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PRODUCTIVITY EFFECT OF SOCIAL CAPITAL MEASURED USING THE RBC MODEL: A TRILATERAL COMPARISON OF JAPAN, THE UK AND THE US

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Abstract

We examine the effect of social capital stock on productivity through a comparison of Japan with the UK and the US. These are both countries whose social capital was among the first in the world to be developed and which, having enjoyed high economic growth for a certain period, are now recognized as requiring re-investment in the face of deterioration. We compare the effect of social capital in the three countries in a simulation using a Real Business Cycle (RBC) model with existing social capital, to measure by how many percentage points production and consumption change with a 1% increase in the government spending-to-GDP ratio. In all three countries, a positive effect on income is produced because the productivity effect of social capital is added to the RBC model. The income first increased in the positive direction and gradually became stationary. Consumption initially decreased, became stationary, and eventually increased. Employment increased immediately following the government spending shock and gradually became stationary. The capital stock first decreased and then increased. We also analyze the effect of public-private partnerships (PPP)/private finance initiatives (PFI) as a method actively implemented in the UK to fund public infrastructure projects, to consider how Japan's social capital development should be oriented in the future.

Keywords: Social capital stock, Productivity effects, RBC model, Public-private partnerships, Public administration

INTRODUCTION

In Chapter 3 of the IMF World Economic Outlook published in October 2014 it states that the recent tendency in public investment cutbacks in advanced economies as a result of their deteriorated fiscal balances had lowered the quality of their social capital stock and compromised productivity, suggesting that it is now time to reconstruct public investment policy.
In Japan, among the 17 categories of social capital on which estimates of social capital stock are based, the nominal investment sum for new installation and improvement investments peaked during the fiscal 1993-1998 period, reaching thirty trillion yen per year, and has since been decreasing.

A survey of the current situation in countries around the world in terms of the quality and quantity of social capital stock indicates, as stated in The Global Competitiveness Report by the World Economic Forum, that Japan, the United Kingdom, and the United States rank lower for infrastructure quality assessment than for an assessment of quality and quantity combined (Japan 9th for quality and 6th for quality and quantity combined; the UK 29th and 10th, and the US 16th and 12th). In light of the early development of the basic infrastructure in the UK and the US, it can be said that these countries now require renewal of their infrastructure.

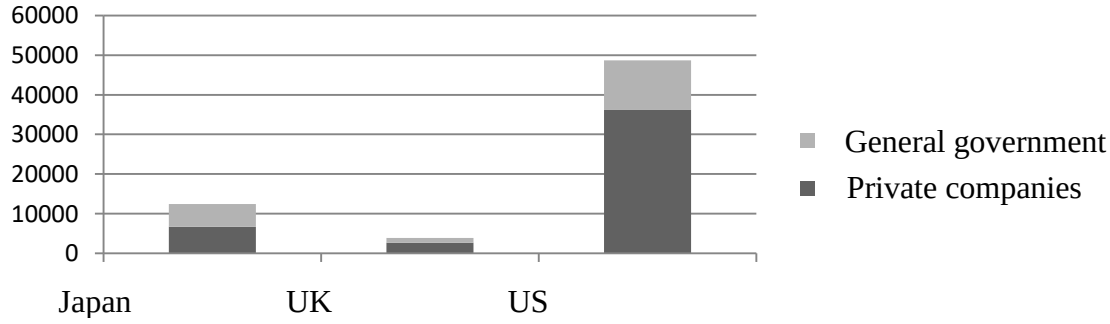
In this paper, we examine the effect of social capital stock on productivity through a comparison of Japan with the UK and the US. These are both countries whose social capital was among the first in the world to be developed and which, having enjoyed high economic growth for a certain period, are now recognized as requiring re-investment in the face of deterioration. We compare the effect of social capital in the three countries in a simulation using a Real Business Cycle (RBC) model with existing social capital, to measure by how many percentage points production and consumption change with a 1% increase in the government spending-to-GDP ratio. We also analyze the effect of public-private partnerships (PPP)/private finance initiatives (PFI) as a method actively implemented in the UK to fund public infrastructure projects, to consider how Japan's social capital development should be oriented in the future.

THE CURRENT SITUATION OF SOCIAL CAPITAL STOCK IN JAPAN, THE UK, AND THE US

To compare Japan, the UK, and the US in terms of social capital, we adopt the general government fixed assets in the national accounts of the respective countries as social capital stock. In 2012, the general government fixed assets (nominal values in the national accounts converted with OECD nominal exchange rates vis-à-vis the US dollar) of Japan, the UK, and the US were, respectively, 5,674.6 billion dollars, accounting for 84.3% of private fixed assets;

1,235.5 billion dollars, 46.7% of private fixed assets; and 12,508 billion dollars, 34.5% of private fixed assets (Fig. 1).

Figure 1. Fixed assets (in billions of dollars, 2012)



Source: Cabinet Office National Accounts, United Kingdom National Accounts, US BEA National Economic Accounts (Blue Book)

TRILATERAL COMPARISON WITH THE RBC MODEL

RBC model with existing social capital

In this paper we examine how consumption and employment respond to a 1% increase in government spending in a simulation using an RBC model with existing social capital, with estimated parameters and realistic numerical values as the structural parameters of the model or as its stationary state.

Our analysis using a dynamic stochastic general equilibrium model with microfoundation starting from an RBC model follows the steps and definition of Kato (2010). The analysis in this sub-section is made with reference to the "model with existing social capital" of Eguchi (2014), and the foundation of the model is composed of 10 equations. Each equation log-linearizes around the stationary state and is formulated as a linear differential equation system. The symbol "~" above each variable denotes a divergence from the stationary equilibrium.

Euler equation for consumption $\tilde{c}_t = E_t\tilde{c}_{t+1} - \frac{1}{\theta}\tilde{r}_t$ (1)

Optimum condition for labor $\varphi\tilde{n}_t = \tilde{w}_t - \theta\tilde{c}_t$ (2)

Condition for interest parity $\tilde{r}_t = \frac{r^k}{R}E_t\tilde{r}^k_{t+1}$ (3)

E_t denotes the conditional default value based on the quantity of information in period t.

Production function $\tilde{y}_t = \tilde{z}_t + \alpha\tilde{k}_{t-1} + (1-\alpha)\tilde{n}_t + \upsilon\tilde{k}_{g,t-1}$ (4)

Capital rental fee $\tilde{r}^k_t = \tilde{z}_t + (\alpha-1)\tilde{k}_{t-1} + (1-\alpha)\tilde{n}_t + \nu\tilde{k}_{g,t-1}$ (5)

Wage ratio $\tilde{w}_t = a_t + \alpha\tilde{k}_{t-1} - \alpha\tilde{n}_t + \nu\tilde{k}_{g,t-1}$ (6)

Private capital transition equation $\tilde{k}_t = (1-\delta)\tilde{k}_{t-1} + \delta\tilde{\imath}_t$ (7)

Social capital transition equation $\tilde{k}_{g,t} = (1-\delta)\tilde{k}_{g,t-1} + \delta\frac{y}{g}g_t$ (8)

Condition for equilibrium in goods market $\tilde{y}_t = \frac{c}{y}\tilde{c}_t + \frac{i}{y}\tilde{\imath}_t + \tilde{g}_t$ (9)

Government spending shock $\tilde{g}_t = \rho_G\tilde{g}_{t-1} + \varepsilon_{gt}$ (10)

The variables above are as follows:

c_t:consumption, y_t: output, n_t: labor volume, k_t: capital, $k_{g,t}$: social capital, g_t: technological standards, r_t: capital rental fee, w_t: wage ratio, i_t: private investment, g_t: public investment, β: discount ratio, θ: inverse of elasticity of consumption substitution, φ: elasticity of labor supply substitution, α: capital distribution ratio, v: production effect of social capital, δ: capital loss ratio

In this model, social capital is fed into the production function, and private companies are able to use social capital without paying fees. The capital rental fee and wage ratio are obtained with the first-order condition for profit maximization.

For simplification, government spending is considered as entirely comprising public investment, which is $g_t = i_{g,t}$. Furthermore, since government bonds and taxes are not differentiated in this model, $g_t = \tau_t$is valid at a given time. Government-related variables are discussed in terms of change (in percentage points) in the to-GDP ratio and defined as $\tilde{g}_t \equiv g_t - g/y$.

Realistic structural parameters and values in the stationary state

Following Edagawa (2015, p. 206), we use estimated values as the capital distribution ratio α and the production effect of social capital υ, and the capital loss ratio δ and the stationary state value g/y of the public investment-to-GDP ratio are set as indicated in Table 1 for model analysis.

Table 1 structural parameters

	Japan	UK	US	Eguchi (2011)
Capital distribution ratio α	0.26	0.18	0.38	0.33
Production effect of social capital υ	0.09	0.67	0.11	0.25
Private company capital loss ratio δ	0.09	0.07	0.06	0.04
Social capital loss ratio	0.03	0.02	0.04	0.04
Public investment-to-GDP ratio stationary state value g/y	0.03	0.02	0.04	0.2

Capital distribution ratio and production effect of social capital

Assauer (1989) is particularly known for his estimation of the production function including social capital stock, using American macro data, thus measuring the productivity of social capital. In Japan, pioneering research has been conducted, notably by Mera (1973) and Asako and Wakasugi (1984) and the effect of social capital stock on production has been measures at national and regional levels and for different industrial sectors.

In the UK and other EU member states, abundant research has been carried out on the theme of social capital stock, and in particular concerning inter-regional infrastructural development and regional economic growth strategies, pointing to the generally recognized effect of social capital stock on productivity.

In this paper, we define the variable y (real GDP) with K (real private company stock), L (number of employees) and G (social capital stock) and, with linear homogeneous restrictions imposed only on productive factors (K and L), formulate it as shown below in (11) to estimate the effect of social capital on productivity.

$$\mathrm{y} = \mathrm{A}K_{t-1}^{\alpha} L^{\beta} G_{t-1}^{\gamma}, \qquad \alpha + \beta = 1 \qquad (11)$$

As social capital stock, general government fixed assets are used, and real figures for private companies and general government fixed assets are obtained using the GDP deflator.

(i) The UK

According to the IMF Working Paper “Another Look at Governments' Balance Sheets: The Role of Nonfinancial Assets” of May 2013, as statistical data on the British government’s fixed assets, OECD-based data (nonfinancial assets, and particularly productive assets [fixed capital and stock, excluding land]) are available from 1990 and are not seamless from the earlier years. Major changes in the British government’s nonfinancial assets occurred in the 1980s and the 1990s, due to the privatization policy and the real estate boom. Historically, the nonfinancial assets decreased from 1948 to 1973, due to the dismantlement of military facilities following the end of World War II. This decrease was partially offset during the same period with the construction of non-military buildings and roads. In the early 1980s, the sale of government-owned housing and businesses began in the move towards privatization (and continued up to the first years of the 21st century). Privatization also reduced government-owned plants, equipment, and transportation systems until the mid-1990s. In 1992, the British government commenced the sale of plots of land occupied by buildings. All this resulted in a continued decrease in general government nonfinancial assets. Since major assets were sold in the 1980s

and the 1990s, there is not much left for sale. The government's fixed assets increased from the early 2000s up to the financial crisis of 2008.

Using the 1991-2012 data for the United Kingdom National Accounts and equation (11), the productivity effect of social capital (v) was measured (Table 2).

Table 2 Productivity effect of social capital stock in the UK

	A	β	γ	R*R	Sey	F correction term	df	ss-reg	ss-resid
Parameter	-11.6523	0.1818	0.6699	0.8692	0.0372	59.8323	18	0.1655	0.0249
t-value	-15.0333	1.8295	10.7371						

NB: Sey: Standard error vis-à-vis projected y, df: degrees of freedom, ss-reg: regression sum of squares, ss-resid: residual sum of squares

(ii) The US

According to the Bureau of Economic Analysis (BEA) of the US, 85.4% of the structures included in the general government fixed assets are owned by state or local governments. Such structures vary considerably, including residential housing; offices; commercial, public health, educational, security, and recreational facilities; ports and other transportation structures; electric power facilities; roads (including expressways), and others (accommodations, religious facilities, sewers and other waste treatment facilities, water supply facilities, industrial plants, etc.). We use data from BEA's Blue Book 1990-2013. While data are available from 1948, we opt for the period 1990-2013 for the correspondence of the conditions for estimates. The same equation (11) as in the estimation for the UK was used to obtain the productivity effect of social capital (v).

Table 3. Effect of social capital stock in the US on productivity

	A	β	γ	R*R	Sey	F correction term	df	ss-reg	ss-resid
Parameter	-8.06479	0.3781	0.1134	0.936	0.0334	146.1708	20	0.326	0.0223
t-value	-3.37234	2.8193	1.0627						

NB: Sey: Standard error vis-à-vis projected y, df: degrees of freedom, ss-reg: regression sum of squares, ss-resid: residual sum of squares

(iii) Japan

We initially calculated the effect of social capital stock on productivity in Japan using equation (11) (Table 4), adopting as social capital stock the general government fixed assets from 1990 to 2012 based on the Cabinet Office National Accounts, 1990 being the first year of the period during which public investment (new installations and improvements) reached its peak.

However, since the parameters for the productivity effect of social capital stock were not statistically significant, we opted for the estimates of Edagawa (2015) which include many observed values of social capital stock.

Table 4. Effect of social capital on productivity

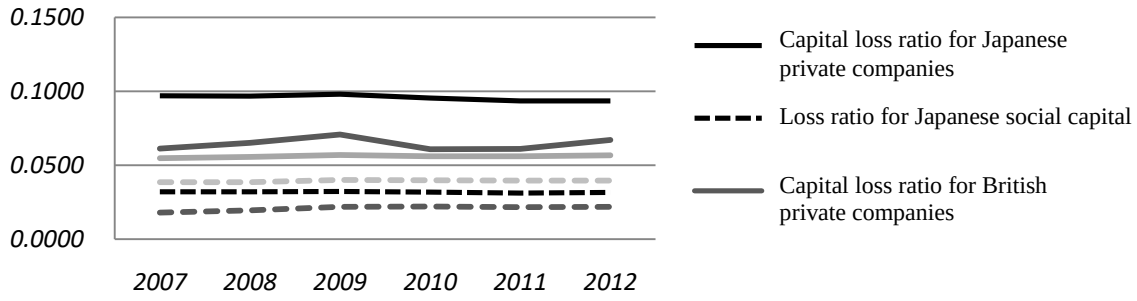
		A	β	γ	R*	sey	F correction term	df	ss-reg	ss-resid
Industrie	Paramete	1.0111	0.2555	0.0503	0.8646	0.0228	57.4710	18	0.0598	0.0094
	t-value	1.3900	1.3241	0.2650						

NB: Sey: Standard error vis-à-vis projected y, df: degrees of freedom, ss-reg: regression sum of squares, ss-resid: residual sum of squares

Capital stock loss ratio

In recent years, the private company capital stock loss ratio has been around 9% for Japan, 6% for the UK, and 5% for the US. The loss ratio for social capital stock has been around 3% for Japan, 2% for the UK, and 3-4% for the US. All three countries show a tendency to a low loss ratio for social capital with a long life period (Fig. 2).

Figure 2. Capital loss ratio



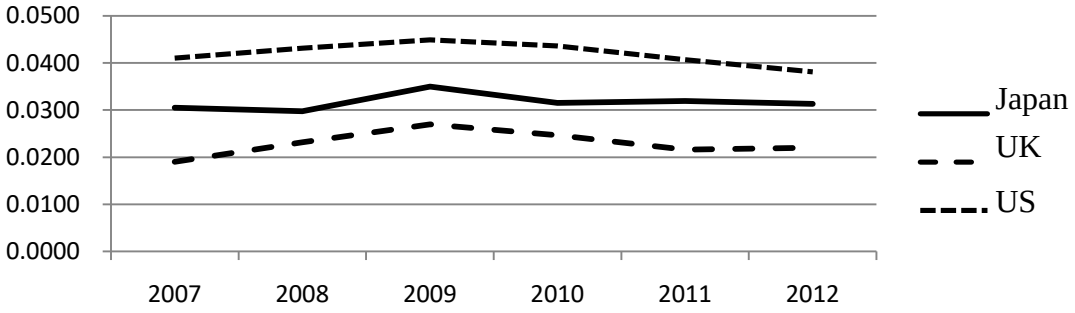
Source: UK: United Kingdom National Accounts, US: BEA National Economic Accounts (Blue Book), Japan: Cabinet Office National Accounts

NB: Each country's fixed asset loss divided by fixed assets

Public investment-to-GDP ratios in the stationary state

In recent years, the public investment-to-GDP ratio (g/y) has been about 3% for Japan, 2% for the UK, and 4-5% for the US with a slightly declining trend (Fig. 3).

Figure 3. g/y



Source: UK: United Kingdom National Accounts, US: BEA National Economic Accounts (Blue Book), Japan: Cabinet Office National Accounts

NB: Each country's total fixed capital formation divided by GDP

SIMULATION RESULTS

Fig. 4 shows how a government spending shock equivalent to 1% of GDP in the positive direction influences several variables in Japan, the UK, and the US. We carried out the simulation with the durability of government spending variables incrementally increased from 0, following Edagawa (2015, p. 208). From the simulation results, this paper presents those obtained with $\rho_G = 0.95$ on the assumption that public investment is continuously made and social capital stock increases.

In the case of Japan, a productivity effect of social capital stock (0.0939) was added to the model, resulting in a positive income effect. The output increased in the positive direction and gradually became stationary. Consumption decreased once and then increased up to 1%, eventually becoming stationary. The labor volume increased immediately after the shock, then decreased, and resumed a stationary state. Capital decreased initially before becoming stationary. The wage ratio fluctuated in the positive direction after the period of the shock (with small interest ratio fluctuations), leading to a labor volume reduction.

In the case of the US, a positive effect on income was produced as a result of a productivity effect (0.1134) of social capital stock added to the model. The output increased about 1.4% in the positive direction before gradually reverting to a stationary state. The capital decreased initially, then increased up to 1.3%, after which it became stationary. The consumption initially decreased about 0.5% and then gradually increased to reach a little over 1% before resuming a stationary state. The wage ratio dropped 0.1% immediately after the

shock, then increased in the positive direction up to over 1.4% (30th-50th terms), and became stationary. The labor volume, on the other hand, increased from 0.1% to over 0.2% immediately after the shock (5th-15th terms), then became stationary (36th term), and slightly decreased thereafter.

The US showed tendencies to change similar to those of Japan, although the US had larger positive changes in output and consumption, and their return to the stationary state was more gradual than in Japan's case. A large increase in capital stock in the positive direction and wider wage ratio fluctuations were also characteristics of the US.

In the case of the UK, a positive income effect also resulted from the addition of a productivity effect of social capital stock (0.6699) to the model. The output decreased 1% after the shock and then increased in the positive direction in and after the 3rd term up to about 7% before gradually becoming stationary. The capital decreased once, then started to increase, and upon reaching 8% became stationary. The consumption increased to reach over 7% (30th-45th terms) and then gradually became stationary. The wage ratio increased in the positive direction up to over 8.5% (30th-40th terms) and became stationary. The labor volume decreased to minus 0.8% immediately after the shock, returned to over minus 0.2% as the range of decrease diminished, but once again dropped to minus 1.1% (40th term) before gradually becoming stationary.

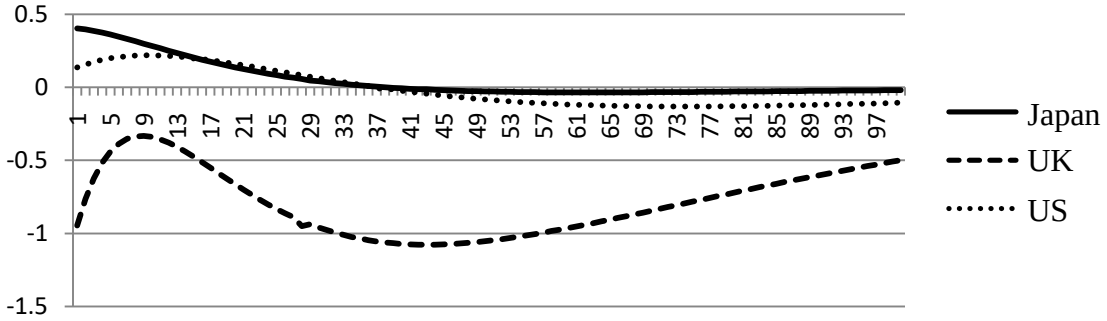
Reflecting the large effect of social capital on productive in the UK, the simulation results showed a markedly large positive increase in output and consumption, as compared to the US and Japan. The UK 's wage ratio remained at a high level, while the labor volume decreased. These results point to a different economic structure.

Figure 5 shows changes in output and consumption in the simulation that we conducted by using an estimated value (v = 0.6699) as the parameter for the productivity effect of social capital stock (v) in the UK and another value modified to match Japan's parameter (v = 0.09) while the other parameters were not modified.

The results indicate that the high productivity effect of social capital stock in the UK is reflected markedly in output and consumption.

In the following section, we will analyze the environment surrounding the UK's social capital stock to contemplate how Japan's social capital development should be oriented in the future.

Comparison of labor volumes

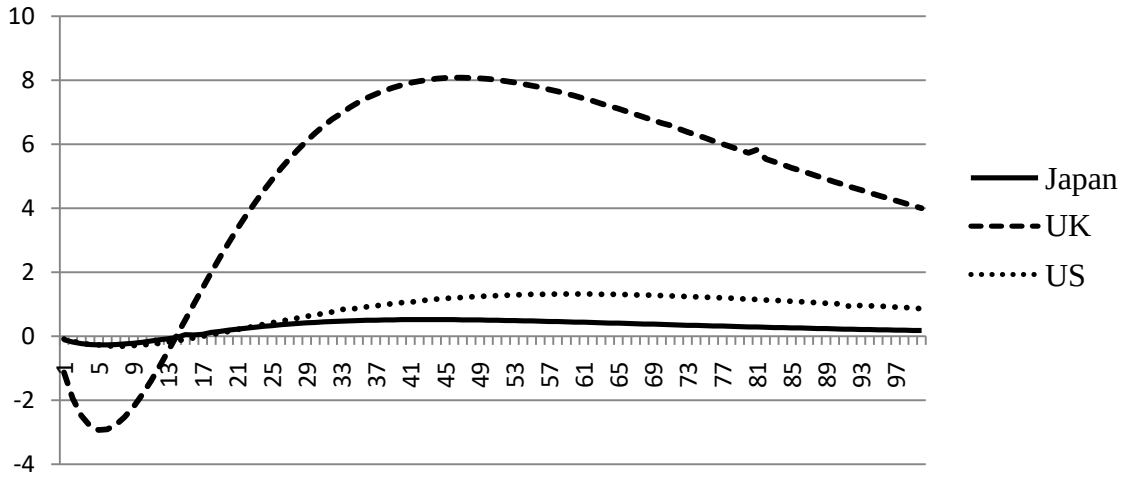


Vertical axis: impact (%) of a positive government spending shock equivalent to 1% of GDP

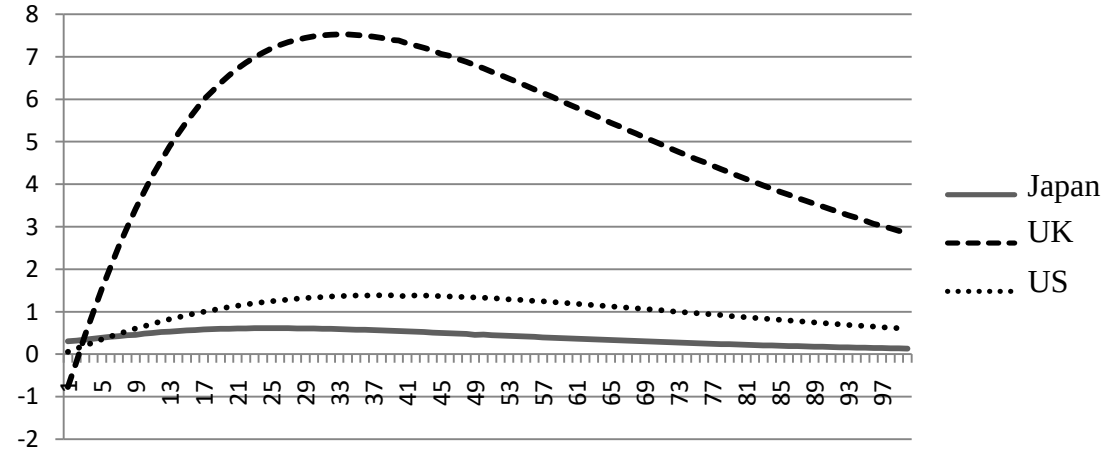
Horizontal axis: Annual (term-by-term) change

* The same denotations apply to the graphs that follow in this section.

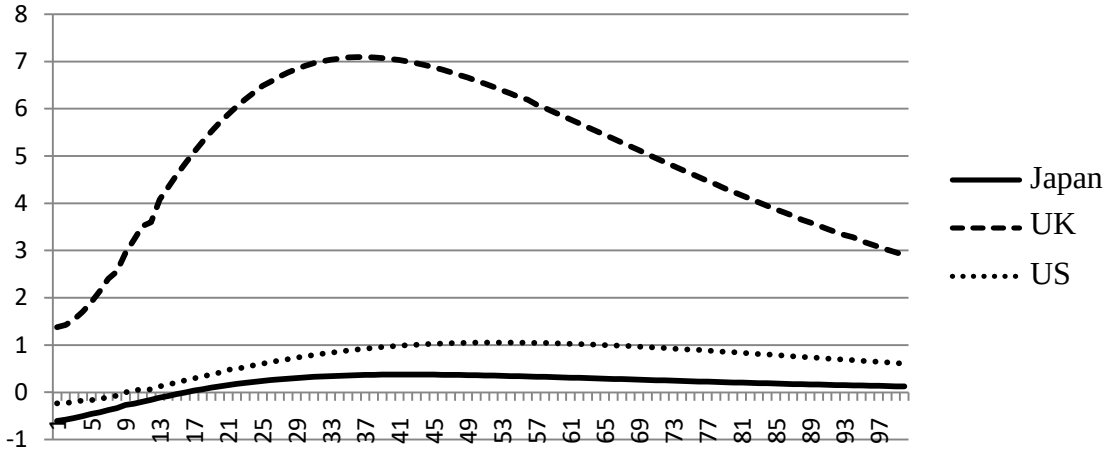
Comparison of capital



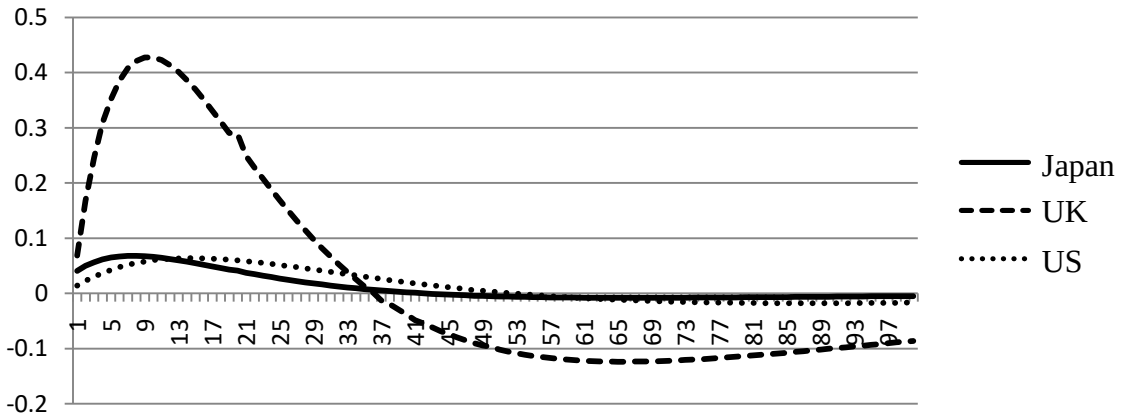
Comparison of output



Comparison of consumption

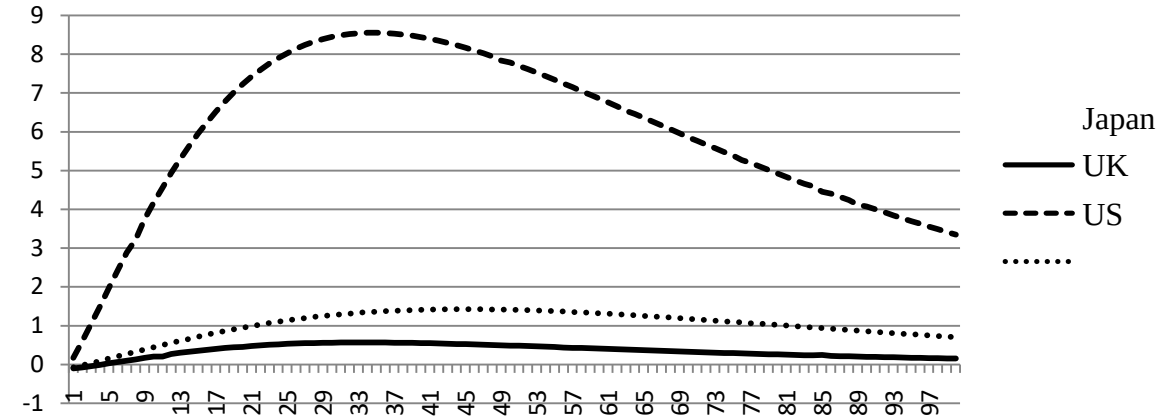


Comparison of capital rental fee

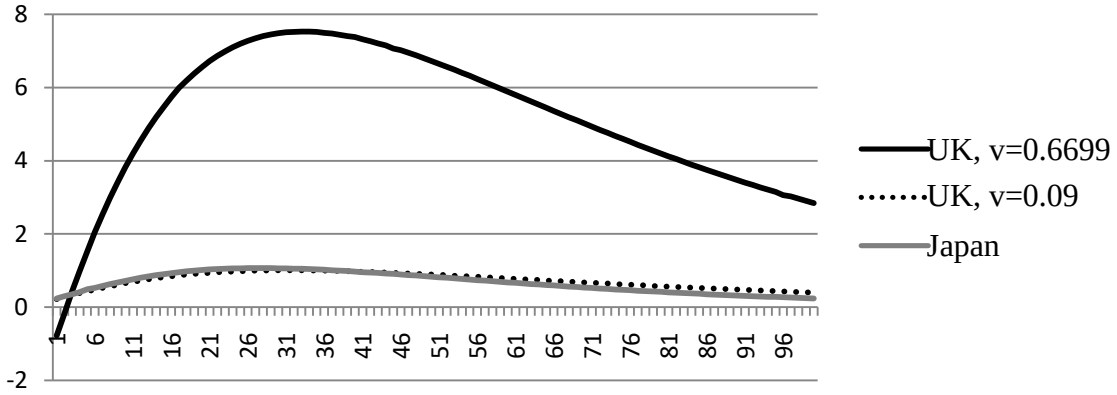


Comparison of wage ratio

Impact of a positive government spending shock of 1% of GDP

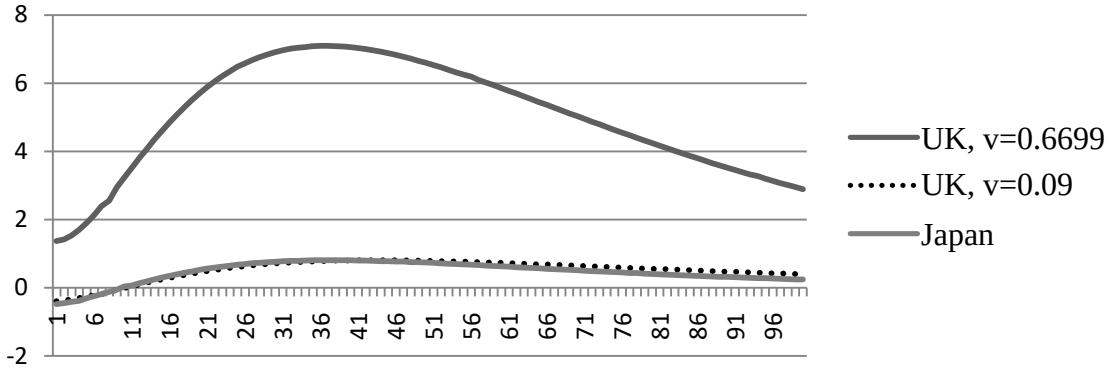


Comparison of output



Comparison of consumption

Impact in the UK of modified productivity effect of social capital stock



Vertical axis: impact (%) of a positive government spending shock equivalent to 1% of GDP

Horizontal axis: Annual (term-by-term) change

v: Productive effect of social capital

CHARACTERISTICS OF SOCIAL CAPITAL DEVELOPMENT IN THE UK

According to the Federal Highway Administration of the US Department of Transportation(2007) and the Japanese Cabinet Office(2009), the Blair administration, which came to power in May 1997, reexamined the Private Finance Initiative (PFI), launched by the British government in 1992, and the privatization projects that had been promoted since that year. Consequently, the Blair administration introduced the concept of Public-Private Partnerships (PPP). Instead of the government showing the way to the private sector, it was presented more or less as a guiding principle based on the philosophy of the optimal distribution of risks between the public and private sectors. Depending on the nature of each project, PPP has taken the form of property

sales, PFI, policy partnerships, and others. Among these various forms, PPP/PFI is frequently adopted as an approach to developing, maintaining, and managing infrastructure, particularly to promote the expansion of national motorway and highway networks including expressways, bridges, and tunnels. In projects operated in the PPP/PFI mode for motorways in the UK, private-sector concessioner teams have been commissioned to design, construct, finance, manage, and maintain motorways and related facilities in partnership with government offices in charge of road development and management. In addition to road networks, PPP/PFI is used for traffic congestion control, subway system maintenance and renovation, and large-scale intermodal tunnels. The situation is the same at the local level. As a result, there are large numbers of private businesses that engage in expressway development, financing, management, and maintenance services in the UK, constituting an important industrial segment. In the UK, PFI/PPP projects worth a total of 54.71 billion pounds have been carried out since 1997 (the total sum of capital costs of the projects on HM Treasury's PFI current projects list, March 2012), approximately 12.6% of the total sum of the general government gross fixed capital formation from 1997 to 2011, or 433.85 billion pounds. In Japan, on the other hand, from 1999, the year in which the Act on the Promotion of the Private Finance Initiative (“PFI Act”) was enacted, to the end of fiscal 2012, the cumulative sum of PFI project costs amounted to 4,200 billion yen, accounting for 1.6% of the general government cumulative gross fixed capital formation for the same period, 268,551.9 billion yen.

Public-private partnerships are a method that promotes or realizes infrastructural development whose timely execution by the public sector alone is otherwise difficult due to budgetary limitations. This method can be applied to the development of not only roads but also other types of social capital such as schools and hospitals. Moreover, it is expected to improve cost effectiveness, thanks to private-sector participation. It is said that efficiency can be generally increased through PPP/PFI because incentives are mutually complementary for the public and private sectors. If the private sector provides assets and services, the public sector can promote reform, ensure better risk management, and maximize “value for money” through holistic lifecycle management.

In the UK, the importance of infrastructure development is well understood against the background of the accumulated superannuated infrastructure, the increasing need for remedial measures for inefficiency, and newly emerging needs in response to intensifying international competition. However, since priority has been accorded to reducing the budget deficit and reviving the economy, privatization and injection of private funds into the public sector have been promoted as policy measures. As for public purchasing, the UK adopted PPP/PFI ahead

of other countries to promote transportation infrastructural development and various other projects.

CONCLUSIONS

Effective infrastructure development, maintenance, and management in collaboration with the private sector, such as through the active application of PPP, enhances the effect of social capital on productivity, as in the case of the UK. This was demonstrated in the simulation by an increase in consumption in the positive direction that was much greater than in the case of the US and Japan, as well as the UK 's high wage ratio.

The example of the UK suggests the direction in which Japan should consider proceeding with its infrastructure development, maintenance, and management, as the ratio of maintenance, repair, and renovation to government spending is expected to increase in the future.

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