most promote economic growth, but in some countries these are oversupplied or undersupplied. On the other hand, this indicates that the electric power is generally undersupplied. Also, Shah (1992) estimated a cost function including infrastructure for Mexico and showed that there was a productivity effect of infrastructure.

There are also studies that empirically analyzed the relationship between infrastructure and economic development based on growth theories. Among the studies showing the contribution to economic development is Easterly and Rebelo (1993). This study, using cross-section data, verified whether or not changes in the level of various policy variables permanently increased the economic growth rate, and clarified whether or not investments related to information and telecommunications raise the economic growth rate. Conversely, there are also studies showing that infrastructure does not contribute to economic development such as the study put forth by Kocherlakota and Yi (1996). This study analysed the endogenous growth theory using time series data for the USA, together with various policy variables including the infrastructure to show that there is no policy variable that permanently raises the economic growth rate. They also reached a conclusion, which was skeptical of the endogenous economic growth theory itself. Also, Devarajan, Swaroop and Zoul (1996) came to analytical conclusions about developing countries based on the endogenous growth theory; in order to verify which type of government expenditures promote economic growth. The major conclusion of this study was that infrastructure in developing countries has a negative effect on the economic growth rate. This indicates that in developing countries infrastructure is oversupplied compared to the economic scale.

The relationship between infrastructure development and poverty reduction has become a new focus of recent studies. The World Bank (1994) touched on relationships between infrastructure development and poverty reduction, where they pointed out that when the cost of using infrastructure is set below the marginal cost needed to adequately treat the low income group, it would benefit the high income group contrary to its intended purpose. Dollar and Kraay (2000) studied the influence on economic

4 These examples are shown in World Bank (1994).

5 According to Canning and Padroni (1999), social capital stock is not viewed on a monetary basis but is quantitative like the pavement rate of roads, electric power supply and the number of telephone circuits. In this case Canning (1998) was used as the data.

policy means by classifying the income hierarchy into the poverty cluster and the wealth cluster.

4. MACRO LEVEL PRODUCTIVITY EFFECT OF SOCIAL CAPITAL STOCK

In this section, the productivity effect of social capital stock in Japan after World War II is estimated and time-series changes are clarified. In analyses introduced henceforth, the fact that the social capital stock raises potential productivity in the private sector is defined as being the productivity effect of social capital stock. A method of directly estimating the production function, including the social capital stock

$Y = f(Kp, E, Kg)$

is estimated. In this equation, Y is the amount of production (based on value-added) of the private sector. This shows that Y is produced by combining Kp (private capital), E (amount of labor input) and Kg (social capital stock). It is presumed that the private sector is always taking actions toward the maximization of profit and that infrastructure is a given condition for the private sector. It should be noted that here the private sector is intended to be the independent actions of producers as representative private enterprises. Here, the trans-log type is used to generalize the function type.

However, there are many parameter in the trans-log type. So, using the estimating method put forth by Kamata et al. (1994), simultaneous estimates are made with the share function under perfect competition. In addition to the fact that the infrastructure is a given condition for the private sector, presuming that production activities are not distributed to social capital stock, profits produced by production activities are supposed to be distributed to the private capital and private labor input. In other words, the homogeneous of degree one in the private capital and labor input is supposed.

The estimating model is expressed as below:

$$(\ln Y - \ln E) = \alpha_0 + \alpha_1 (\ln Kp - \ln E) + \alpha_3 \ln Kg + \beta_2\left(\ln Kp \ln E - \frac{1}{2}(\ln Kp)^2 - \frac{1}{2}(\ln E)^2\right) + \beta_3 (\ln Kp \ln Kg - \ln E \ln Kg) + \beta_6 \frac{1}{2}(\ln Kg)^2 \quad (1)$$

$$\frac{wE}{pY} = (1 - \alpha_1) + \beta_2 (\ln Kp - \ln E) - \beta_3 \ln Kg \quad (2)$$

By simultaneously estimating equations (1) and (2) by SUR (Seemingly Unrelated Regression), a parameter is estimated, and then estimates are made as to how the productivity in the private sector rises when social capital stock is increased.

Changes in social capital stock after World War II (1951 and on) are clarified using the results of the estimates made by Yoshino and Nakahigashi (1999). The results are summarized in Table 2. The following three points cause the difference in values:

(1) Whether the GDP figures including the government sector (Yoshino and Nakahigashi (1999)) or the GDP in private sector (Yoshino and Nakajima (1999)) was used and an ensuing difference in the estimation model

(2) A difference in the national accounts system, which was used (Ex.: the former was prepared based on 1953 SNA, and the latter on 1968 SNA)

(3) A difference in stock series (Yoshino and Nakahigashi (1999) used the author's estimation, and Yoshino and Nakajima (1999) used the series in Planning Bureau of Economic Planning Agency ed. (1998)

Table 2 shows that the productivity effect of social capital stock started to decline from 1970 according to Yoshino and Nakahigashi (1999) and Chapter 2 of Yoshino and Nakajima (1999). This indicates a possibility that there was a change in production structures or in public investment policy from 1970.

5. THE PRODUCTIVITY EFFECT OF SOCIAL CAPITAL STOCK BY INDUSTRIES

In this section, whether or not the distribution of public investment is effective for production activities is verified by estimating the productivity effect of social capital stock in each industry since 1975.

Estimates are made in the following manner using a production function such as the one in the preceding chapter. Each industry (primary, secondary and tertiary) is each 'i' industry and a production function

$$Y^i = f(Kp^i, E^i, Kg^i) \quad (3)$$

is assumed. In other words, each industry estimate is made by using the private capital, the labor input and social capital stock data by regions. However, for the social capital stock data, an estimate is made for each of the five categories (agriculture, forestry and fisheries, national land preservation, and others) of public investment and for the degree of contribution of social capital stock in each public investment category to each industry. Social capital stock for each industry is estimated by adding these, as weights, to each industry[6].

6 For the estimation method of the weight for each industry, refer to Yoshino and Nakajima (1999).

The regional classification is shown in Table 3. Here, the reason for employing the regional category instead of the prefectural category is to internalize the spill over effect of infrastructure as the infrastructure of a prefecture has also impact on the production activities in neighboring prefectures.

Although the result of the estimate of the production function is not shown here, in form it is the simultaneous estimate of the production function equation (1) and the labor share function equation (2) of the preceding chapter. For each industry, the following estimated formula is estimated by SUR (Seemingly Unrelated Regression).

$$\ln Y = \alpha_0 + \alpha_1 \ln Kp + (1 - \alpha_1) \ln E + \alpha_3 \ln Kg + \ln Kp \left(-\frac{1}{2}\beta_2 \ln Kp + \beta_2 \ln E + \beta_3 \ln Kg\right) + \ln E \left(-\frac{1}{2}\beta_2 \ln E - \beta_3 \ln Kg\right) + \frac{1}{2}\beta_6 - (\ln Kg)^2 \quad (4)$$

$$S_E = \frac{wE}{pY} = \frac{\partial \ln Y}{\partial \ln E} = (1 - \alpha_1) + \beta_2 \ln Kp - \beta_2 \ln E - \beta_3 \ln Kg \quad (5)$$

For the 20-year period from 1975 to 1994, estimates were made by using the panel data, and the estimated parameter was constant for each region. Estimates were made by the fixed effect model, which represents the existence of region specific factors that cannot be explained by the production function alone.

To examine the productivity effect of social capital stock in greater detail, estimates were made by classifying the 'direct effects' and 'indirect effects' according to Yoshino and Nakano (1994). Direct effects refer to increments in production amounts by an increase in the marginal productivity of production factor (private capital and private labor) due to an increase in social capital stock. Indirect effects refer to the effect of increasing the production amount by private enterprises that maximize profits additionally investing production elements, based on the increase in marginal productivity of each production element due to the direct effects.

These are shown in Figure 2, which describes the relationship between the private capital and the production amount. The bottom figure of Figure 2 shows the top figure with the marginal productivity.

Point A is the point where optimal production is performed by a private enterprise under the maximization of profit when the factor price is given and the level of social capital stock is Kg^0. Y_A is the product amount which corresponds to the optimum private capital amount Kp^0. Here, it is presumed that the level of social capital stock is raised from Kg^0 to Kg^1. When the productivity effect of social capital stock works positively, the production function shifts upward on the top figure of Figure 2 and the marginal productivity curve of the bottom figure shifts upward. This is point B. In this case, the difference between production amounts Y_B and Y_A is the direct effect. Also, since the factor price ratio *r/p* (r: capital cost, p: product price) is given and the marginal productivity shift upward as social capital stock increases, the private enterprise can obtain gains by further investing the private capital. In this case, the private enterprise can attain the maximization of profit by shifting the private capital from Kp^0 to Kp^1. Thus, the private enterprise increases the private capital and the production amount is increased (from point B to point C). In this case, the production amount is raised from Y_B to Y_C, and the difference is the indirect effect.

The aforementioned explanation is described mathematically in the following manner. Like the preceding explanation, supposing the production function of equation (1) and that factor prices and infrastructure are given to producers of private sector, the productivity effect of social capital stock can be written as

$$\frac{dY}{dKg} = \frac{\partial f(Kp, E, Kg)}{\partial Kg} + \frac{\partial f(Kp, E, Kg)}{\partial Kp}\frac{\partial Kp}{\partial Kg} + \frac{\partial f(Kp, E, Kg)}{\partial E}\frac{\partial E}{\partial Kg} \quad (6)$$

That is, the effect of infrastructure is classified into three categories; in equation (5), the first term on the right comes under the direct effect, the second term thereof is the indirect effect in regard to the private capital, and the third term represents the indirect effect related to the labor input.

The effect of the productivity effect of social capital stock is expressed in marginal productivity. However, since equation (1) is a logarithmic expression, the directly calculated productivity effect of social capital stock takes the form of an elastic value. Since relations of both can be expressed as

$$\frac{dY}{dKg} = \frac{d \ln Y}{d \ln Kg}\frac{Y}{Kg}$$

it is corrected to the marginal productivity by multiplying elastic value of the productivity effect of social capital stock by the average productivity of social capital stock (*Y/Kg*). In this paper, the average value of the productivity effect of social capital stock between 1975 and 1994 is used.

The result of the estimate of the productivity effect of social capital stock by industries is shown in Table 4. According to this comparison by industries, the result is the largest in the tertiary industry, followed by the secondary industry and then the primary industry. This indicates that it is preferable to distribute social capital stock to the tertiary industry. Further, the productivity effect of social capital

stock on each industry when compared between regions shows a tendency to be larger in the productivity effect of social capital stock, Southern Kanto, Tokai and Kinki and smaller in other regions.

6. THE PRODUCTIVITY EFFECT OF SOCIAL CAPITAL STOCK BY SECTORS

The production function used for estimating the productivity effect of social capital stock by sectors is calculated as

$$Y = f(Kp, E, Kg^1, Kg^2, ..., Kg^7) \quad (7)$$

Here, Kg^1 represents the social capital stock of agriculture, forestry and fisheries, Kg^2 the physical distribution efficiency sector, Kg^3 the welfare and medical care sector, Kg^4 the education and research sector, Kg^5 the environment sector, Kg^6 the urban regeneration sector and Kg^7 the information and telecommunications sector. Additionally, the estimation method of each social capital stock is the same as the estimated method of each category of administrative investment (old administrative investment result) in social capital stock by industries (see Yoshino and Nakajima (1999)). For the information and communications sector, estimates were made by using the asset items of the NTT Securities Report. The data used for estimating the social capital stock of each sector are summarized in Table 5. The formula used to estimate is as follows.

$$\begin{aligned}\ln Y - \ln E = {} & \alpha_0 + \alpha_1 (\ln Kp - \ln E) \\ & + \alpha_2 \ln Kg^1 + \alpha_3 \ln Kg^2 + \alpha_4 \ln Kg^3 \\ & + \alpha_5 \ln Kg^4 + \alpha_6 \ln Kg^5 + \alpha_7 \ln Kg^6 + \alpha_8 \ln Kg^7 \\ & + \beta_2 \left[\ln Kp \ln E - \frac{1}{2} (\ln Kp)2 - \frac{1}{2} (\ln E)2 \right] \\ & + \gamma_1 \ln Kg^1 (\ln Kp - \ln E) + \gamma_2 \ln Kg^2 (\ln Kp - \ln E) \\ & + \gamma_3 \ln Kg^3 (\ln Kp - \ln E) + \gamma_4 \ln Kg^4 (\ln Kp - \ln E) \\ & + \gamma_5 \ln Kg^5 (\ln Kp - \ln E) \\ & + \gamma_6 \ln Kg^6 (\ln Kp - \ln E) + \gamma_7 \ln Kg^7 (\ln Kp - \ln E) \\ & + \delta_1 \frac{1}{2} (\ln Kg^1)^2 + \delta_2 \frac{1}{2} (\ln Kg^2)^2 + \delta_3 \frac{1}{2} (\ln Kg^3)^2 \\ & + \delta_4 \frac{1}{2} (\ln Kg^4)^2 + \delta_5 \frac{1}{2} (\ln Kg^5)^2 + \delta_6 \frac{1}{2} (\ln Kg^6)^2 \\ & + \delta_7 \frac{1}{2} (\ln Kg^7)^2 \end{aligned} \quad (8)$$

$$\begin{aligned}\frac{wE}{pY} = {} & (1 - \alpha_1) + \beta_1 (\ln Kp - \ln E) \\ & + \gamma_1 \ln Kg^1 + \gamma_2 \ln Kg^2 + \gamma_3 \ln Kg^3 + \gamma_4 \ln Kg^4 \\ & + \gamma_5 \ln Kg^5 + \gamma_6 \ln Kg^6 + \gamma_7 \ln Kg^7 \end{aligned} \quad (9)$$

A difference from the productivity effect on industries discussed in the preceding chapter is that the production amount Y, private capital Kp and labor input E use values of the entire industry of the region. In other words, the productivity effect of social capital stock of each sector in this analysis is estimated with regard to the private sector production of the region. In this empirical analysis, is used, the data of 10 regions in Japan (Hokkaido, Tohoku, Kanto, Shin-etsu, Hokuriku, Tokai, Kinki, Chugoku, Shikoku and Kyushu), which is pooled from FY1985 and FY1994. Prefectures included in each region are shown in Table 6. The reason for the classification of 10 regions is that, like the case of estimates of the productivity effect of social capital stock by industries, infrastructure is subject to the spill over effect (an external effect), and it is considered that the productivity effect of social capital stock outside the prefecture cannot be grasped by data for each prefecture. However, the regional classification is not the same as that of the productivity effect of social capital stock by industries, because it had to be made based on restricted primary statistics.

The estimated result is shown in Table 7. Applying the method used for estimating productivity effect of social capital stock by industries to this result, the estimated result of the productivity effect of social capital stock by sectors is shown in Table 8. Additionally, it should be noted that unlike the productivity effect of social capital stock by industries (Table 4), this is an influence of infrastructure by sectors on productivity of the entire region. It indicates that, the effect of infrastructure productivity is on average large in the information and telecommunications and environment sectors. Also, after comparing regions for each sector it was found that the effect was high in the Kanto, Kinki and Tokai regions, including large urban areas, and low in Hokkaido and Kyushu regions, similar to the estimated results by industries.

7. CONCLUSION: JAPAN'S EXPERIENCES AFTER WORLD WAR II AND INTERNATIONAL DEVELOPMENT

This paper has estimated the productivity effect of social capital stock by industry, sector and region, and clarified the relationship between social capital stock and economic development.

Viewing the productivity effect of social capital stock in a time series, the macro effect started to decline from 1970. Next, taking into account the possibility that public investment is not distributed efficiently for production, the

productivity effect of social capital stock was estimated by industries, sectors and regions. As a result, (1) by industries, the productivity effect of social capital stock is large in the tertiary industry, (2) by sectors, the productivity effect of social capital stock is large in information and telecommunications and environment sectors, and (3) by regions, the effect is large in regions with large urban areas such as Southern Kanto, Kinki and Tokai.

Lastly, to see the result of this analysis from the viewpoint of the development of developing countries, relationship between social capital stock and economic growth were examined from statistical data.

First, Japan's public investment ratios to GDP are compared with the level before the war. Figure 3 shows the ratio of public investment to GDP from the Meiji era to 1940, just before World War II[7]. When the ratio of public investment to GDP is viewed on changes in the non-military sector (dotted line in Figure 3), the ratio is small compared to that of the post-war. Next, to see the contribution of social capital stock to production, average productivity of social capital stock is shown in Figure 4. Further, it is known that damages caused by the war were not huge. Also, Figure 5 plots the growth rates of social capital stock and real GDP between 1905 and 1960, where we can see that the growth rate of social capital stock did not change so much between before and after the war. However, real GDP was generally at a high level after the war. Therefore, it can be assumed that the reason for the high productivity effect of social capital stock after the war was a high degree of infrastructure existed then. It seems difficult to apply this to developing countries where the infrastructure is not firmly established. For this reason, in the case of Japan, it seems necessary to make analyses using data before the war to determine the relationships between economic growth and infrastructure.

Next, the relationships between infrastructure and economic growth are compared by the same aforementioned methods for Thailand, which has enjoyed rapid economic growth recently. Figure 6 shows the ratio of public investment to GDP from 1960 to 1996. According to this, we can see that though there were two sudden declines on the way, the ratio generally maintained a high level of 7% or more. This is similar to the level in Japan after the war. Also, the GDP growth rate is added to the figure for reference, but correlations cannot be seen in fluctuation patterns since 1980. The growth rates of social capital stock and GDP are shown in Figure 7. The figure shows no strong correlations between the two. However, Figure 8, plotting the average productivity of social capital stock, shows that social capital stock has been accumulated almost constantly, which is rather similar to the pattern in Japan before the war.

Based on the contents described above, analysis on the productivity effect of social capital stock in Japan before the war, similar to that of this paper, are currently being conducted. In the future, authors plan to combine the results with those of analyses of Asian countries and to clarify relationships between social capital stock and development.

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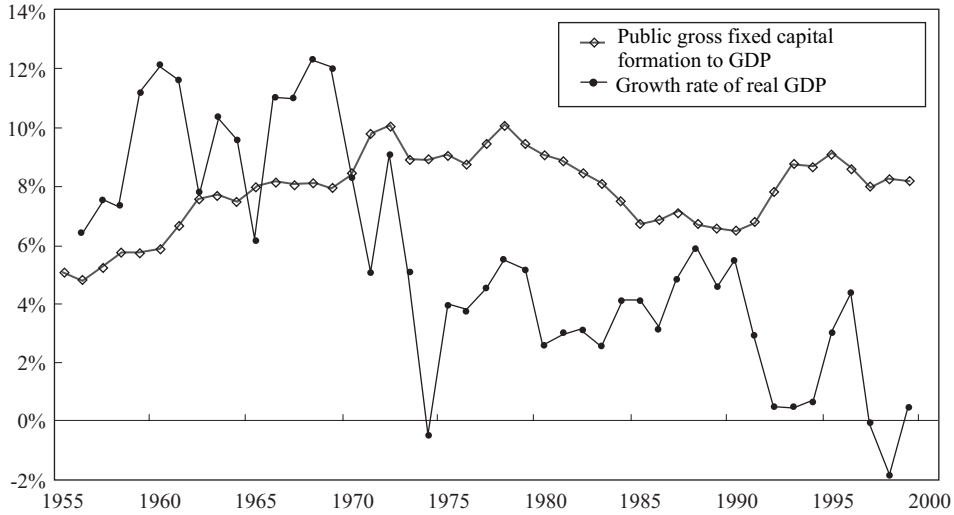
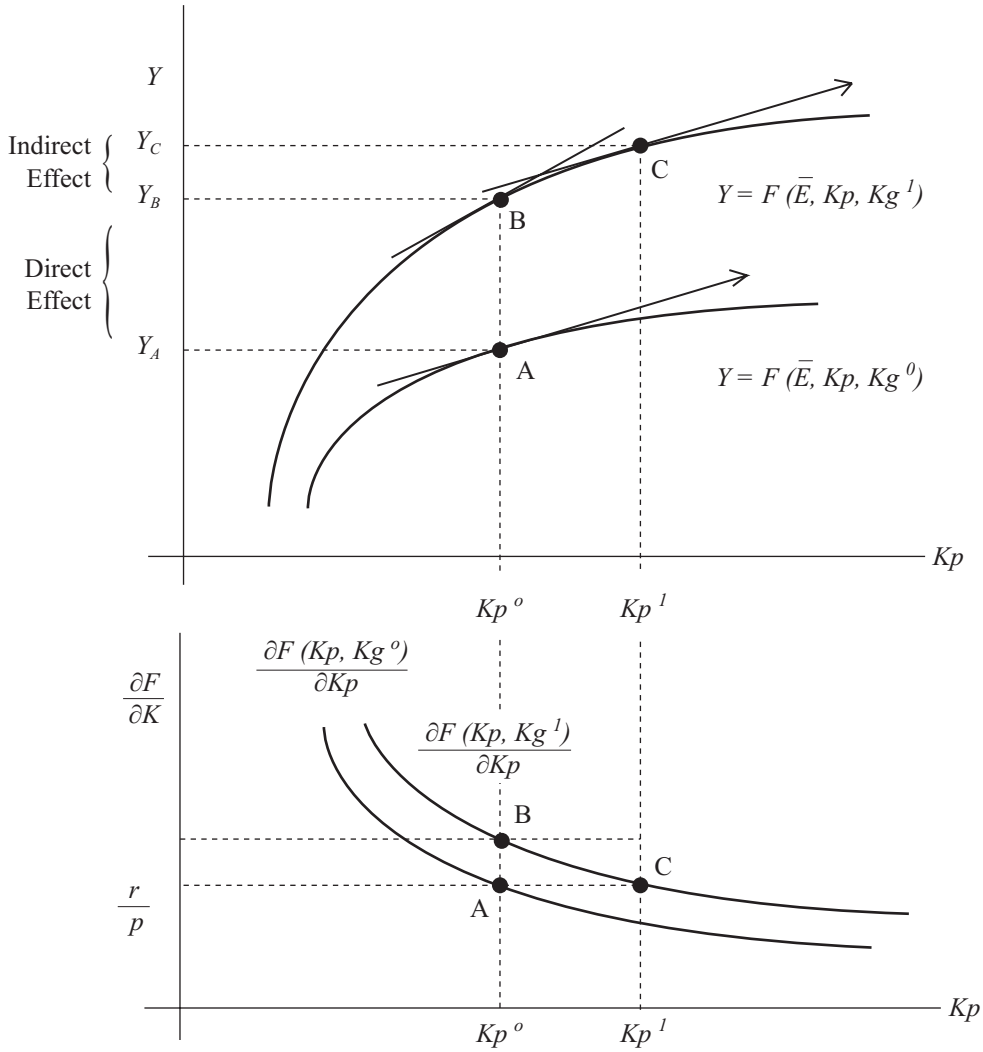
Figure 1 Ratio of Public Investment to GDP and Growth Rate of Real GDP



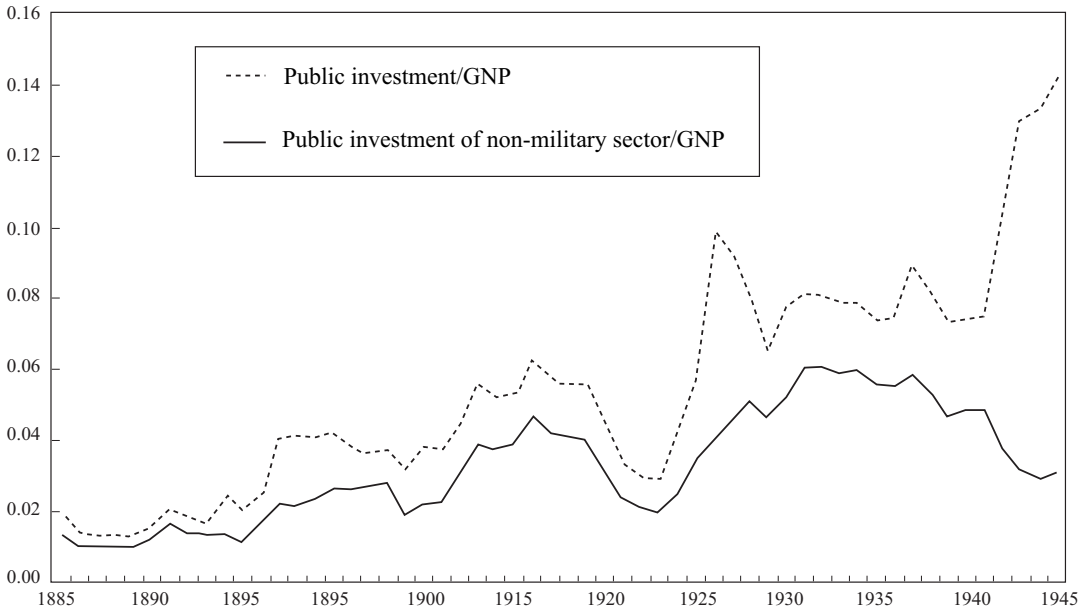
Source: Prepared from Economic Planning Agency "Annual Report on National Accounts". The ratio of public investment to GDP uses the real series.

Figure 2 Explanation of Direct and Indirect Effects



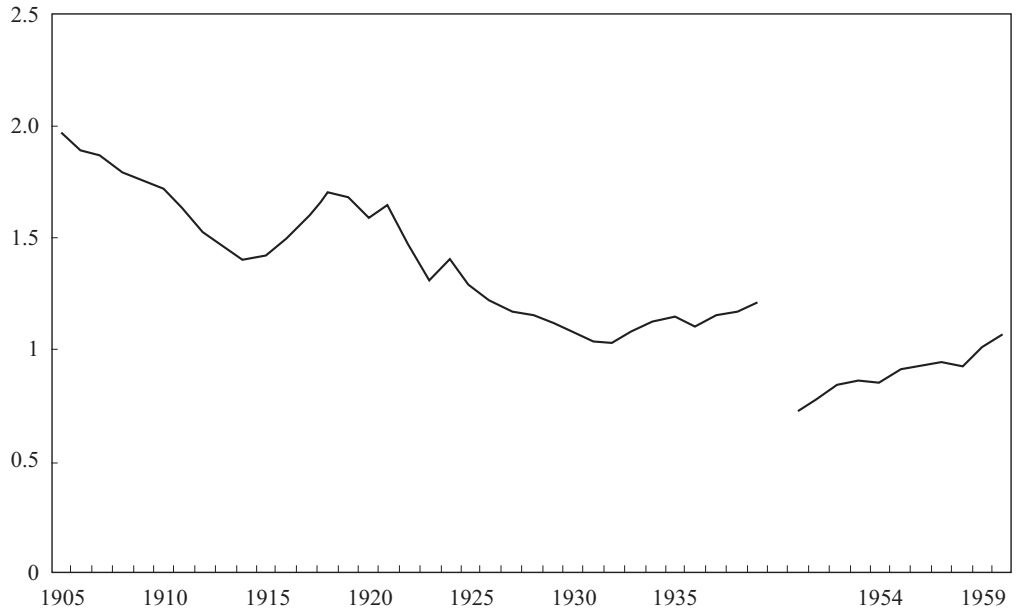
Source: Reproduction from Yoshino and Nakajima (1999)

Figure 3 Ratio of Public Investment to GNP in Pre-War Japan



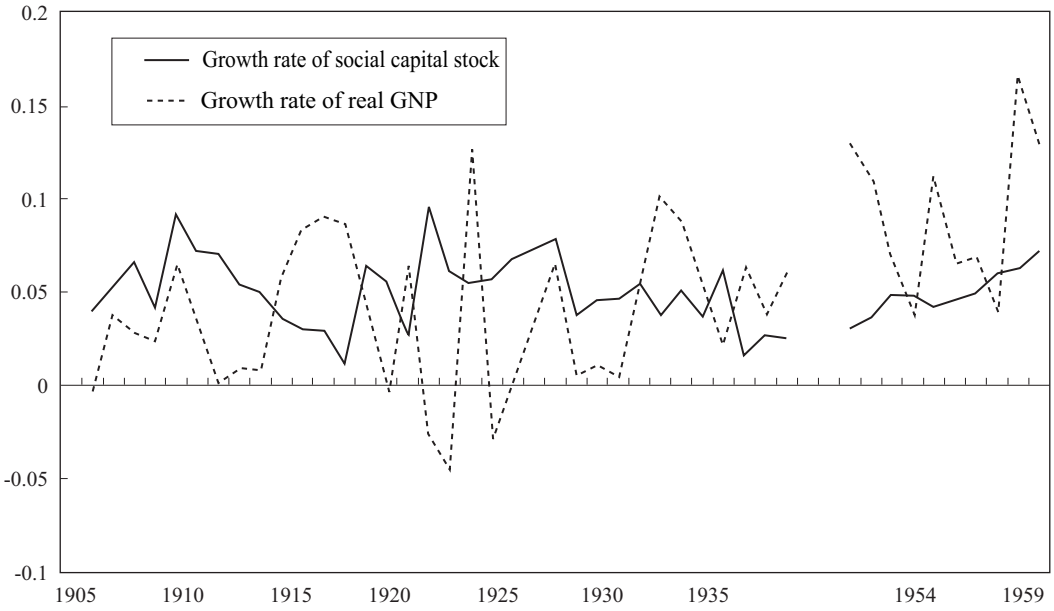
Source: Prepared by the author from Okawa et al. (1971) "National Income" Table 18 and 21

Figure 4 Ratio of GNP to Social Capital Stock in Japan (1905-1960)



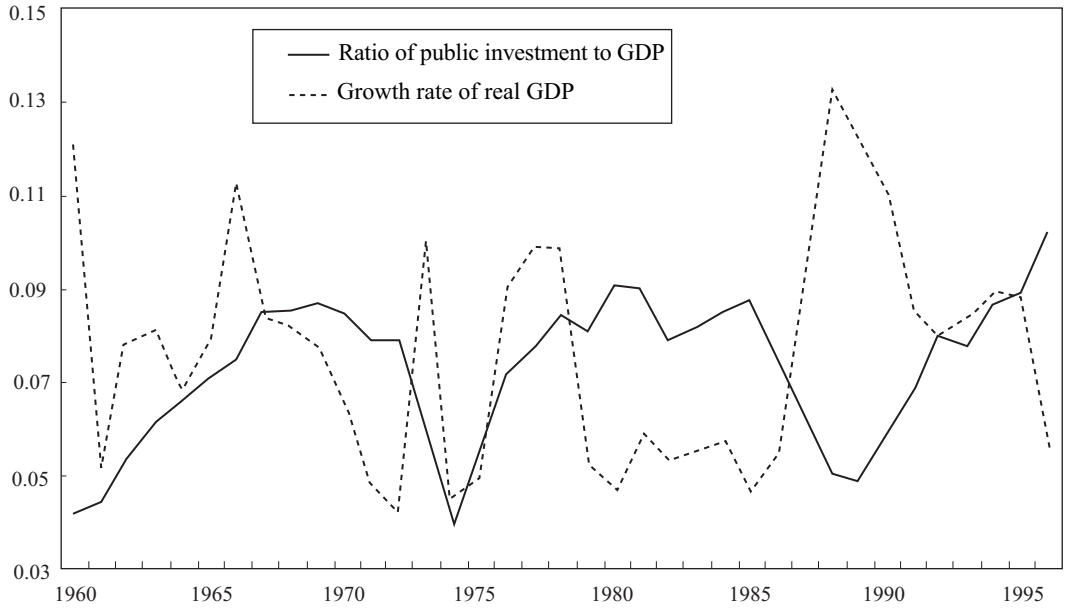
Source: Social capital stock is based on "Long-term Macro Model Basic Statistic Data Work Chart" (Dec. 1964) of Measurement Team, Planning Bureau, Economic Planning Agency inserted in Okawa et al.(1971) Reference Table 3, and uses the slightly adjusted government capital stock; and the GNP used values of Okawa et al. (1971) for the 1905-1939 period and "Showa Fiscal History - From the End of the War to the Peace Treaty" Vol.19 8 (a) Table for the 1950-1960 period. Since both differ regarding the reference price, the reference price was equalized by adjusting the deflator in the duplicated portions.

Figure 5 Growth Rates of Social Capital Stock and Real GNP in Japan



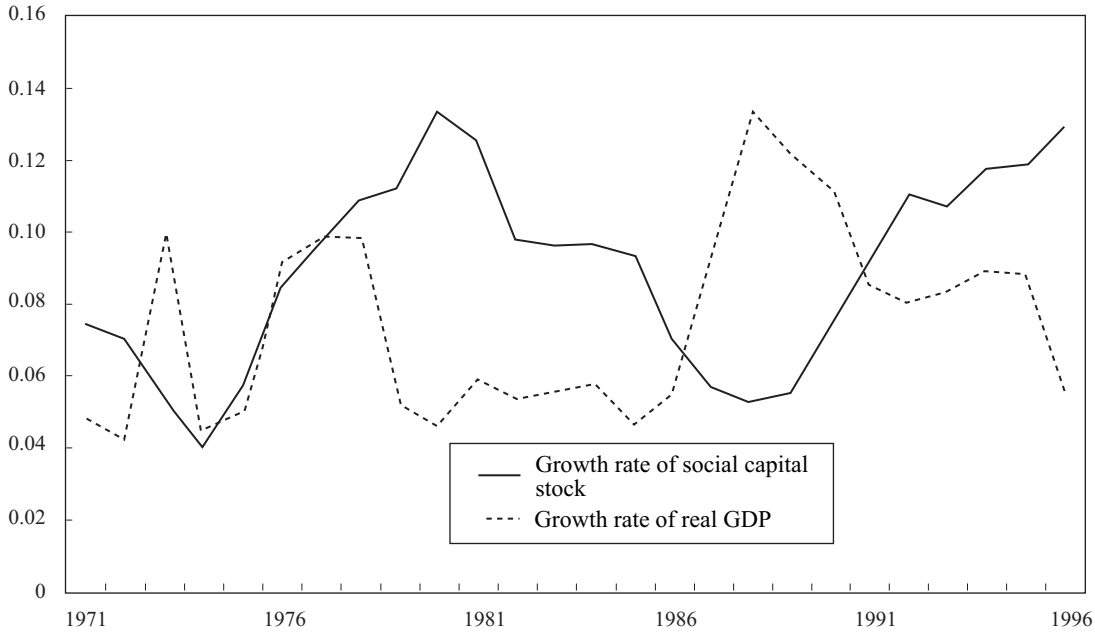
Source: Values used in Figure 4 were processed by the author.

Figure 6 Ratio of Public Investment to GDP and Growth Rate of Real GDP in Thailand



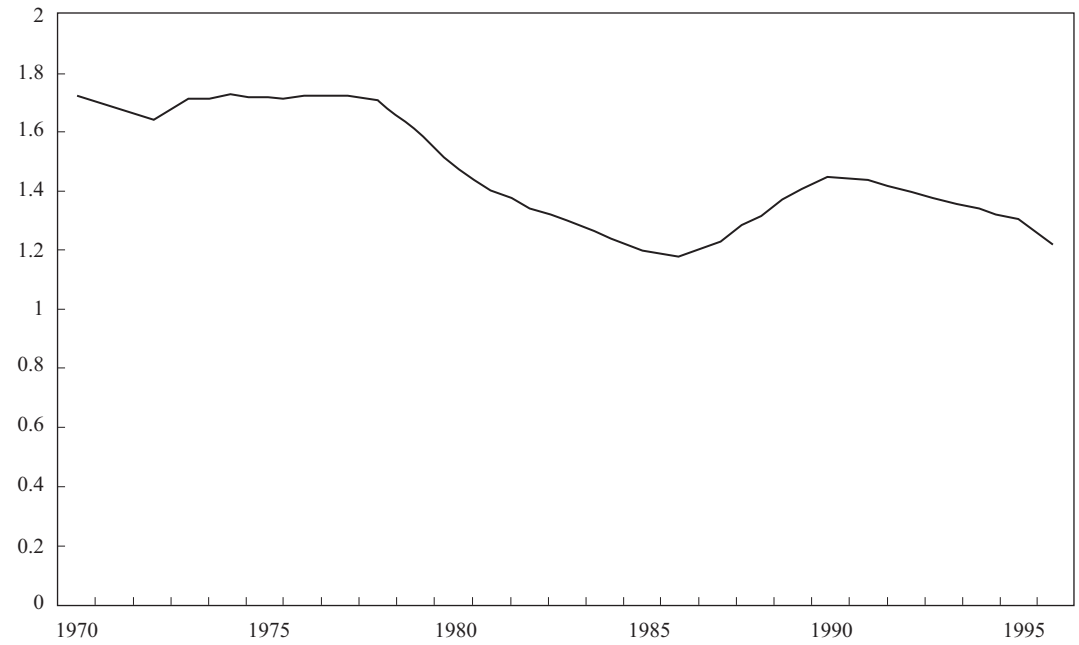
Source: GDP in production series provided by the NESDB (National Economic and Social Development Board) in used. Public capital formation used as public capital, which was not traced back to 1960, is processed by the author.

Figure 7 Growth Rates of Social Capital Stock and Real GDP in Thailand



Source: Real GDP in production series is used, and social capital stock was obtained from the homepage of NESDB (http://www.nesdb.go.th).

Figure 8 Changes in Average Productivity of Social Capital Stock in Thailand



Source: The data used in Figure 7 were processed by the author.

Table 1 Economic Plans after World War II

Title	Formulation	Term	Purpose	Contents related to public investment and infrastructure
Five-Year Economic Independence Plan	Dec. 1955	1956-1960	Economic independence; full employment	Rehabilitation/improvement of traffic and telecommunication facilities; development and promotion of national land preservation; housing for securing the people's lives
New Long-Term Economic Plan	Dec. 1957	1958-1962	Maximum growth; improvement in standard of living; full employment	Reinforcement of transportation capacity centering on modernization of roads; securing of resource development; preservation of national land; reinforcement of agricultural production infrastructure; housing construction
National Income Doubling Plan	Dec. 1960	1961-1970	Same as above	Development of infrastructure for reinforcing industrial infrastructure; improvement in living environmental facilities in cities; reinforcement of national land preservation facilities
Medium-Term Economic Plan	Jan. 1965	1964- 1968 (Abolished in Jan. 1966)	Correction of economic strains and distortions	Development of housing/living environmental facilities; reinforcement of agriculture, forestry and fisheries infrastructures; establishment of traffic and telecommunication systems; establishment of national land preservation systems; development of water resources
Socioeconomic Development Plan	Mar. 1967	1967-1971	Growth toward balanced and enriched socioeconomy	Comprehensive development of housing/living environmental facilities; reinforcement of agriculture, forestry and fisheries infrastructures; establishment of traffic and telecommunication systems; development of national land preservation systems; development of water resources
New Socioeconomic Development Plan	May 1970	1970-1975	Construction of livable Japan through balanced economic growth	Development of preferable living environment (development of housing/ living environmental facilities)
Basic Socioeconomic Plan	Feb. 1973	1973-1977	Simultaneous achievement of fuller national welfare and promotion of international cooperation	Social development (development of housing and living environment, prevention of environmental degradation, etc.)
Economic Plan for 2nd Half of the 1970s	May 1976	1976-1980	Achievement of stable economic growth and enriched living for citizens	Securing of houses; formation of traffic and telecommunication systems
New Seven-Year Socioeconomic Plan	Aug. 1979	1979-1985	Shift to sustainable growth path; qualitative improvement of citizens' lives; contribution to growth of international and economic society	Establishment of living environmental facilities; development of facilities for stabilizing national life (national land preservation, development of water resources, agriculture, forestry and fisheries); development of traffic and telecommunication facilities
Socioeconomic Prospects and Guidelines for the 1980s	Aug. 1983	1983-1990	Formation of peaceful and stable international relations; formation of dynamic economic society; formation of secure and affluent lives for citizens	Development of security system; development of the comfortable living environment
Co-Prosperity with the World	May 1988	1988-1992	Correction of huge external surpluses and contribution to the world; realization of lifestyles of true affluence; balanced growth of local economies and communities	Development of highway transportation networks; infrastructure development for the nation; infrastructure development to lubricate industrial structural adjustment
Five-Year Economic Superpower Plan	Jun. 1992	1992-1996	Enhancement of superpower "quality of life", coexistence with global society; buildup of infrastructure for further growth	Environmental preservation; infrastructure development corresponding to society's needs; infrastructure development for decentralization
Socioeconomic Plan for Structural Reform - Dynamic Economy/ Comfortable Living	Dec. 1995	1995-2000	Creation of free, dynamic economic society; securing of substantial, comfortable houses; creation of economic society to establish infrastructure; participation in global society	Securing of housing; development of infrastructure
Ideal Socioeconomy and Policies for Economic Rebirth	Jul. 1999	1999- (For about 10 years)	Knowledge based society; low-birthrate and aging society; globalization; environmental restrictions	Infrastructure development preparing for again society with the low-birth rate; infrastructure development for evrironmental-friendly and sustainable development

Source: Kohama/Watanabe (1996) Table 5 (p.135); Research Bureau, Economic Planning Agency "Economic Outline"; each plan

Table 2 Changes in the Productivity Effect of Social Capital Stock

Estimation by Yoshino and Nakahigashi (1999)

Estimation period	1951-1955	1956-1960	1961-1965	1966-1970	1971-1975
Direct effect	0.114	0.170	0.236	0.270	0.246
Indirect effect on private capital	0.085	0.123	0.162	0.175	0.156
Indirect effect on labor	0.425	0.611	0.871	1.077	1.115
Total	0.624	0.904	1.268	1.522	1.517

Estimation by Yoshino and Nakajima (1999), Chapter 2

Estimation period	1955-1959	1960-1964	1965-1969	1970-1974	1975-1979	1980-1984	1985-1989	1990-1993
Private capital	0.756	0.730	0.646	0.413	0.312	0.258	0.228	0.200
Social capital	0.648	0.801	0.816	0.080	0.040	0.059	0.253	0.225

Source: Table 4-1: Results of Figures 2 to 5 in Yoshino and Nakahigashi (1999) were processed by the author.
Table 4-2: Reproduction from Yoshino and Nakajima (1999), Tables 2 to 4 (p.32)

Table 3 Regional Classification in Estimation of Productivity Effect of Social Capital Stock by Industry

Area	Prefecture
Hokkaido	Hokkaido
Tohoku	Aomori, Iwate, Akita, Yamagata, Miyagi, Fukushima
Northern Kanto	Tochigi, Gunma, Ibaragi, Nagano, Yamanashi
Southern Kanto	Saitama, Chiba, Tokyo, Kanagawa
Hokuriku	Niigata, Toyama, Ishikawa, Fukui
Tokai	Shizuoka, Gifu, Aichi, Mie
Kinki	Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama
Chugoku	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi
Shikoku	Tokushima, Kagawa, Ehime, Kochi
Northern Kyushu	Fukuoka, Saga, Nagasaki, Ohita
Southern Kyushu	Kumamoto, Miyazaki, Kagoshima

Source: Reproduction from Yoshino and Nakajima (1999), Table 3-3.

Table 4 Estimation of Productivity Effect of Social Capital Stock by Industry and Region

Region or Area	Primary Industries			Secondary Industries			Tertiary Industries		
	Direct effect	Indirect effect	Aggregate effect	Direct effect	Indirect effect	Aggregate effect	Direct effect	Indirect effect	Aggregate effect
Hokkaido	0.004	0.019	0.023	0.108	0.079	0.187	0.211	0.212	0.423
Tohoku	0.007	0.030	0.037	0.091	0.097	0.187	0.251	0.253	0.503
Northern Kanto	0.006	0.033	0.039	0.340	0.249	0.589	0.217	0.219	0.436
Southern Kanto	0.005	0.028	0.033	0.391	0.366	0.757	0.309	0.311	0.620
Hokuriku	0.006	0.016	0.022	0.195	0.143	0.338	0.241	0.243	0.483
Tokai	0.007	0.020	0.027	0.468	0.344	0.812	0.257	0.259	0.515
Kinki	0.007	0.019	0.026	0.416	0.305	0.721	0.249	0.251	0.500
Chugoku	0.006	0.022	0.028	0.231	0.170	0.401	0.260	0.262	0.523
Shikoku	0.007	0.029	0.036	0.164	0.120	0.284	0.269	0.271	0.541
Northern Kyushu	0.006	0.031	0.037	0.207	0.152	0.359	0.282	0.284	0.566
Southern Kyushu	0.004	0.033	0.037	0.137	0.101	0.238	0.259	0.261	0.519
Average	0.006	0.025	0.031	0.250	0.193	0.443	0.255	0.257	0.512

Source: Extracted from Yoshino and Nakajima (1999) Tables 3-12 to 3-14.
Note: The aggregate effect represents the sum of direct effect and indirect effect.

Table 5 Primary Data by Sector Used for the Estimation of Infrastructure

Field	Primary statistic of use
Agriculture, forestry and fisheries	Administrative investment results, sub-classification: "Agriculture, forestry and fisheries," "Forestry conservation and flood control," "Coast preservation"
Distribution efficiency	Administrative investment results, sub-sub-classification: "National and prefectural roads," sub-classification: "Ports and harbors," "Airports"
Welfare and medical care	Administrative investment results, sub-classification: "Welfare facilities"
Education and research	Administrative investment results, sub-classification: "Educational facilities," Statistic Bureau, Management and Coordination Agency "Scientific and Technological Research and Surveys"
Environment	Administrative investment results, sub-classification: "Environmental sanitation"
Urban regeneration	Administrative investment results, sub-classification: "Urban life," "Streets," "Housing," "Waterworks," "Industrial water," sub-sub-classification "Municipal roads"
Information and telecommunications	NTT Securities Report

Source: Yoshino, Nakata and Nakahigashi (1999)

Table 6 Regional Classification in Estimating Productivity Effect of Social Capital Stock by Sector

Area	Prefecture
Hokkaido	Hokkaido
Tohoku	Aomori, Iwate, Akita, Yamagata, Miyagi, Fukushima
Kanto	Tochigi, Gunma, Ibaragi, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi
Shinetsu	Nagano, Niigata
Hokuriku	Toyama, Ishikawa, Fukui
Tokai	Shizuoka, Gifu, Aichi, Mie
Kinki	Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama
Chugoku	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi
Shikoku	Tokushima, Kagawa, Ehime, Kochi
Kyushu	Fukuoka, Saga, Nagasaki, Ohita, Kumamoto, Miyazaki, Kagoshima, Okinawa

Source: Yoshino, Nakata, Nakahigashi (1999)

Table 7 Result of Estimation on Systems of Equations (8) and (9)

Estimation parameters

Parameter	Variable	Estimated value	*t*-value
α_1	$\ln Kp - \ln E$	0.512	1.940*
α_2	$\ln Kg^1$	0.107	1.045
α_3	$\ln Kg^2$	0.153	1.448
α_4	$\ln Kg^3$	–	–
α_5	$\ln Kg^4$	0.073	1.120
α_6	$\ln Kg^5$	0.332	1.568
α_7	$\ln Kg^6$	–	–
α_8	$\ln Kg^7$	–	–
β_1	(※)	–	–
γ_1	$\ln Kg^1 (\ln Kp - \ln E)$	–	–
γ_2	$\ln Kg^2 (\ln Kp - \ln E)$	–	–
γ_3	$\ln Kg^3 (\ln Kp - \ln E)$	-0.110	-3.524***
γ_{3d} (+)		-0.109	-3.334***
γ_4	$\ln Kg^4 (\ln Kp - \ln E)$	0.014	1.301
γ_5	$\ln Kg^5 (\ln Kp - \ln E)$	0.022	0.535
γ_6	$\ln Kg^6 (\ln Kp - \ln E)$	0.065	1.530
γ_7	$\ln Kg^7 (\ln Kp - \ln E)$	-0.020	-2.190**
δ_3	$1/2 (\ln Kg^3)^2$	-0.081	-3.939***

Note:

(1) Symbols in t-value column:
***: Statistically significant at 1% level.
**: Statistically significant at 5% level.
*: Statistically significant at 10% level.

(2) (※) $\ln Kp \ln E - \frac{1}{2} (\ln Kp)^2 - \frac{1}{2} (\ln E)^2$

(3) "-" in each estimated value indicates that it is not included in the estimation formula. Also, the trans-log coefficient parameter of sectoral social capital stock excluding δ_3 is not included in the final estimation formula.

(4) (+) γ_{3d} shows the estimation parameter of the coefficient dummy for the Kanto region.

Coefficient of determination

Production function $R^2 = 0.978$

Labor share function $R^2 = 0.132$

Table 8 Productivity Effect of Social Capital Stock by Sector and Region

Direct Effect

	Agriculture, forestry and fisheries	Distribution efficiency	Welfare and medical care	Education and research	Environment	Urban regeneration	Information and telecommunications
Hokkaido	0.15	0.22	0.97	0.22	4.71	0.07	4.69
Tohoku	0.23	0.32	0.94	0.32	6.30	0.07	5.57
Kanto	1.30	1.85	-2.10	0.82	8.18	0.07	8.26
Shinetsu	0.23	0.33	0.84	0.18	3.98	0.07	6.89
Tokai	0.56	0.80	0.92	0.51	6.97	0.07	9.82
Kinki	0.87	1.25	-0.49	0.55	8.08	0.07	7.23
Chugoku	0.33	0.48	1.33	0.32	5.72	0.07	6.52
Shikoku	0.22	0.32	1.50	0.23	3.87	0.07	5.84
Kyushu	0.32	0.46	0.12	0.40	7.10	0.07	6.14
Average	0.45	0.64	0.73	0.37	6.20	0.07	6.82

Indirect Effect (Capital)

	Agriculture, forestry and fisheries	Distribution efficiency	Welfare and medical care	Education and research	Environment	Urban regeneration	Information and telecommunications
Hokkaido	0.19	0.19	-2.51	0.27	5.06	0.29	2.51
Tohoku	0.55	0.37	-4.08	0.49	8.70	0.43	4.26
Kanto	15.27	1.81	-9.26	1.10	9.74	0.43	5.15
Shinetsu	0.50	0.33	-2.21	0.25	4.90	0.29	4.51
Hokuriku	0.66	0.40	-2.04	0.30	9.57	0.47	5.36
Tokai	3.17	0.87	-6.80	0.76	9.23	0.51	7.09
Kinki	7.33	1.29	-6.35	0.78	10.12	0.39	4.83
Chugoku	1.13	0.52	-4.02	0.48	7.56	0.45	4.69
Shikoku	0.55	0.38	-2.26	0.36	5.46	0.50	4.58
Kyushu	1.04	0.50	-4.79	0.58	9.34	0.45	4.38
Average	3.04	0.67	-4.43	0.54	7.97	0.42	4.74

Indirect Effect (Labor)

	Agriculture, forestry and fisheries	Distribution efficiency	Welfare and medical care	Education and research	Environment	Urban regeneration	Information and telecommunications
Hokkaido	0.18	0.25	4.96	0.17	4.31	-0.19	7.18
Tohoku	0.20	0.28	5.31	0.17	4.21	-0.25	6.71
Kanto	1.33	1.90	5.22	0.53	6.59	-0.30	11.45
Shinetsu	0.23	0.32	3.85	0.11	3.07	-0.15	9.24
Hokuriku	0.23	0.32	8.14	0.11	4.92	-0.30	8.96
Tokai	0.51	0.73	7.97	0.29	4.92	-0.34	12.31
Kinki	0.85	1.21	5.19	0.33	6.11	-0.25	9.55
Chugoku	0.30	0.43	6.21	0.18	4.04	-0.29	8.19
Shikoku	0.19	0.27	4.71	0.12	2.52	-0.30	6.91
Kyushu	0.29	0.42	4.62	0.22	5.04	-0.29	7.75
Average	0.43	0.61	5.62	0.22	4.57	-0.26	8.83

Direct Effect + Indirect Effect

	Agriculture, forestry and fisheries	Distribution efficiency	Welfare and medical care	Education and research	Environment	Urban regeneration	Information and telecommunications
Hokkaido	0.52	0.66	3.42	0.65	14.08	0.16	14.38
Tohoku	0.97	0.98	2.17	0.98	19.20	0.24	16.53
Kanto	17.90	5.56	-6.14	2.45	24.52	0.19	24.86
Shinetsu	0.95	0.98	2.48	0.54	11.95	0.20	20.64
Hokuriku	1.13	1.08	9.42	0.61	21.60	0.24	21.57
Tokai	4.23	2.40	2.08	1.55	21.12	0.24	29.22
Kinki	9.05	3.75	-1.65	1.66	24.31	0.21	21.61
Chugoku	1.76	1.43	3.52	0.98	17.32	0.23	19.40
Shikoku	0.97	0.97	3.95	0.70	11.85	0.26	17.33
Kyushu	1.65	1.37	-0.06	1.20	21.48	0.23	18.27
Average	3.91	1.92	1.92	1.13	18.74	0.22	20.38

Source: Excerpt from Yoshino, Nakata and Nakahigashi (1999)