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Cost Approach to the Impact of Technological Innovation and Public Infrastructure on Private Economy

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Abstract

This paper is intended to measure the economic effects of both technological innovation and the accumulation of social infrastructure. Unlike traditional approach from the production aspect, this paper makes an attempt to focus upon the analysis in terms of cost structure. At the same time, technological progress is also treated within the different framework, being assumed to be the mixture of innovative factor and economic circumstance surrounding the researchers, from the traditional analyses having captured it as a type of investment characterized as R & D. With these approaches, the transition of productivities of those factors, in terms of cost effect, is observed quantitatively.

Keywords : Social Overhead Capital, Technology, Principal Component Analysis (PCA)

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1. Introduction

A great deal of effort has been made on the productivity of social capital. Aggregated macro-based production function, involving publicly provided infrastructure, has been developed by Aschauer[1] and Munnell[2]. At the regional level, Eberts[3] and Holtz-Eakin[4] have contributed on the analysis with state level data. Those analyses have focused upon production aspect so far. In terms of cost approach, on the other hand, Lynde and Richmond[5] and Nadiri and Mamuneas[6] play significant roles in utilizing duality for this kind of analysis. This paper aims at proposing the means to measure the impact of both social capital and technological progress onto the private economy. Traditional analyses on technological issues have focused upon investment such as R & D. In this trial, technological progress is captured as a kind of infrastructure which generates an externality on the market economy. Moreover, this paper proposes to use several variables (or data in other words) in order for technological variable to reflect diverse perspective. At the same time, this analysis makes an attempt to construct a non-linear type of technology within an empirical framework. In order to achieve the objective, the means for compound variable as a substitute for technological innovation is discussed in section 2, and it is applied to the estimation of the model in section 3. The model is researched from the perspective of the cost structure, and the impact of social capital and technological innovation on cost structure at the national level is also argued in section 4.

2. Approach from PCA method

In this section, let us discuss the purpose, means, and the result of Principal Component Analysis. The use of PCA can play a significant role to create a single (possible for any number, though) variable from diverse observations. It has hardly been used in the framework of economic analysis due to the restriction of the data. However, in terms of technological factor, there exist several candidates as the substitute for technological variable. Arai[7] applies the cumulative patent rights in Japan as the technological factor, for instance. This attempt; however, might be not enough to reflect diverse characteristics of technology itself. Then Arai[8] makes an attempt to apply principal component analysis toward constructing the "composite" variable indicating technological term. Since this trial aims at producing a compounds of several factors, methodology of PCA seems to be relatively effective in achieving the goal.

2.1 Analytical Framework for PCA

PCA is a method to extract respective characteristics from observed data, and at the same time, to change the vector to lower dimension. To describe, if the observation x consists of $(n\times p)$ elements, it can be converted to $(m\times p)$ factors as given by[1)]

$$z_1=l_{11}x_1+l_{12}x_2+\cdots+l_{1p}x_p=\sum_{i=1}^{p}l_{1i}x_i$$

$$z_2=l_{21}x_1+l_{22}x_2+\cdots+l_{2p}x_p=\sum_{i=1}^{p}l_{2i}x_i$$

$$\vdots \qquad\qquad \vdots$$

$$z_m=l_{m1}x_1+l_{m2}x_2+\cdots+l_{mp}x_p=\sum_{i=1}^{p}l_{mi}x_i$$

under the following condition

$$\sum_{i=1}^{p}(l_{ki})^2=1 \qquad (k=1,2,\cdots,m) \tag{1}$$

Then, let us describe the means to acquire respective l_{ki}. According to the assumption in which l_{it} for the first component (z_1) maximizes the variance of Z_1, variance of Z_k:

$$V[z_k]=\sum_{\alpha=1}^{n}(z_{\alpha k}-\overline{z_k})^2/(n-1)=\sum_{\alpha=1}^{n}\left\{\sum_{i=1}^{p}l_{ki}(x_{\alpha i}-\overline{x_i}\right\}^2/(n-1)$$
$$=\sum_{i=1}^{p}\sum_{i'=1}^{p}l_{ki}l_{ki'}\sum_{\alpha=1}^{n}(x_{\alpha i}-\overline{x_i})(x_{\alpha i'}-\overline{x_{i'}}/(n-1)=\sum_{i}\sum_{i'}l_{ki}l_{ki'}V_{ii'}$$

must be maximized under the constraint (1). Thus, this problem can be described as

$$\begin{cases}\max Q=\sum_{i}\sum_{i'}l_{ki}l_{ki'}V_{ii'} \\ s.t.\ \sum_{i=1}^{p}(l_{ki})^2=1\end{cases} \tag{2}$$

To be concrete, as to the first component, being assumed to possess the largest variance, the problem becomes the simple case given by

$$(n-1)V[z_1]=\sum_{\alpha=1}^{n}(z_{\alpha 1}-\overline{z_1})^2=\sum_{\alpha}\{l_1(x_{\alpha 1}-\overline{x_1})+l_2(x_{\alpha 2}-\overline{x_2})\}^2$$
$$=l_1^2S_{11}+l_2^2S_{22}+2l_1l_2S_{12}$$

1) The argument here is based upon the discussion of Arai [8] .

where S_{ij} is an expression for squared. Let the equation above be Q, l_k^* can be found by maximizing the following:

$$\max Q = l_1^2 S_{11} + l_2^2 S_{22} + 2 l_1 l_2 S_{12} + \lambda (l_1^2 + l_2^2 - 1) \quad (3)$$

The second component (PC 2), on the other hand, can also be described as

$$z_{\alpha 2} = m_1 x_{\alpha 1} + m_2 x_{\alpha 2}$$

with the same condition $\sum_{i=1}^{2} m_i^2 = 1$. It can be obtained by setting its covariance $Cov\ [z_1, z_2]$ zero by

$$(n-1) Cov[z_1, z_2] = \sum_{\alpha=1}^{n} (z_{\alpha 1} - \overline{z_1})(z_{\alpha 2} - \overline{z_2})$$
$$= l_1 m_1 S_{11} + l_2 m_2 S_{22} + (l_1 m_2 + l_2 m_1) S_{12} = 0$$

and by proceeding the same procedures discussed above. These components z_1, z_2 are known to be orthogonal, and hence those can be interpreted as

$$z_1 = x_1 \cos\theta + x_2 \sin\theta$$
$$z_2 = -x_1 \sin\theta + x_2 \cos\theta$$

This indicates the fact that both axes of z_1 and z_2 intersect orthogonally, and those two are created by the rotation of original axes of x_1 and x_2 to particular angie of θ.

2.2 Result and Analysis

In this trial, twenty data have been used. Those are described in Table 1. All of the data have been obtained from Report on the Survey of Research and Development (Statistics Bureau) and Annual Report on National Accounts (Economic Planning Agency) except the number of Ph.D. which can be found in Report on Basic School Statistics (Ministry of Education). Results are shown in Table 2 to 7, and Figure 1 to 9. These outputs are categorized into three groups: innovation I_{t-s}, economic environment E_t, and total technological compounds T_t. Moreover, three results; eigenvalue, eigenvector, and loading, are measured for respective group. "PC" stands for respective principal component, "Det" for rates of determination, and "Cum. Det" for accumulation of determination. Eigenvector stands for the coefficient for each variable, and loading indicates the correlation between the variable and component. From Table 2・4・6, both PC 1 (first component) and PC 2 (second) occupy more than 90% of accumulation in eigenvalue. It seems to be reasonable for the analysis to reduce the number of components to two. Thus, measurement for eigenvector has been focused upon PC 1 and PC2 in Table 3, 5, and 7. In Figure 1・4・7, principal component scores are plotted

Table 1.

Variable	Innovation Factor	Variable	Eco. Environmental Factor
X 1	Number of Researchers	Y 1	Capacity Utilization Rates
X 2	Number of Research Assistants	Y 2	Number of Housing Construction
X 3	Number of Research Institute	Y 3	Number of Unemployment
X 4	Amount of Research Investment	Y 4	Index of Shipments for Goods
X 5	Number of Receipts of Technological Exports	Y 5	Number of Companies for Service Department
X 6	Number of Receipts of Technological Imports	Y 6	Number of Orders for Machinery
X 7	Number of Ph. D. of Science Department	Y 7	Number of Bankruptcy
X 8	Number of Ph. D. of Technology Department	Y 8	Index for Stock in Distribution
X 9	Number of Current Patent Rights		
X10	Amount of Semi-Conductor Production		
X11	Number of Institutes for Information Services		
X12	Amount of Computer Production		

Tabie 2. (I)

Component	eigenvalue	Det	Cum. Det
P C 1	10. 16812	84. 73%	84. 73%
P C 2	1. 23347	10. 28%	95. 01%
P C 3	0. 29642	2. 47%	97. 48%
P C 4	0. 13891	1. 16%	98. 64%
P C 5	0. 06691	0. 56%	99. 20%
P C 6	0. 03205	0. 27%	99. 47%
P C 7	0. 02698	0. 22%	99. 69%
P C 8	0. 01831	0. 15%	99. 84%
P C 9	0. 00790	0. 07%	99. 91%
P C10	0. 00651	0. 05%	99. 96%
P C11	0. 00282	0. 02%	99. 99%
P C12	0. 00161	0. 01%	100. 00%

in the form of scattered diagram. Figure 1 and 4 (I, E) implies similar transition in some sense. As a compound, Figure 7 has also shown us the similarity with other two. Figure, 2・3・5・6・8 and 9, on the other hand, have indicated factor loading for two components.

This result might be controversial in interpretation. One might recognize the first component as a total index since it reflects all the data in quite similar weights. This might be true for innovative factor I to a greater degree. As to E and T, the same interpretations might be acceptable in some sense, $Y1$ (capacity utilization rates) presents unique feature though. The second component, on the other hand, seems to reflect

Table 3. (I)

eigenvector	PC1	PC2
X1	0.31110	0.08872
X2	0.23763	0.54566
X3	0.23393	0.56222
X4	0.30756	−0.09770
X5	0.30039	−0.26034
X6	0.30797	0.10151
X7	0.29247	0.16938
X8	0.30529	−0.14122
X9	0.30442	−0.01857
X10	0.24527	−0.40347
X11	0.30234	−0.25092
X12	0.29894	−0.12627

Table 5. (E)

eigenvector	PC1	PC2
Y1	−0.04921	0.85761
Y2	0.35102	0.38157
Y3	0.37016	−0.28843
Y4	0.41411	0.00421
Y5	0.41134	−0.09438
Y6	0.38413	−0.05921
Y7	0.31370	0.12329
Y8	0.38819	0.09408

Table 4. (E)

Component	eigenvalue	Det	Cum. Det
PC1	5.99992	75.00%	75.00%
PC2	1.05299	13.16%	88.16%
PC3	0.46780	5.85%	94.01%
PC4	0.36000	4.50%	98.51%
PC5	0.08762	1.10%	99.60%
PC6	0.02168	0.27%	99.88%
PC7	0.00744	0.09%	99.97%
PC8	0.00254	0.03%	100.00%

the input-output feature of technology in some sense through the whole categories, except circumstance factor E since the relation of data taking opposite position seems not to be clear. In general, it is quite dangerous to overestimate the relations. From the experiments described above, the first component of three categories, I, E, and T, should be selected as the candidate for regression process since the loss of information seems to be lower than the one for the second component.

Table 6. (T)

Component	eigenvalue	Det	Cum. Det
P C 1	15. 80297	79. 01%	79. 01%
P C 2	2. 12665	10. 63%	89. 65%
P C 3	0. 80151	4. 01%	93. 66%
P C 4	0. 51649	2. 53%	96. 19%
P C 5	0. 28106	1. 41%	97. 59%
P C 6	0. 18903	0. 95%	98. 54%
P C 7	0. 10517	0. 53%	99. 06%
P C 8	0. 05439	0. 27%	99. 34%
P C 9	0. 03851	0. 19%	99. 53%
P C10	0. 03093	0. 15%	99. 68%
P C11	0. 02184	0. 11%	99. 79%
P C12	0. 01203	0. 06%	99. 85%
P C13	0. 00840	0. 04%	99. 89%
P C14	0. 00729	0. 04%	99. 93%
P C15	0. 00497	0. 02%	99. 96%
P C16	0. 00289	0. 01%	99. 97%
P C17	0. 00256	0. 01%	99. 98%
P C18	0. 00161	0. 01%	99. 99%
C P19	0. 00111	0. 01%	100. 00%
P C20	0. 00060	0. 00%	100. 00%

Figure 1. Positioning of I (Innovative Factors)

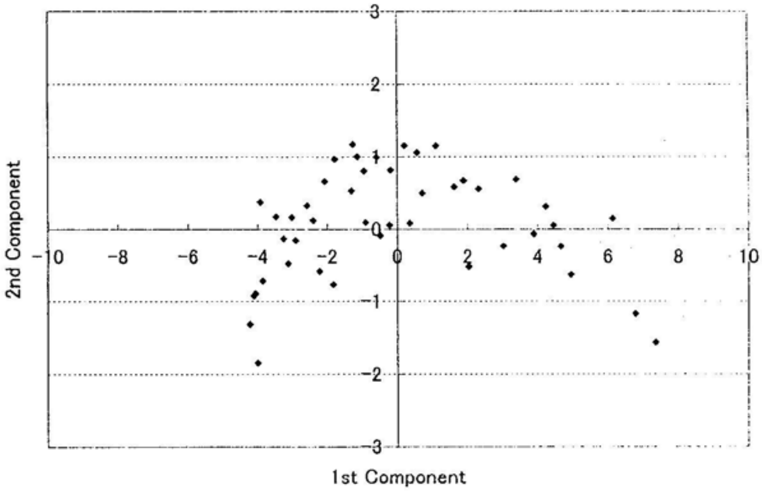


Table 7. (T)

eigenvector	PC1	PC2
X1	0.25230	−0.01738
X2	0.19651	0.32945
X3	0.20030	0.34788
X4	0.24524	−0.16073
X5	0.23101	−0.18780
X6	0.24674	0.06431
X7	0.23513	0.13690
X8	0.23731	−0.09806
X9	0.24650	−0.10122
X10	0.18732	−0.34520
X11	0.23161	−0.19912
X12	0.23321	−0.12785
Y1	0.03087	0.45243
Y2	0.20231	0.33975
Y3	0.22998	−0.18448
Y4	0.25162	0.04535
Y5	0.25087	−0.02200
Y6	0.24511	−0.09089
Y7	0.17773	0.30195
Y8	0.23463	0.18713

Figure 2. (I)
Factor Loading for I (1st Component)

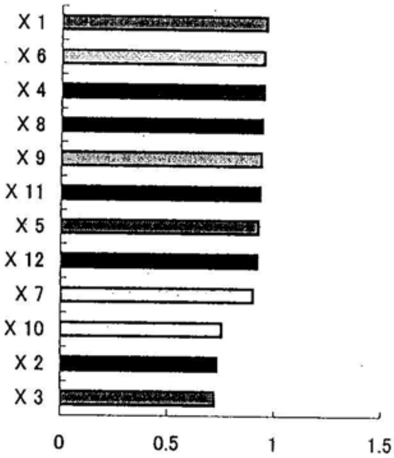


Figure 3. (I)
Factor Loading for I (2nd Component)

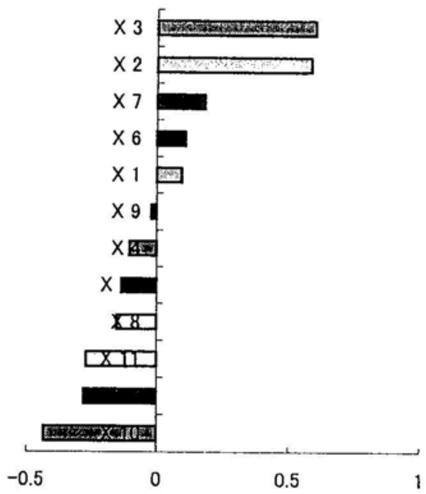


Figure 4. Positioning of Economic Environmental Factors (E)

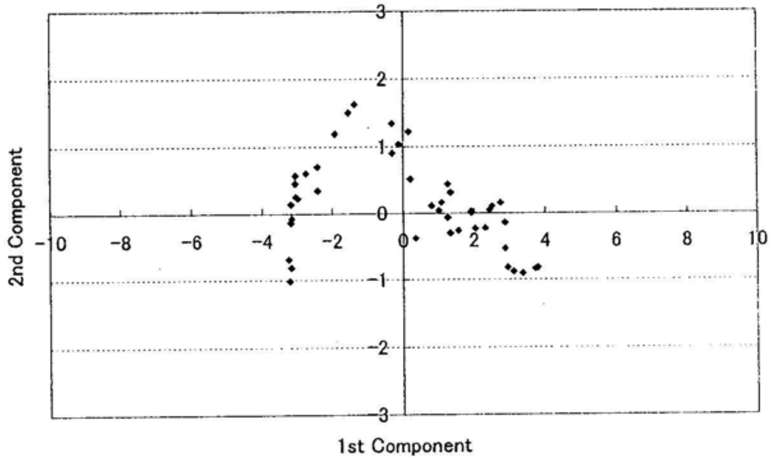


Figure 5. (E)
Factor Loading for E (1st Component)

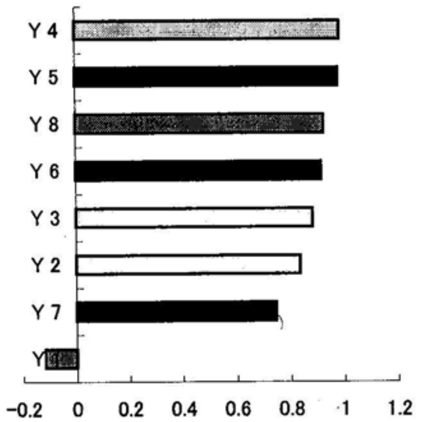


Figure 6. (E)
Factor Loading for E (2nd Component)

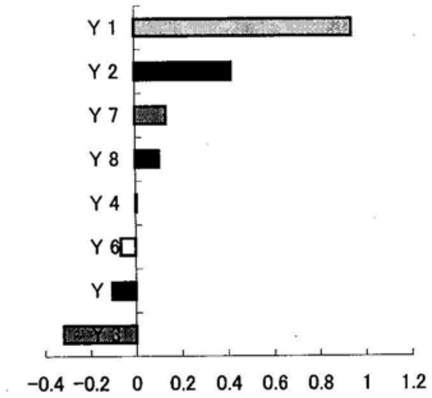


Figure 7. Positioning of Total Composite for Technology (T)

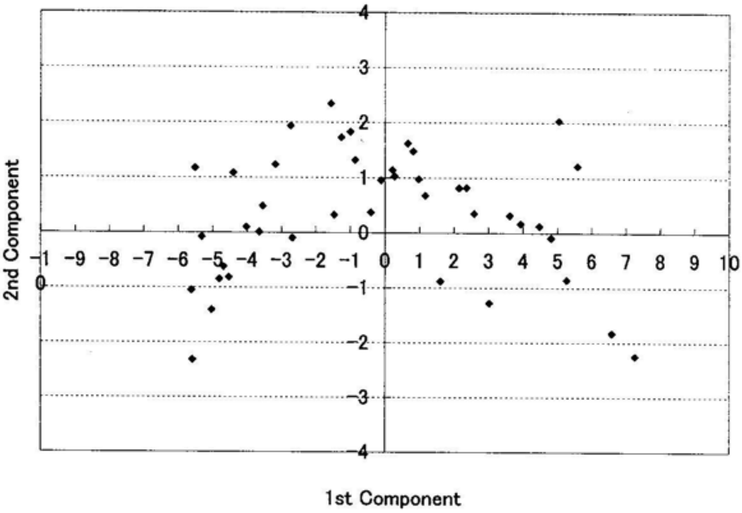


Figure 8. (T)
Factor Loading for T (1st Component)

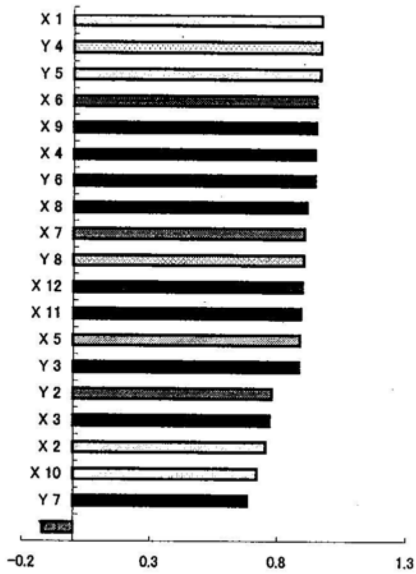


Figure 9. (T)
Factor Loading for T (2nd Component)

3. Basic Framework for Estimation

3.1 Theoretical Context

Before proceeding to the argument on estimation, let us first discuss theoretical framework to deal with the issue concerning social capital. The basic framework is presented by Arrow & Kurz[9] with social capital as single variable, and extended further by Mitsui & Ohta[10] with multi-variable framework for social capital. In this paper, extended framework proposed by Mitsui & Ohta is applied.

Now let us consider an economy where

$$K_t = K_{pt} + K_{gt}$$

where K_t is the total amount of the capital stock in the society, and it is divided into two factors; private capital K_{pt}, and social capital K_{gt}. Assuming δ to be the depreciation rate, and I_t to be the total amount of investment at particular time of t, the relation of those variables is given by

$$\dot{K}_{pt} = I_{pt} - \delta K_{pt} \dot{K}_{gt} = I_{gt} - \delta K_{gt} \qquad (4)$$

Respective δ for two capitals are assumed to be equivalent. As a next step, let us consider the production function for the whole society. With the social capital stock presented in the production function, it it is given by

$$Y_t = F(L_t, K_{pt}, K_{gt}, t)$$

The objective function for dynamic optimization is considered to be

$$\int_0^\infty e^{-\rho t} u(C_t, K_{gt}, t)\, dt$$

where C_t is consumption per person, and $e^{-\rho t}$ is the constant rate of time preference. $e^{-\rho t}$ is assumed to be $\rho > 0$ in this case. As the objective function implies, social capital plays a role as an input in productive process while it has a significant influcence on the utility function for individual. Now the optimization problem takes a form as

$$\max \int_0^\infty e^{-\rho t} u(C_t, K_{gt}, t)\, dt$$

$$s.t. \quad \dot{K}_t = F(L_t, K_{pt}, K_{gt}, t) - \delta K_t - C_t \qquad (5)$$

$$K_t \geq K_{pt} + K_{gt}$$

where both K_{pt} and K_{gt} are non-negative, and L_t, $e^{-\rho t}$ are assumed to be given exogenously. Moreover, F is assumed to satisfy the following:

$$I_{pt}+I_{gt}+C_t \leq F(L_t, K_{pt}, K_{gt}, t) \quad (6)$$

Optimal solution $\{K_{pt}^*, K_{gt}^*, C_t^*\}_{t=0}^{\infty}$ is assumed to be internal solution, and it is supposed to fulfill the following conditions:

$$K_{pt}^* > 0, \qquad K_{gt}^* > 0 \quad (7)$$

At this particular point, necessary condition is given by

$$u_c \cdot F_K = u_{Kg} + u_c \cdot F_{Kg} \quad (8)$$

where

$$F_{kp} = \frac{\partial}{\partial K_p} F(L_t, K_{pt}^*, K_{gt}^*, t) \quad (9)$$

$$F_{kg} = \frac{\partial}{\partial K_g} F(L_t, K_{pt}^*, K_{gt}^*, t) \quad (10)$$

$$u_c = \frac{\partial}{\partial C}(C_t^*, K_{gt}^*, t) \quad (11)$$

$$u_{kg} = \frac{\partial}{\partial K_g}(C_t^*, K_{gt}^*, t) \quad (12)$$

Assuming $u_c > 0$, $u_{kg} > 0$ in equation (4), we have

$$F_{kp} - F_{kg} = \frac{u_{kg}}{u_c} \geq 0 \quad (13)$$

From the equation above, the optimality condition is considered to be satisfied under the condition

$$F_{kp} \geq F_{kp} \quad (14)$$

while the optimal allocation is not regarded as being achieved if we face the follwing case;

$$F_{kp} \leq F_{kg} \quad (15)$$

The accumulative level of the social capital in this case is considered to be relatively lower than the one for former equation.

3.2 Application to the Cost Functional Form

As the next step, technological innovation, T_t, is introduced into the model instead of single variable, A. In this paper, technology itself is assumed to be non-linear shaped relation. Significant factors in this relation are I_t; indicating technological innovation, and E_t; describing environmental factor for the economy. Functional form is proposed as

$$T_t = e^{\theta t} \cdot E_t^{\delta} \cdot I_{t-i}^{\rho} \quad (i=0,1,2,\cdots) \quad (16)$$

where $t-i$ indicates the past impact of technological innovation to the present. This proposal is based upon the assumption which allows a time lag for technological progress to be achieved. When this framework is combined with production function, the specification with Cobb-Douglas form is given by

$$Y_t = e^{0t} E_t^{\delta} I_{t-i}^{\rho} K_{pt}^{\beta 1} L_t^{\beta 2} K_{gt}^{\beta 3}$$

This framework drives us to the agument how it is applied to the cost function. The framework mentioned above implies the dual nature of the production function. It leads us to the interpretation as the following:

$$C = T_t C(p_K, p_L, Y_t, K_{gt}, t)$$

In this paper, cost framework described above is applied to two types of functional forms: the first order approximation (Cobb-Douglas) form, and the second order (translog) flexible form. The first order form is specified as

$$\ln(C_t/p_m) = \alpha_0 + \alpha_1 t + \beta_1 \ln Y_t + \beta_2 \ln K_{gt} + \sum_{i=1}^{2} \gamma_i \ln(p_i/p_m) + \delta \ln E_t + \rho \ln I_{t-s} + \varepsilon_t \quad (17)$$

This form is quite restrictive when being compared with flexible functional form. The typical specification for the flexible one is a translog type, and it is given, in this case of both social capital and technological progress are involved, by the following form

$$\begin{aligned}\ln(C_t/p_m) = {} & \alpha_0 + \alpha_1 t + \beta_1 \ln Y_t + \beta_2 \ln K_{gt} + \sum_{i=1} \gamma_i \ln(p_i/p_m) + \psi \ln T_t \\ & + \sum_{i=1} \theta_i \ln Y_t \ln(p_i/p_m) + \lambda_1 \ln Y_t \ln K_{gt} + \lambda_2 \ln Y_t \ln T_t \\ & + \sum_{i=1} \mu_i \ln K_{gt} \ln(p_i/p_m) + \lambda_3 \ln K_{gt} \ln T_t \\ & + \sum_{i=1} \phi_i \ln T_t \ln(p_i/p_m) + (1/2)\pi_1 \ln(Y_t)^2 + (1/2)\pi_2 \ln(K_{gt})^2 \\ & + (1/2)\pi_3 \ln(T_t)^2 + (1/2)\sum_{i=1}\sum_{j=1} \omega_{ij} \ln(p_i/p_m) \ln(p_j/p_m) \\ & + \varepsilon_t \end{aligned} \quad (18)$$

where P_m is a numeraire price meaning the intermediate input price, and p_i $(i=1, 2)$ indicates capital price and labor service price respectively. This model has usually been estimated simultaneously with cost share equations which take forms of

$$S_i = \alpha_i + \alpha_{1i} t + \sum_{i=1} \omega_{ij} \ln(p_i/p_m) + \theta_i \ln Y_t + \mu_i \ln K_{gt} + \phi_i \ln T_t + \varepsilon_i t \quad (19)$$

Stochastic error term in this particular point is assumed to be the standard one that satisfies

$$\varepsilon \sim IID, \quad E(\varepsilon)=0, \quad E(\varepsilon^2)=\sigma_\varepsilon^2$$

In addition, two more assumptions get to be necessary: the first, symmetry condition for parameters

$$\zeta_{ij}=\zeta_{ji} \qquad (i \neq j)$$

and secondly, homogeneity condition for degree one with respect to input price

$$\sum_{i=1}^{2}\gamma_i=1, \quad \sum_{i=1}^{2}\omega_{ij}=0, \quad \sum_{i=1}^{2}\theta_i=0$$

It should be marked that innovation factor I_{t-i} and economic environmental factor E_t are substituted by a single term T_t, which is the principal component for the whole factors, in the second order form. This is due to avoid the complicated specification.

3.3 Data and the Means for Estimation

One of the most significant features of this analysis is data for technological progress; I_{t-i}, E_t, and T_t. Since these variables consist of diverse elements in the society, the author applies respective principal components as substitutes.

As to the other data, all the data are annual and cover Japanese private sector from 1955 to 1997. Data for GDP, cost, public capital, private capital, and compensation of all employees have been obtained from Annual Report on National Account, published by Economic Planning Agency (Government of Japan). Cost is treated in this paper as the difference between GDP (at constant prices) and the surplus. This might be controversial, the data for cost on the national basis can hardly be obtained though. Input price for private capital is cbtained from Economic Statistics Annual (Bank of Japan). In this paper, average contracted interest rates on loans and discounts is applied. As to the price of intermediate goods, finally, is found in Price Indexes Annual (also Bank of Japan).

As to the estimation, two types of means have been applied in this paper. For the first order approximation model, instrumental variable estimation is applied since the social capital Kgt is found to be endogenous variable by Hausman Test in preliminary attempt. For the second order translog model, seemingly unrelated estimation (SURE) is applied. Some restrictions are imposed upon parameters of share equations to be equivalent with the one in cost funcion.

4. Results and an Analysis

Results for two types of estimations are described in both Table 10 and Table 11. Table 10 captures the first order model, and at the same time, Table 11 describes the result of translog model. Moreover, two cases are attempted in the first order form; the first case using I_{t-i} and E_t, and the second case using total factor, T_t. First of all, as to the case 1 in the first order form, respective elasticities for an output, social capital, and technological term seem to be valid in terms of the sign of estimated parameters. As Table 12 describes respective elasticities, 1% increase in output leads to 0.43% increase in cost level. More to be marked, both social capital and technological term have shown minus sign, implying slight increase in each variable generates 0.35% and 0.05% decrease in cost level. In this case, elasticities of technology terms involving I and E are calculated by adding those two estimators. This is due to the assumption for the framework of technological progress in which two factors are related tightly in the process of development. Thus, the elasticity e_T is given by

$$e_T = \delta + \rho \quad (20)$$

The impact level of both variables for cost level to be reduced seems to be high to some degree. Since the output elasticity is relatively close to the sum of both two factors, increase in accumulation of both social capital and technological level tends to play a significant role to cancel the impact of output out. As to the second case, the result seems to be close to the one for case 1. The impact of K_{gt} and T_t; however, might be

Table 10.

	Case 1		Case 2	
Parameter	Estimate	(t-statistics)	Estimate	(t-statistics)
α_0	6.0971	(10.209)	5.8079	(8.445)
α_1	0.0381	(9.004)	−0.0715	(4.587)
d_{85}	−0.0725	(−2.733)	−0.8754	(−2.302)
β_1	0.43354	(5.133)	0.35421	(2.501)
γ_1	0.21451	(2.110)	0.1247	(1.987)
γ_2	0.71205	(28.314)	0.7613	(12.541)
β_2	−0.35112	(−4.551)	−0.3714	(−3.964)
β_3	−	−	−0.0985	(2.224)
δ	−0.15223	(−6.213)	−	−
ρ	0.04882	(2.479)	−	−

Table 11.

	2nd	Order	S_{kp}		S_L	
Parameter	Estimate	(t-statistics)	Estimate	(t-statistics)	Estimate	(t-statistics)
α_0	−59.467	(−2.877)	0.3519	(2.873)	−0.83451	(−2.962)
α_1	0.0763	(6.985)	−0.0248	(3.558)	−0.00341	(−2.579)
d_{85}	−0.0204	(−2.186)	−0.0321	(−1.970)	−0.01087	(−0.859)
β_1	9.1279	(3.107)	−	−	−	−
γ_1	0.4227	(2.511)	−	−	−	−
γ_2	0.6959	(2.455)	−	−	−	−
β_2	−0.1021	(−1.788)	−	−	−	−
ψ	−2.7472	(−1.801)	−	−	−	−
δ	−	−	−	−	−	−
ρ	−	−	−	−	−	−
θ_1	0.0597	(3.211)	0.0597	(3.211)	−	−
θ_2	0.2113	(6.201)	−	−	0.2113	(6.201)
λ_1	0.2499	(1.489)	−	−	−	−
λ_2	0.3979	(1.814)	−	−	−	−
μ_1	−0.0912	(−4.418)	−0.0912	(−4.418)	−	−
μ_2	−0.0597	(−2.048)	−	−	−0.0597	(−2.048)
λ_3	0.0648	(0.987)	−	−	−	−
ϕ_1	−0.08974	(−0.875)	−0.08974	(−0.875)	−	−
ϕ_2	−0.03687	(−2.016)	−	−	−0.03687	(−2.016)
π_1	−1.3354	(−3.571)	−	−	−	−
π_2	−0.3804	(−1.761)	−	−	−	−
π_3	−0.71245	(−1.699)	−	−	−	−
ω_1	0.02457	(2.587)	0.02457	(2.587)	0.02457	(2.587)
ω_2	0.10874	(1.642)	0.10874	(1.642)	−	−
ω_3	−0.1681	(−1.851)	−	−	−0.1681	(−1.851)

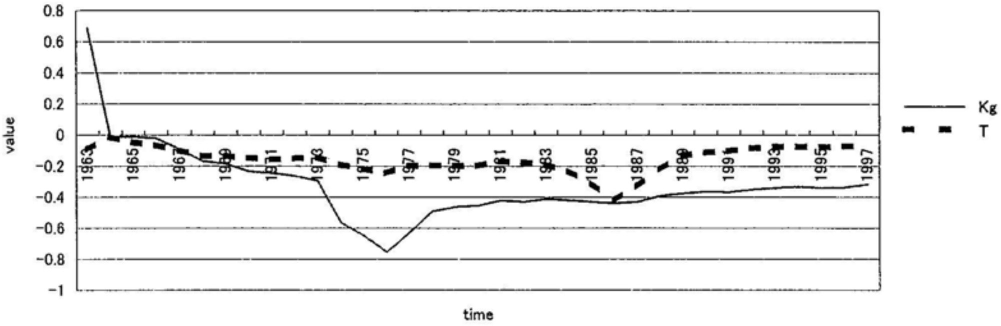
Table 12.

Variable	case 1	case 2
Y_t	0.43	0.35
K_{gt}	−0.35	−0.37
T_t	−0.10	−0.09

slightly different from the one of case 1, since it seems to be higher than the impact of output increase in case 2. From these two experiments described above, it is not impossible to recognize the influence of both social capital and technological progress on private economy to reduce the cost structure.

As to the second order form, the results are described in Table 11. From the estimated parameters listed on the table, one can see relatively lower reliability in statistical sense. Estimation of social capital β_2 and technological term Ψ shows us minus sign which is quite similar with the result of Cobb-Douglas type; however, t statistics

Figure 10. Respective Elasticities in Transition



for those two variables might seem to be relatively lower than the one for Cobb-Douglas case. At the same time, estimated parameter for output (β_1) shows quite large number which might be not realistic in some sense. Thus, in comparison with both two models, the first order approximation form should be applied in the analysis of elasticity which is plotted from 1963 to the present in the diagram.

The result of plotting is shown in Figure 10. This indicates us several significant points. First of all, the impact of social capital K_{gt} tends to be a downward movement from early 1960s to mid 70's. It goes to the peak in 1976 in times of oil shock. Then its impact gradually decreases up to the present time. As to the impact of technological term, it remains relatively constant throughout the sample period except middle of 1980s. This is the period when rapid growth of Japan's technological progress has been evaluated in the international market. It; however, begins to reduce its "plus" impact on the market after that.

5. Concluding Remarks

From the argument mentioned above, we have recognized the compounds variable might become one candidate for the technology consisting of quite complicated nature. It tends to be significant statistically in the first order model, and the estimate of technological parameter shows an important message that the accumulation of knowledge or technical training might support the activity of the private economy with the impact of cost reduction. The mechanism of the impact; however, is not clear at the present time. Externality might be one of the most significant element for it. The same interpretation can be applied to the accumulation of social capital. From the result of experiments, the elasticities of these two factors with respect to the cost level are not quite few. This seems to be realistic to a greater degree; however, there are several points which require further analysis. Second order form, and other data for the compounds variable indicating technology are necessary to be reconsidered.

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