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Estimates of Intangible Investment by Industry and Productivity Growth in Japan

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Abstract

Using JIP database and other primary statistics, we estimate intangible investment in Japan at the industry level. Intangible investment/GVA ratios in the IT sector are higher than other industries while the ratios in some service sector have declined in the 2000s. Although intangible capital stock in 2008 is 136 trillion yen, growth rate in intangibles turned to be negative in some industries in the 2000s due to the harsh restructuring. When we examine impacts of intangible investment on TFP growth, we find a significant and positive effect on TFP growth in the market economy and the IT sector. In the revised estimation considering congestion effect of intangible investment and intertemporal knowledge spillovers in the IT sector, we find that the estimated rate of return on intangibles is quite high after the IT revolution. The estimation results imply underinvestment in intangible investment in the IT sector and require the reformulation of economic policies which has been based on the traditional industry classification.

JEL classification numbers: E01, E22, O31, O32
Keywords: intangible investment, TFP, IT sector, intertemporal knowledge spillover

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1. Introduction

The IT revolution in the 1990s and the productivity growth induced by its revolution in the US led to many studies on intangible investment. To explain the accelerated productivity growth in the US, Hall (2000), (2001), Bresnahan, Brynjolfsson, and Hitt. (2002), and Basu, Fernald, Oulton, and Srinivasan, (2003) focused on intangible assets, which are complementary to IT assets and played a crucial role in productivity improvement. However, they estimated the effects of intangible assets on productivity growth indirectly due to the difficulty in measuring intangibles.[1]

Corrado, Hulten and Sichel (2009) overcame this difficulty and measured intangible investment at the aggregate level in the US for the first time. Based on their estimation, they found that the ratio of intangible investment to GDP exceeded the ratio of tangible investment to GDP in the early 2000s, and that one third of the productivity growth in the late 1990s and the early 2000s is attributable to the growth in intangible asset. After their success in measuring intangible assets, many economists followed their method and estimated intangible investment in their own countries.[2]

However, the aggregate data does not provide enough information to conduct productivity analysis. As Jorgenson, Ho, and Stiroh (2005), Inklaar, O'Mahony and Timmer (2005), Fukao, et al. (2012) suggested, there is a significant productivity gap between IT industries and non-IT industries. In addition, even in IT-intensive service industries, there is a productivity gap between the US and Japan. To understand the above gaps, we require intangible investment data at the industry level. Moreover, the aggregate series also constrains our analysis. The measured time series intangible investment data are at most 30 years. This size of data is not sufficient for several econometric analyses.

As a result, we measure intangible investment at the industry-level in Japan to clarify the puzzle between the productivity gap and intangible investment. A few studies focus on intangible investment at the sectoral level. For example, Fukao, et al. (2009) measure intangible investment in the manufacturing and service sectors. Following their

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[1] Miyagawa and Kim (2008) also considered the role of intangible assets on productivity improvement through the indirect measurement in intangible assets by using firm-level data.

[2] Marrano, Haskel, and Wallis (2009) for the UK, Fukao et, al. (2009) for Japan, Delbecque and Bounfour (2011) for France and Germany, Hao, Manole, and van Ark(2008) and Piekkola (2011) for major EU countries, Burnes and McClure (2009) for Australia, and Pyo, Chun and Rhee (2011) for Korea..

work, Barnes (2010) summarized the measurement in intangible investment at the sectoral level. However, the industry classification in the previous studies is close to the aggregate level. In our paper, we measure intangible investment at the two-digit industry level following the Japan Industrial Productivity (JIP) database.[3]

In the next section, we explain how to measure intangible investment by industry. In the third section, we show some features of intangible investment at the industry level in Japan. In the fourth section, using the industry level data, we examine the effect of intangible assets on productivity improvement empirically. In the final section, we summarize our results.

2. Measurement in Intangible Investment by Industry in Japan

Following Corrado, Hulten, and Sichel (2005, 2009), we measure intangible investment by industry in Japan. Intangible assets consist of computerized information, innovative property, and economic competencies. Regarding industry classifications, we follow the Japan Industrial Productivity (JIP) database. The JIP database consists of 108 industries that correspond to the two-digit industry classification. In the JIP database, the market economy consists of 92 industries, the manufacturing sector consists of 52 industries, and the service sector consists of 33 industries. Combining the JIP database with other statistics, we estimate intangible investment by industry in Japan. We explain the measurement in the following sub-sections. The detailed explanation of the measurement is summarized in Appendix 1.

2-1. Measurement of Computerized Information

Computerized information consists of custom and packaged software, and own account software. Custom and packaged software is estimated in the SNA. In the JIP database, we obtain the SNA data and distribute the total custom and software investment into each industry by using the *Fixed Capital Formation Matrix* (FCFM). Our estimation follows that in the JIP database.

We estimate the cost of workers who are involved in the development of software for their own firms to measure own account software. We estimate the ratio of the system engineers (SE) and programmers to total workers by industry using *the Population Census*. Multiplying this ratio by the number of total workers in the JIP database, we obtain an estimate of the number of SEs and programmers by industry. We

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[3] The JIP database consists of 108 industries. The website of the database is **http://www.rieti.go.jp/en/database/JIP2011/index.html**. Fukao et al. (2007) explain how this database was constructed.

obtain wage data for SEs and programmers from *Basic Survey on Wage Structure*. Multiplying this wage by the number of SEs and programmers, we estimate own account software investment. The Cabinet Office (CAO) in Japan recently published own account software investment at the aggregate level in the new estimation of SNA. Our estimation method is similar to that by the CAO. However, due to the difference in coverage, our estimate in 2008 is smaller than that by CAO.

2-2. Measurement of Innovative Property

Innovative property consists of science and engineering R&D, mineral exploitation, copyright and license costs, and other product development, design, and research expenses. First, we estimate science and engineering R&D costs by using the *Survey of Research and Development* published by the Statistical Bureau of the Ministry of Internal Affairs and Communications. However the survey does not cover R&D data in most service sectors before 2000. Using service sectors' expenditures for R&D outsourcing in the JIP database, we calculate backwards to find the service sectors' R&D costs.

Because expenditures of mineral exploitation are allocated to only the mining industry, we follow the estimation by Fukao, et al. (2009) which measured the aggregate intangible investment in Japan. The *Mining Industry Handbook* and the *Establishment and Enterprise Survey* provide data on expenses for mineral exploitation (the total expenses for geological investigation). Combining the above two surveys with FCFM, we estimate expenditures of mineral exploitation.

Copyright and license costs are assumed to consist of the input from the publishing industry (JIP industry no. 92) and the video picture, sound information, character information production and distribution industry (JIP industry no. 93) to JIP industries nos. 1-71 and 73-107. By using the I-O table in the JIP database, we allocate these inputs into 108 industries. The allocation device is as follows. For example, when we estimate copyright and license costs in industry i at year t, we obtain the input data from JIP industry no. 92 and no. 93 to industry i by using JIP I-O table at year t. As JIP database has I-O tables from 1973 to 2008, we are able to obtain the data of cost and license costs by industry in the above period.

We estimate the outsourcing costs of design, display, machine design and architectural design by using the sales data of these industries from *the Survey of Selected Service Industries* and the input from the other services for businesses industry (JIP industry no.88). We calculate the ratio of the sales of design and display industries to the nominal output of the other services for businesses industry (JIP industry no.88) of the JIP database. Like the estimation in copyright and license costs, we allocate the estimated costs to 108 industries by using the I-O table in the JIP database.

As for in-house expenditures, we only estimate in-house designing. We estimate the ratio of the designers to total workers by industry using *the Population Census*. Multiplying this ratio by the number of total workers in the JIP database, we obtain the number of designers by industry. The Census data is available for every five years. For other years, we estimate the ratio by linear interpolation. We obtain wage data from *the Basic Survey on Wage Structure*, and multiplied it by the number of estimated workers. Like the estimation in the own account software investment, we do not take account of other expenditures except labor cost.

As for the estimation in product development in financial services, the estimation method by Corrado, Hulten, and Sichel (2005) was very controversial because they assumed that 20 percent of intermediate inputs produced by the financial services can be regarded as expenditures in intangible assets. Recently, Corrado suggested that the cost of new product development in the financial services is equal almost 8% of the compensation of high skilled workers in the financial industry to harmonize their estimate to estimates in EU countries by COINVEST and INNODRIVE projects.[4] Thus, following Corrado's suggestions, we assume that 8 percent of the compensation of workers graduated from college in the financial industry (JIP industry no. 69) and the insurance industry (JIP industry no. 70) can be regarded as expenditures in intangible assets. These expenditures are treated as those in the financial sector and insurance industry respectively.

2-3. *Measurement of Economic Competencies*

Economic competencies consist of three components; brand equity, firm specific human capital, and organizational structure. Regarding the measurement of brand equity, we obtain the input data of the advertising industry (JIP industry no. 85) and allocate it into 108 industries by using the I-O table in the JIP database. The allocation device is similar to the case in copyright and license costs or the outsourcing costs of design, display, machine design and architectural design.

In estimating firm specific human capital, we focus on off-the-job-training costs. We estimate the ratio of off-the-job training costs to the total labor costs from the *General Survey on Working Conditions* by industry published by the Ministry of Health, Labor and Welfare. Multiplying this ratio by the total labor costs in the JIP database, we estimate off-the-job training costs by firms by industry. For the opportunity cost of

[4] Intangible investment in Euro area is available at www.INTAN-invest.net

off-the-job training in terms of working hours lost, we use the results obtained by Ooki (2003). Using micro-data of Survey on Personnel Restructuring and Vocational Education/Training Investment in the Age of Performance-based Wage Systems (Gyoseki-shugi Jidai no Jinji Seiri to Kyoiku/Kunren Toshi ni Kansuru Chosa) conducted by the Japan Institute for Labour Policy and Training, Ooki calculated the average ratio of the opportunity cost of off-the-job training to direct firm expenses for training in 1998 for the entire business sector. The value was 1.51. We use this same value to estimate the opportunity cost.

To estimate expenditures into organizational structure, Corrado, Hulten, and Sichel (2005) assumed that 20% of the remuneration of executives is counted as intangible assets for organizational structure. However, we replaced 20% by 9%, because only 9% of the total working time of executives is spent on organizational reform and the restructuring of organization, according to Robinson and Shimizu (2001). We calculated the ratio of the remuneration of executives to value added using *the Financial Statements Statistics of Corporations by Industry* published by the Ministry of Finance. Then, we find the expenditure for the organizational structure by industry by multiplying this ratio to value added in the JIP database.

2-4. Measurement of Capital Stock in Intangible Assets

Based on the measurement of expenditures in intangible assets, we estimate capital stock in intangible assets. Corrado, Hulten, and Sichel (2005) pointed out that some of expenditures in intangible assets should not be accounted for as capital formation, because their service lives are too short. Therefore, based on the argument in Corrado, Hulten, and Sichel (2005), we revise our estimates in expenditures in intangible assets as follows to find a capital formation series;

(1) New product development costs in the entertainment industry are assumed to be short lived.
(2) 60% of advertisement costs are counted as capital formation.
(3) 80% of remuneration of executives that is spent for organizational reform is counted as capital formation.

The capital formation series is measured in nominal terms. Using the deflator by assets shown in Table1, we construct a real capital formation series in intangible assets. Then, we accumulate the capital formation series by use of the perpetual inventory method and find real capital stock in intangible assets. The depreciation rate by asset that is used for the perpetual inventory method is shown in Table 2.

(Place Tables 1 and 2 around here)

3. Accumulation of Intangible Assets

3-1. Expenditures in Intangible Assets

Our estimates of expenditures in intangible assets at the aggregate and the sector levels are summarized in Table 3. The total annual spending on intangible assets in Japan for the period 2001-2008 is about 44 trillion yen on average. Annual capital spending on intangibles is about 39 trillion yen in the same period. In the market economy, the annual expenditures for the same period are about 40 trillion yen and the annual capital spending is about 36 trillion yen.

(Place Tables 3 around here)

When we focus on the spending on intangible assets at the sector level, spending in the manufacturing sector for the period 2001-08 is about 18 trillion yen, which is almost the same as that for the period 1991-2000. On the other hand, spending on intangible assets in the service sector is about 22 trillion yen for the period 2001-08, which increased at 24% from the previous period.

In Table 4, we compare the ratios of intangible investment to GVA. In the 1980s, the total intangible investment/GVA ratio in Japan was 6.1% on average, which is higher than that in Korea (3.4%) estimated by Chun.[5] This gap between Japan and Korea has reduced in the 2000s. While the Japanese intangible/GVA ratio is 9.4%, that in Korea is 7.4% in 2008.[6] At the sectoral level, intangible investment/GVA ratios in the manufacturing sector is larger than the ratio in the service sector due to the large investment in innovative property in the manufacturing sector.

(Place Tables 4 around here)

Table 5 shows the intangible investment/GVA ratio by industry.[7] Intangible investment ratios in the IT intensive industries such as machinery industries and information and communication service industry are much larger than those in other industries. On the other hand, in some service industries such as education, health and

[5] Intangible investment in Korea is estimated in Chun, et, al. (2012).

[6] In Korea, software investment may not include own account software which is estimated in Japan. If own account software investment in Korea is correctly estimated, the gap between Japan and Korea will be lower.

[7] When we compare intangible investment by industry between Japan and Korea, we harmonize the Japanese industry classification with Korea industry classification.

social work, and culture and entertainment industries, these ratios are smaller than those in Korea, because these ratios have declined in the 2000s.

(Place Table 5 around here)

3-2 Capital Stock in Intangible Assets

The amount of capital stock and its growth rate in Japan are summarized in Table 6. The total capital stock in 2008 is about 136 trillion yen. The amount of capital stock in the manufacturing sector is almost the same as that in the service sector. The annual growth rate of intangible capital in the market economy from 1985 to 2008 is 4.2%. Although the growth rate in the late 1980s exceeded 10%, it declined after 1990. In particular, the growth rate in the 2000s is 1.3% in the market economy due to the negative growth in capital in economic competencies. Although assets in computerized information increased in the late 1990s due to the IT revolution, it also declined in the 2000s.

(Place Table 6 around here)

Figure 1 shows the growth in intangible assets by industry. As seen in Table 6, we find negative growth in intangible assets in the 2000s in some industries such as textile and leather, construction and wholesale and leather. Figure 2 shows the growth rate in intangible assets by industry and by component in the 2000s. In most industries, assets in economic competencies declined. Few industries such as petroleum, coal and chemicals, transport equipment and information and communication industries grew these assets. In the cultural and entertainment, education and health and social work industries, assets in computerized information have declined greatly since 2000. The decline in assets in economic competencies is caused by the harsh restructuring due to the long-term economic slump. On the other hand, assets in computerized information in the non-market sector declined because the network system among establishments has not improved due to regulation and a lack of management skill.

(Place Figures 1 and 2 around here)

4. The Impacts of Intangible Assets on Productivity Growth

4-1. Conventional Estimation

Based on our estimates of intangible investment, we examine their impacts on productivity growth using the conventional econometric approach developed by Griliches and others.[8] We assume the following production function at industry i.

(1) $$V_{t,i} = A_{t,i} F(K_{t,i}, L_{t,i}),$$

where *V* is value added, *A* is TFP, *K* is tangible capital, and *L* is labour for each industry for each industry. We assume that intangible assets (Z) are exogenous and affect TFP.

(2) $$A_{t,i} = Z_{t,i}^{\gamma} \exp(\lambda_i t)$$

When we take the logarithm of Equation (2) and differentiate it with respect to time, we get

(3) $$\frac{\dot{A}_{t,i}}{A_{t,i}} = \lambda_i + \gamma \frac{\dot{Z}_{t,i}}{Z_{t,i}} = \lambda_i + \rho_Z \frac{\dot{Z}_{t,i}}{Q_{t,i}}$$

where we define the time difference of x as $\frac{\partial x}{\partial t} = \dot{x}$, and ρ_Z is $\frac{\partial Q}{\partial Z}$. If ρ_Z , gross rate of return on intangible assets, is positive, intangible investment improves TFP growth.

We obtain TFP growth and value added data from the JIP database. We estimated the intangible investment of 108 industries from 1980 to 2008. As the industry classification of intangible investment is same as JIP database, we are able to conduct panel estimation for Equation (3).[9] Estimation method is fixed effects estimation, fixed effects estimation with instrumental variables. Instruments are ratio of highly educated workers, cash flow ratio, and 2 years lagged variable of intangible investment ratio. As

[8] The conventional approach is summarized in Griliches (2000).
[9] Although the JIP database consists of 108 industries, we focus on the market economy which consists of 92 industries.

we take a one-year lag of an explanatory variable in (3) to avoid a simultaneous bias, the estimation period is from 1981 to 2008. A summary of the resulting statistics in variables is shown in Table 7.

(Place Table 7 around here)

Table 8 summarizes the estimation results in the market economy. the coefficient of total intangible investment are is positive and significant. When we divide total intangible investment into three components and estimate (3) using each component, the estimation results are similar to that using total intangible investment. Thus, we find a positive and significant effect of intangible investment on productivity growth.

(Place Table 8 around here)

Then, we divide the whole period into two sub-periods at 1995 and estimate (3) by period, because the IT revolution started from around 1995. In the first period, the estimation results are similar to those in the whole period. However, after the IT revolution, the estimated coefficients of intangible investment are positive, but not significant.

Next, we divide the market economy into two sectors; the IT sector and the non-IT sector. As we found in Table 5, not only the manufacturing sector but also the service sector includes intangible investment intensive industries. Therefore, following Fukao et, al. (2012), we reclassify 92 industries in the market economy into the IT sector and the non-IT sector.[10] If we find the positive and significant effect of intangible investment in the IT sector, we are able to capture the possibility of the complementary effect of intangible assets on IT assets.

Table 9 summarizes the estimation results in the IT sector and the non-IT sector. While all estimated coefficients in the intangible investment show positive signs in the IT sector, we are not able to find a clear evidence of the contribution of intangible investment to TFP growth in the non-IT sector. The results imply that the intangible assets are likely to be complementary to tangible IT assets.

(Place Table 9 around here)

[10] In the industry which belongs to the IT sector, the ratio of tangible IT investment to output is above the median value of the ratio in the whole industry. The detailed industry classification in the IT and non- IT sectors is described in Appendix 2.

However, the estimation results in Tables 8 and 9 are not satisfactory, because the effects of intangible investment on productivity growth are not significant after the IT revolution. In addition, ρ_z which shows the estimated gross rate of return of intangible assets is 3.9% in the market economy which is lower than the benchmark gross rate of return (25.7%) considering Japanese national bond rate and depreciation rate of intangible assets.[11] Therefore, we will show alternative estimations in the next sub-section.

4.2 Alternative Estimations Following Jones and Williams (1998)

Jones and Williams (1998) pointed out that the estimated rate of return in Equation (3) is biased because the conventional estimation does not consider congestion effects of accumulation in intangible assets and intertemporal knowledge spillovers which are included in a standard endogenous growth model. Following their approach, we revise Equation (3) as follows.

(4) $$\dot{A} = \theta \dot{Z}^{\mu} A^{\phi}$$
$$(0 < \mu \leq 1, \phi > 0)$$

Log linearizing (4) around the balanced growth path, we get

(5) $$\frac{\dot{A}_{t,i}}{A_{t,i}} = \rho_Z \frac{\dot{Z}_{t,i}}{Y_{t,i}} + \mu g_A \ln(\frac{Y_{t,i}}{\bar{Y}_i}) + (\phi - 1) g_A \ln(\frac{A_{t,i}}{\bar{A}_i})$$

In (5), g_A is balanced growth rate of *A* and $\bar{Y}$ and $\bar{A}$ are steady state values of *Y* and *A*, respectively. We measure $\frac{Y}{\bar{Y}}$ and $\frac{A}{\bar{A}}$ as gaps from long-run growth path of *Y* and *A*, respectively.

Instead of (3), we estimate (5). The estimation method and instruments are the same as those in the conventional estimations. Our estimation results are shown in Tables 10 and 11.

(Place Tables 10 and 11 around here)

[11] In the case of IT sector, estimated rate of return is 7.2% which is also lower than the benchmark rate of return.

In Table 10, estimation results are similar to those in Table 8. The estimated coefficients of intangible investment are positive and significant except estimation results after the IT revolution. However, estimation results in the IT sector shown in Table 11 are different from the corresponding results in Table 9. While the coefficients of intangible investment after the IT revolution are positive but not significant in Table 9, these coefficients in the revised estimation show positive and significant signs after the IT revolution. Moreover, estimated gross rate of return of the total intangible investment after the IT revolution is 40% which is higher than the benchmark gross rate of return. The results imply that intangible investment in the IT sector turned to be profitable after the IT revolution. Although the effects of intangible investment on productivity growth are positive and significant before the IT revolution, we do not find a clear evidence of these effects after the IT revolution.

In the revised estimation results, intangible assets are likely to be complementary to tangible IT assets again in the IT sector. In addition, we find that the rate of return on intangible assets in the IT sector is quite high after the IT revolution. This result implies that intangible investment in the IT sector after the IT revolution is lower than the optimal level.

5. Concluding Remarks

Based on the framework of Corrado, Hulten and Sichel (2005, 2009), we estimated intangible investment by industry. Using the JIP database, we were able to construct intangible investment in 108 industries for the period from 1980 to 2008. The total annual expenditures in intangible assets in Japan are about 44 trillion yen on average for the period 2001-08. Annual capital spending on intangibles is about 39 trillion yen in the same period. Its ratio to GVA in 2008 is 9.4%.

When we look at the intangible investment/GVA ratio t by industry, the IT intensive industries such as machinery industries and information and communication service industry are much higher than those in other industries. On the other hand, in some service industries such as education, health and social work, and culture and entertainment industries, these ratios which have declined in the 2000s are smaller than those in Korea estimated in Chun, et, al (2012).

Using intangible investment data, we construct capital stock by industry using the perpetual inventory method. The total capital stock in 2008 is about 136 trillion yen and the annual growth rate of intangible capital in the market economy from 1985 to 2008 is

4.2%. However the annual growth rate in the 2000s is very slow. The slow growth of intangible assets in the 2000s is due to the decline in capital accumulation in economic competencies in many industries. This decline is caused by the harsh restructuring due to the long-term economic slump.

Using our estimated data on intangibles and the JIP database, we examined the effect of intangible investment on TFP growth. Estimation results using the conventional approach showed that intangible investment in the market economy contributes to TFP growth positively and significantly in the period from 1981 to 2008. As the estimation results in the IT sector showed the similar results to those in the market economy and we did not find the clear evidence of the positive and significant effect of intangible investment in the non-IT sector, these results imply that intangible assets are likely to be complementary to tangible IT assets in the IT sector.

However, in the conventional approach, the positive and significant effect of intangible investment after the IT revolution were not found and estimated rate of return on intangible assets was lower than the benchmark rate of return. Then, we conducted an alternative estimation developed by Jones and Williams (1998). The revised estimation results in the IT sector showed the positive and significant effects of intangible investment after the IT revolution. In addition, we found the higher rate of return on intangible assets than that the benchmark rate of return in the same period. These results imply the underinvestment in intangible assets after the IT revolution.

Our estimation results give us important implications for the long-term low productivity growth in the Japanese economy. In the IT sector, we found the positive and significant effects of intangible investment on productivity growth and the high rate of return on intangible assets. After the IT revolution, the output share of IT sector was over 40% which was almost equal to that of manufacturing sector which has been believed to be the leading sector of the Japanese economy. However, TFP growth in the IT sector has declined since the 1980s. Our estimation results suggest that productivity slowdown in this sector was caused by low accumulation in intangible assets. Only 1.4% growth in intangible assets in the IT sector in the 2000s supports the implications from our estimation results.

The government policies which promote economic growth should consider the above implications. If the government aims to enhance productivity growth through accumulation in intangible assets, the policies which promote intangible investment should focus on the IT sector, because we did not find the positive and significant effects of intangible investment on productivity growth in the non-IT sector. At the same time, the Japanese government should reformulate the conventional policy framework, because many economic policies are based on the traditional industry classification. However, after the IT revolution, the policies based on the traditional industry classification are not effective. The Japanese government should reconstruct a policy framework which is consistent with new industry classification stimulated by the IT revolution.

Our next task is to extend our measurement and analyses to the firm level data. If we are able to measure intangible assets at the listed firm level as shown in Hulten and Hao (2008) and Hulten (2010), we will examine the effect of intangible assets not only on productivity growth but also on firm value. The estimated coefficients of intangible investment at the industry level include not only firm's own effect but also external effect within an industry. When we apply the econometric approaches in Section 4 to the firm level data, we are able to separate the external effect from the mixed effects estimated at the industry level. If we are able to identify tangible IT assets at the firm level, complementarities between intangible assets and tangible IT assets will be also examined.

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Table 1: Deflators for Intangible Investment

	Data source and comments
Computerized information	
Custom and packaged software	Investment deflator in the JIP 2011 Database based on SNA
In-house software	Investment deflator in the JIP 2011 Database based on SNA
Innovative property	
Science and engineering R&D	Output deflators for JIP 2011 Database industry nos. 99 and 106
Mineral exploitation	Investment deflator in the JIP 2011 Database
Copyright and license costs	Output deflators for JIP 2011 Database industry nos. 92 and 93
Other product development,	Output deflators for JIP 2011 Database industry nos. 69, 70, and 88
Economic competencies	
Brand equity	Output deflator for JIP 2011 Database industry no. 85
Firm-specific human capital	Output deflator in JIP 2011 Database industry no. 80
Organizational structure	Output deflator in JIP 2011 Database industry no. 88

Table 2: Depreciation rates for intangible assets

Category	Depreciation rate (%)
Computerized information	33
Innovative property	20
Brand equity	60
Firm-specific human capital	40

Source: Corrado, Hulten and Sichel (2005)

Table 3: Estimated Spending on Intangible Assets in Japan

(billions of JPY)

		Total	Market Economy	Manufacturing	Service
1991-2000	**Computerized information**	**5,572**	**4,986**	**1,530**	**3,445**
		(5,572)	**(4,986)**	**(1,530)**	**(3,445)**
	Innovative property	**17,978**	**17,651**	**12,166**	**5,435**
		(17,761)	**(17,452)**	**(12,166)**	**(5,207)**
	Economic competencies	**14,176**	**12,166**	**3,831**	**8,592**
		(10,296)	**(9,031)**	**(2,615)**	**(6,233)**
	Total	**37,725**	**35,278**	**17,527**	**17,461**
		(33,628)	**(31,440)**	**(16,311)**	**(14,885)**
2001-2008	**Computerized information**	**9,319**	**8,227**	**2,654**	**5,546**
		(9,379)	**(8,227)**	**(2,654)**	**(5,546)**
	Innovative property	**19,931**	**19,182**	**11,996**	**7,158**
		(19,518)	**(18,552)**	**(11,996)**	**(6,829)**
	Economic competencies	**14,627**	**11,996**	**3,791**	**9,037**
		(10,118)	**(8,858)**	**(2,497)**	**(6,191)**
	Total	**43,777**	**40,434**	**18,441**	**21,725**
		(38,955)	**(35,938)**	**(17,147)**	**(18,566)**

*** Capital spending on intangibles is shown in parenthesis.**

Authors' calculation

Table 4: Intangible Investment/GVA Ratio in Japan

	1981-1990	1991-2000	2001-2008	1981-2008
Total economy				
CI	0.75%	1.35%	2.16%	1.34%
IP	3.23%	4.09%	4.46%	3.87%
EC	2.12%	2.35%	2.30%	2.25%
Total	6.10%	7.79%	8.92%	7.46%
Manufacturing				
CI	0.64%	1.55%	2.76%	1.53%
IP	8.31%	11.41%	12.05%	10.43%
EC	2.04%	2.43%	2.51%	2.31%
Total	10.99%	15.40%	17.32%	14.26%
Service				
CI	0.77%	1.32%	1.95%	1.28%
IP	1.25%	1.78%	2.25%	1.71%
EC	2.20%	2.39%	2.30%	2.30%
Total	4.23%	5.49%	6.51%	5.29%

***CI: compuerized information, IP: innovative property, EC: economic competencies**

Authors' calculation

Table 5: Intangible Investment/GVA Ratio by Industry in Japan

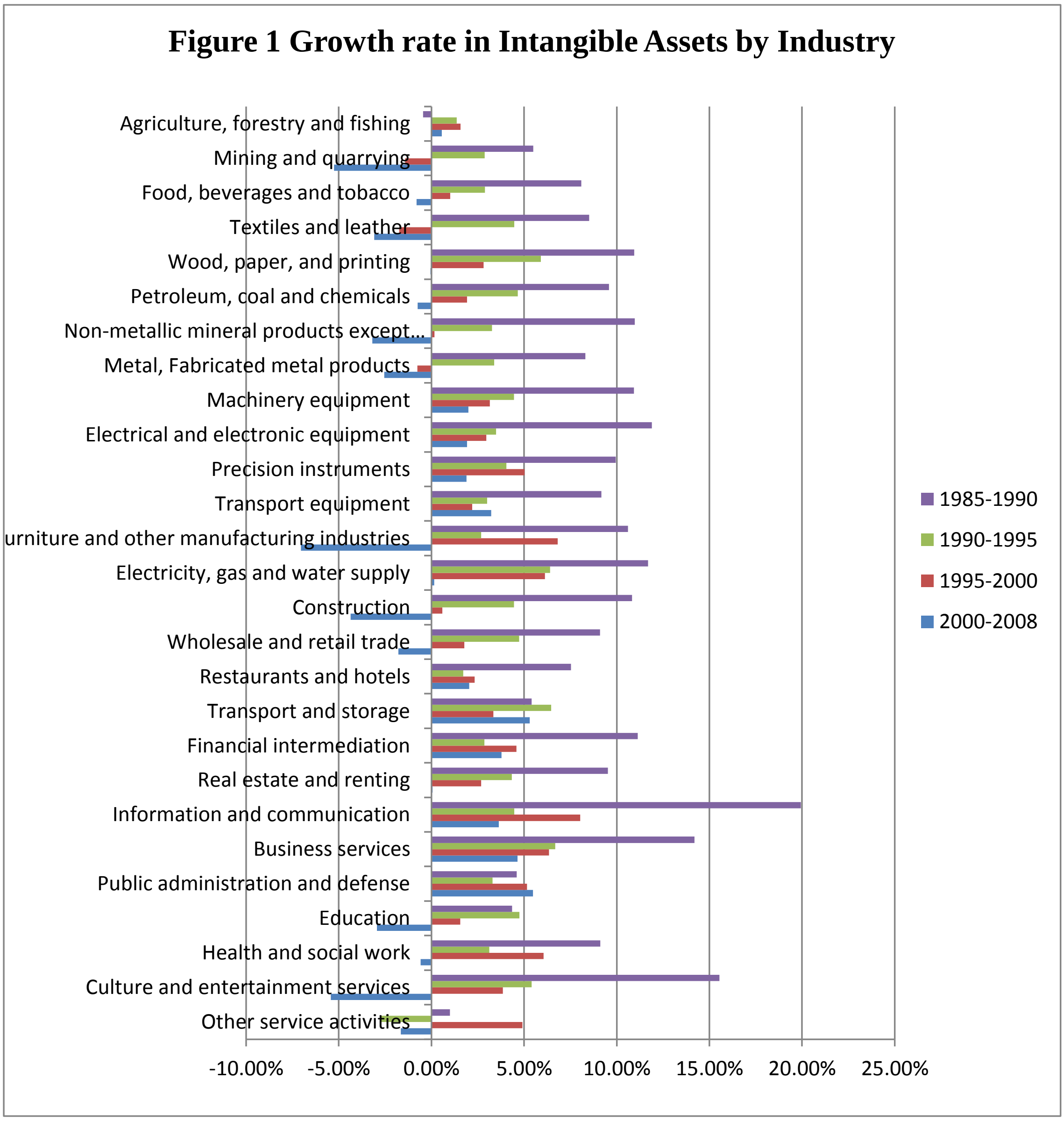
Industry name	1980	1990	2000	2008
Agriculture, forestry and fishing	1.70%	1.71%	2.60%	3.68%
Mining and quarrying	2.30%	4.78%	7.59%	10.99%
Food, beverages and tobacco	3.14%	6.20%	6.45%	6.32%
Textiles and leather	3.98%	6.30%	9.60%	16.81%
Wood, paper, and printing	3.32%	5.22%	7.17%	9.09%
Petroleum, coal and chemicals	11.89%	17.50%	21.48%	21.24%
Non-metallic mineral products except petroleum and coal	5.17%	8.27%	10.00%	8.73%
Metal, Fabricated metal products	4.35%	6.48%	7.79%	7.01%
Machinery equipment	6.55%	9.74%	14.77%	14.25%
Electrical and electronic equipment	17.38%	23.28%	30.06%	46.68%
Precision instruments	11.06%	22.31%	39.31%	38.48%
Transport equipment	10.14%	16.84%	20.11%	20.21%
Furniture and other manufacturing industries	7.88%	12.23%	29.45%	17.33%
Electricity, gas and water supply	1.75%	3.97%	5.45%	8.40%
Construction	2.06%	3.06%	3.81%	2.83%
Wholesale and retail trade	3.05%	5.25%	5.62%	4.44%
Restaurants and hotels	1.87%	5.36%	4.57%	4.33%
Transport and storage	1.93%	2.15%	2.67%	4.23%
Financial intermediation	4.10%	5.29%	9.21%	14.02%
Real estate and renting	2.04%	3.01%	4.85%	4.47%
Information and communication	5.43%	19.03%	21.56%	23.38%
Business services	3.96%	7.11%	9.24%	10.26%
Public administration and defense	3.12%	4.36%	5.81%	7.26%
Education	1.49%	1.76%	1.85%	1.47%
Health and social work	1.77%	3.40%	3.41%	1.79%
Culture and entertainment services	5.96%	5.22%	8.54%	6.65%
Other service activities	2.04%	3.19%	4.21%	3.49%

Authors' calculation

Table 6: Capital Stock in Intangible Assets in Japan

	2008 billions of JPY	1985-1990 annual growth rate (%)	1990-1995 annual growth rate (%)	1995-2000 annual growth rate (%)	2000-2008 annual growth rate (%)	1985-2008 annual growth rate (%)
Market economy						
CI	26,839	15.07%	5.90%	8.72%	4.84%	8.07%
IP	91,351	11.28%	4.40%	2.68%	1.05%	4.29%
EC	17,493	5.68%	1.49%	1.36%	-1.68%	1.23%
Total	135,600	10.34%	4.00%	3.23%	1.29%	4.22%
Manufacturing						
CI	9,116	12.80%	7.22%	8.95%	6.13%	8.40%
IP	63,232	10.89%	3.98%	1.99%	0.25%	3.68%
EC	4,757	4.36%	-0.06%	0.76%	-1.57%	0.53%
Total	77,106	10.23%	3.78%	2.34%	0.68%	3.73%
Service						
CI	17,662	16.07%	5.34%	8.58%	4.24%	7.90%
IP	27,957	12.86%	5.90%	4.87%	3.17%	6.18%
EC	12,265	6.61%	2.17%	1.66%	-1.81%	1.59%
Total	57,801	10.79%	4.43%	4.72%	2.19%	5.05%

***CI: computerized information, IP: innovative property, EC: economic competencies**



Authors' calculation

Figure 2 Growth Rate in Intangible Assets by Industry and Component (2000-08)

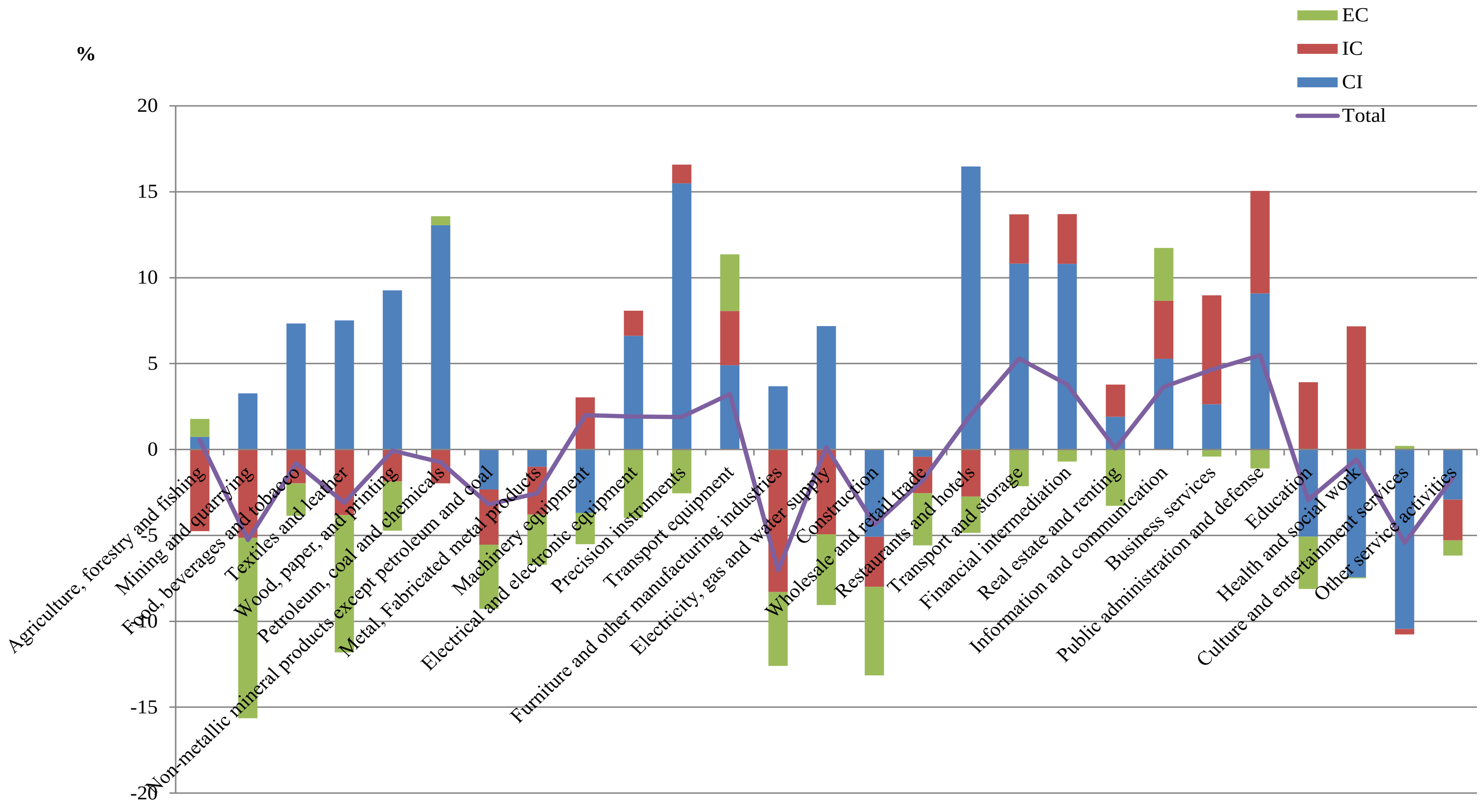


Table 7: A summary of statistics in variables

	Number of Observation	Mean	Standard Derivation	Minimum	Maximam	Median
TFP	2,668	0.004	0.052	-0.634	0.570	0.002221
I(T)	2,668	319,988	388,095	374	2,664,098	177,412
I（E)	2,668	90,931	153,144	218	1,028,715	38,132
I(I)	2,668	175,579	253,326	0	1,767,127	84,710
I（C)	2,668	53,478	114,720	0	1,246,050	15,679
Q	2,668	7,533,394	9,165,578	114,639	64,400,000	4,539,904
I(T)/Q	2,668	0.058	0.087	0.002	1.181	0.029
I(E)/Q	2,668	0.010	0.008	0.001	0.111	0.008
I(I)/Q	2,668	0.042	0.082	0.000	1.121	0.013
I(C)/Q	2,668	0.006	0.008	0.000	0.106	0.004

Table 8 Estimation Results in the Market Economy

Dependent variable: TFP growth

	Market Economy				Market Economy				Market Economy			
ΔZ(T)/Y	0.039243				0.092395				0.020268			
	[1.84]*				[3.29]***				[0.26]			
ΔZ(EC)/Y		0.611667				1.354558				1.271895		
		[1.97]**				[3.46]***				[0.49]		
ΔZ(IP)/Y			0.042621				0.101477				0.014748	
			[1.80]*				[3.25]***				[0.16]	
ΔZ(CI)/Y				1.277961				3.429186				0.567533
				[2.12]**				[3.57]***				[0.84]
⊿TFP(-1)	0.021576	0.020516	0.020362	0.055888	-0.12468	-0.12729	-0.12555	-0.0932	0.097091	0.113682	0.09527	0.118128
	[0.93]	[0.89]	[0.88]	[1.80]	[4.30]***	[4.44]***	[4.32]***	[2.88]***	[2.43]**	[2.04]**	[2.44]**	[2.45]**
Constant	-0.13459	-0.14303	-0.13269	-0.17048	-0.00989	-0.02863	-0.00768	0.032267	-0.12948	-0.15765	-0.12765	-0.14478
	[10.51]***	[9.87]***	[10.58]***	[7.16]***	[0.84]	[1.99]**	[0.66]	[2.06]**	[6.85]***	[2.39]**	[7.66]***	[5.56]***
Year Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	1982-2008	1982-2008	1982-2008	1982-2008	1982-1995	1982-1995	1982-1995	1982-1995	1996-2008	1996-2008	1996-2008	1996-2008
Observations	2576	2576	2576	2576	1380	1380	1380	1380	1196	1196	1196	1196
Number of industry	92	92	92	92	92	92	92	92	92	92	92	92

*** t-values are shown in parenthesis. ***, **, * show that a coefficient is significant at 1%, 5%, and 10% level respectively.**

Table 9-1 Estimation Results in the IT Sector

Dependent variable: TFP growth

	IT Sector				IT Sector				IT Sector			
ΔZ(T)/Y	0.072486				0.113721				0.161623			
	[2.82]***				[3.21]***				[1.43]			
ΔZ(EC)/Y		0.961814				1.524694				3.562959		
		[2.62]***				[2.95]***				[1.20]		
ΔZ(IP)/Y			0.080897				0.126359				0.195682	
			[2.82]***				[3.20]***				[1.58]	
ΔZ(CI)/Y				2.080713				3.60816				-0.42896
				[2.79]***				[3.33]***				[0.39]
⊿TFP(-1)	-0.17207	-0.1785	-0.1737	-0.11977	-0.21966	-0.22785	-0.22118	-0.16397	-0.12831	-0.09615	-0.13293	-0.17749
	[4.74]***	[4.97]***	[4.80]***	[2.67]***	[4.57]***	[4.77]***	[4.59]***	[2.93]***	[2.10]**	[1.22]	[2.24]**	[2.45]**
Constant	-0.09287	-0.10195	-0.08896	-0.17036	0.00252	-0.0139	0.005547	0.006848	-0.11684	-0.17931	-0.11093	-0.05435
	[3.88]***	[4.02]***	[3.77]***	[4.06]***	[0.10]	[0.50]	[0.22]	[0.18]	[3.16]***	[1.98]**	[3.47]***	[0.97]
Year Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	1982-2008	1982-2008	1982-2008	1982-2008	1982-1995	1982-1995	1982-1995	1982-1995	1996-2008	1996-2008	1996-2008	1996-2008
Observations	896	896	896	896	480	480	480	480	416	416	416	416
Number of industry	32	32	32	32	32	32	32	32	32	32	32	32

*** t-values are shown in parenthesis. ***, **, * show that a coefficient is significant at 1%, 5%, and 10% level respectively.**

Table 9-2 Estimation Results in the Non IT Sector

Dependent variable: TFP growth

	Non IT Sector				Non IT Sector				Non IT Sector			
ΔZ(T)/Y	0.017892				0.004384				-0.04845			
	[0.35]				[0.04]				[0.46]			
ΔZ(EC)/Y		4.157022				10.20105				-0.0826		
		[2.15]**				[4.21]***				[0.02]		
ΔZ(IP)/Y			0.011574				-0.018				-0.08277	
			[0.22]				[0.17]				[0.65]	
ΔZ(CI)/Y				2.28089				73.92643				0.436173
				[1.85]*				[2.00]**				[0.60]
⊿TFP(-1)	0.231387	0.268941	0.229889	0.30475	0.005561	0.09152	0.00307	0.176836	0.300374	0.306465	0.300233	0.327834
	[7.44]***	[7.55]***	[7.50]***	[5.77]***	[0.14]	[2.11]**	[0.08]	[1.70]*	[5.74]***	[4.16]***	[5.85]***	[5.39]***
Constant	-0.14799	-0.24006	-0.14661	-0.20579	-0.01114	-0.21919	-0.00973	-0.1744	-0.13583	-0.14021	-0.1354	-0.1533
	[9.57]***	[5.21]***	[10.00]***	[5.72]***	[0.77]	[4.30]***	[0.74]	[1.51]	[6.51]***	[1.57]	[7.19]***	[6.24]***
Year Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	1982-2008	1982-2008	1982-2008	1982-2008	1982-1995	1982-1995	1982-1995	1982-1995	1996-2008	1996-2008	1996-2008	1996-2008
Observations	1652	1652	1652	1652	885	885	885	885	767	767	767	767
Number of industry	59	59	59	59	59	59	59	59	59	59	59	59

*** t-values are shown in parenthesis. ***, **, * show that a coefficient is significant at 1%, 5%, and 10% level respectively.**

Table 10 Alternative Estimation Results in the Market Economy

	Market Economy				Market Economy				Market Economy			
ΔZ(T)/Y	0.045176 [2.13]**				0.152281 [6.29]***				0.066477 [0.87]			
ΔZ(EC)/Y		0.660618 [2.14]**				2.068018 [6.02]***				2.694042 [1.06]		
ΔZ(IP)/Y			0.049116 [2.09]**				0.168122 [6.24]***				0.06191 [0.71]	
ΔZ(CI)/Y				1.57785 [2.63]***				5.877253 [6.25]***				1.236181 [1.83]*
Gap of GDP	0.028512 [4.78]***	0.027589 [4.64]***	0.0286 [4.80]***	0.027485 [4.43]***	0.45279 [8.79]***	0.416821 [7.90]***	0.459271 [8.89]***	0.331221 [5.43]***	0.073685 [8.06]***	0.074644 [7.99]***	0.073479 [8.06]***	0.075039 [7.88]***
Gap of TFP	0.010813 [3.65]***	0.01066 [3.60]***	0.010849 [3.66]***	0.009945 [3.21]***	-0.08349 [1.39]	-0.05281 [0.86]	-0.0906 [1.51]	0.071032 [0.98]	0.008885 [2.82]***	0.009218 [2.88]***	0.008903 [2.83]***	0.008308 [2.53]**
⊿TFP(-1)	0.016295 [0.70]	0.014831 [0.64]	0.014887 [0.64]	0.059428 [1.91]*	-0.26016 [10.11]***	-0.26294 [10.11]***	-0.26158 [10.14]***	-0.20892 [6.76]***	0.066234 [1.68]*	0.097116 [1.78]*	0.061446 [1.61]	0.106479 [2.23]**
Constant	-0.1751 [12.24]***	-0.18265 [11.66]***	-0.17304 [12.30]***	-0.2181 [8.98]***	-0.38865 [15.60]***	-0.41037 [15.50]***	-0.38447 [15.47]***	-0.42568 [12.82]***	-0.22106 [10.41]***	-0.27788 [4.13]***	-0.2164 [11.28]***	-0.25127 [8.83]***
Year Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	1982-2008	1982-2008	1982-2008	1982-2008	1982-1995	1982-1995	1982-1995	1982-1995	1996-2008	1996-2008	1996-2008	1996-2008
Observations	2576	2576	2576	2576	1380	1380	1380	1380	1196	1196	1196	1196
Number of industry	92	92	92	92	92	92	92	92	92	92	92	92

*** t-values are shown in parenthesis. ***, **, * show that a coefficient is significant at 1%, 5%, and 10% level respectively.**

Table 11-1 Alternative Estimation Results in the IT Sector

	IT Sector				IT Sector				IT Sector			
ΔZ(T)/Y	0.067906				0.159989				0.39603			
	[2.90]***				[5.37]***				[4.33]***			
ΔZ(EC)/Y		0.772733				2.126492				7.950519		
		[2.27]**				[4.77]***				[3.13]***		
ΔZ(IP)/Y			0.0761				0.177506				0.42586	
			[2.92]***				[5.34]***				[4.23]***	
ΔZ(CI)/Y				2.352757				5.409177				2.95955
				[3.44]***				[5.04]***				[3.08]***
Gap of GDP	0.441461	0.427626	0.441843	0.474191	0.448759	0.420048	0.454875	0.341335	1.183193	1.281752	1.174773	1.187014
	[11.64]***	[10.89]***	[11.65]***	[11.94]***	[6.67]***	[5.97]***	[6.73]***	[4.15]***	[13.32]***	[12.53]***	[13.21]***	[12.30]***
Gap of TFP	-0.21826	-0.21485	-0.21824	-0.23135	-0.04049	-0.02744	-0.04773	0.133468	-0.5089	-0.5752	-0.50568	-0.51508
	[7.40]***	[7.17]***	[7.39]***	[7.61]***	[0.48]	[0.31]	[0.56]	[1.23]	[9.66]***	[9.73]***	[9.57]***	[9.02]***
⊿TFP(-1)	-0.27302	-0.27665	-0.27462	-0.21843	-0.3386	-0.34456	-0.34094	-0.26136	-0.31366	-0.26041	-0.33071	-0.27276
	[8.07]***	[8.11]***	[8.13]***	[5.41]***	[8.29]***	[8.18]***	[8.31]***	[5.01]***	[6.33]***	[4.10]***	[6.80]***	[4.40]***
Constant	-0.31287	-0.30727	-0.30967	-0.42369	-0.41767	-0.42455	-0.41225	-0.55285	-0.84819	-1.01029	-0.8185	-0.87947
	[11.13]***	[10.92]***	[11.10]***	[9.06]***	[9.08]***	[8.77]***	[8.97]***	[7.88]***	[15.19]***	[9.42]***	[15.53]***	[11.92]***
Year Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	1982-2008	1982-2008	1982-2008	1982-2008	1982-1995	1982-1995	1982-1995	1982-1995	1996-2008	1996-2008	1996-2008	1996-2008
Observations	896	896	896	896	480	480	480	480	416	416	416	416
Number of industry	32	32	32	32	32	32	32	32	32	32	32	32

*** t-values are shown in parenthesis. ***, **, * show that a coefficient is significant at 1%, 5%, and 10% level respectively.**

Table 11-2 Alternative Estimation Results in the Non-IT Sector

	Non IT Sector				Non IT Sector				Non IT Sector			
ΔZ(T)/Y	0.038215 [0.75]				0.384477 [3.94]***				-0.02471 [0.24]			
ΔZ(EC)/Y		5.657607 [2.65]***				13.8133 [5.82]***				0.899691 [0.23]		
ΔZ(IP)/Y			0.032021 [0.59]				0.37467 [3.70]***				-0.06121 [0.50]	
ΔZ(CI)/Y				2.539737 [2.20]**				113.036 [2.45]**				0.789505 [1.11]
Gap of GDP	0.008101 [1.38]	0.017604 [2.50]**	0.007961 [1.35]	0.003528 [0.53]	0.685921 [4.52]***	-0.00029 [0.00]	0.696911 [4.52]***	0.115823 [0.30]	0.050993 [5.54]***	0.051747 [5.44]***	0.050785 [5.51]***	0.051905 [5.46]***
Gap of TFP	0.011255 [4.03]***	0.011891 [4.19]***	0.011264 [4.04]***	0.009435 [2.94]***	-0.36553 [2.27]**	0.407069 [1.98]**	-0.37969 [2.32]**	0.224364 [0.53]	0.010759 [3.42]***	0.010815 [3.41]***	0.01077 [3.42]***	0.010326 [3.16]***
⊿TFP(-1)	0.243673 [7.83]***	0.289717 [7.98]**	0.241376 [7.86]***	0.322223 [6.31]***	-0.11769 [3.32]***	-0.06039 [1.45]	-0.1219 [3.44]***	0.110828 [0.82]	0.284134 [5.44]***	0.299767 [4.13]***	0.282605 [5.51]***	0.322262 [5.31]***
Constant	-0.16954 [9.88]***	-0.30333 [5.52]***	-0.16704 [10.26]***	-0.22517 [6.87]***	-0.36504 [11.58]***	-0.7012 [9.54]***	-0.35097 [11.44]***	-0.65382 [3.84]***	-0.20154 [8.77]***	-0.22581 [2.48]**	-0.19959 [9.45]***	-0.22564 [8.50]***
Year Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	1982-2008	1982-2008	1982-2008	1982-2008	1982-1995	1982-1995	1982-1995	1982-1995	1996-2008	1996-2008	1996-2008	1996-2008
Observations	1652	1652	1652	1652	885	885	885	885	767	767	767	767
Number of industry	59	59	59	59	59	59	59	59	59	59	59	59

* t-values are shown in parenthesis. ***, **, * show that a coefficient is significant at 1%, 5%, and 10% level respectively.

Appendix 1: Measurement of Intangible Investment

Category	Industry classification	Estimation method and data sources
Computerlized information		
Custom and packaged software	108	We use data of custom and package software investment of JIP Database 2011 (JIP asset alassification no. 38).
Own account software	108	We estimate the ratio of the system engineers and programmers to total workers by industry using *Population Census* . Multiplying this ratio by the number of total workers in JIP Database 2011, we obtain the number of SE and programmer by industry. The Census data is available for every five years. For other years, we estimate the ratio by linear interpolation. We multiply the number of estimated workers by the average wage of system engineers and programmers. We get wage data from *Basic Survey on Wage Structure* . We do not take account of other expenditures except labor cost. We used this result as the expenditure for in-house software except the case of the information service industry.
Innovative Property		
Science and enginnering R&D	108	We get data of R&D expenditures from *Survey of Research and Development* . However the survey does not cover R&D data in most of service sectors before 2000. Using service sectors' expenditures for R&D outsourcing, which is available at JIP 2011, we extraporate service sectors' R&D expenditures backwards. Because the survey is conducted on a fiscal-year basis, the values are then converted to a calendar-year basis.
Mineral exploitation	1	Because expenditures of mineral exploitation are allocated to only mining industry, we follow the estimation by Fukao, et, al (2009). The Mining Industry Handbook and the Establishment and Enterprise Survey provide data on expenses for mineral exploitation (the total expenses for geological investigation). Combined the above two surveys with FCFM, we estimate expenditures of mineral exploitation.

Copyright and licence costs	**108**	**Intangible investment in copyright and license costs is assumed to consist of the input from the publishing industry (JIP industry no. 92) and the video picture, sound information, character information production and distribution industry (JIP industry no. 93) to JIP industries nos. 1-71 and 73-107.**
Other product development, design, and research expenses	**108 (2 for prodcut development in financial services**	**In the case of outsourcing of design, display, machine design and architectual design, we estimate intangible investment by using the sales data of these industries in the Survey of Selected Service Industries and the input from the other services for businesses industry (JIP industry no.88). We calculate the ratio of the sales of these industries in the Survey of Selected Service Industries to the nominal output of the other services for businesses industry (JIP industry no.88) of the JIP 2011 Database for each year that the survey was conducted. The survey is conducted every three years. Then, the ratio for years in which the survey was not conducted is obtained by linear interpolation. The estimated value of sales is adjusted by using the number of firms taken from the Establishment and Enterprise Survey because the Survey of Selected Service Industries is a sample survey. In the case of in-house expenditures, we only estimated in-house designing. We estimate the ratio of the designers to total workers by industry using the Population Census. Multiplying this ratio by the number of total workers in JIP Database 2011, we get the number of designers by industry. The Census data is available for every five years. For other years, we estimate the ratio by linear interpolation. We multiply the number of estimated workers by the average wage of designers. We get wage data from the Basic Survey on Wage Structure. We do not take account of other expenditures except labor cost. As for the estimation in product development in financial service, we assume that 8 percent of the compasation of high-skilled labors (workers graduated from college) in the financial industry (JIP industry no. 69) and the insurance industry (JIP industry no. 70) can be regarded as expenditures in intangible assets, following Corrado's suggestions. These expenditures are treated as those in financial sector and insurance industry respectively.**

Economic competencies		
Brand equity	**108**	**We get the input from the advertising industry (JIP industry no. 85) from JIP Database 2011.**
Firm specific human capital	**108**	**We estimate the ratio of off-the-job training costs to the total labor costs from the General Survey on Working Conditions by industry. Multiplying this ratio by the total labor costs in JIP database (2011 version), we get off-the-job trainig costs expensed by firms by industry. For the opportunity cost of off-the-job training in terms of working hours lost, we use the results obtained by Ooki (2003). Using micro-data of The Japan Institute for Labour Policy and Training's *Survey on Personnel Restructuring and Vocational Education/Training Investment in the Age of Performance-based Wage Systems* (Gyoseki-shugi Jidai no Jinji Seiri to Kyoiku/Kunren Toshi ni Kansuru Chosa), Ooki calculated the average opportunity cost ratio of off-the-job training to direct firm expenses for training in 1998 for the whole business sector. The value was 1.51. We use this value to estimate the opportunity cost.**
Organizational structure	**108**	**We assume that 9% of the remuneration of executives is counted as intangible investment for organizational structure, because 9% of the total working time of executives is spent for the organizational reform and the restructuring of organization accroding to Robinson and Shimizu (2001). We calculate the ratio of the remuneration of executives to value added using the *Financial Statements Statistics of Corporations by Industry* published by the Ministry of Finance. Then, we get the expenditure for the organizational structure by industry by multiplying this ratio to value added in JIP database (2011 version)**

Appendix 2: Industry Classification of the IT and non- IT sSectors

JIP code	IT-using manufacturing sector
20	Printing, plate making for printing and bookbinding
23	Chemical fertilizers
24	Basic inorganic chemicals
29	Pharmaceutical products
34	Pottery
38	Smelting and refining of non-ferrous metals
42	General industry machinery
45	Office and service industry machines
46	Electrical generating, transmission, distribution and industrial apparatus
53	Miscellaneous electrical machinery equipment
56	Other transportation equipment
59	Miscellaneous manufacturing industries

JIP code	IT-using non-manufacturing sector
63	Gas, heat supply
67	Wholesale
68	Retail
69	Finance
70	Insurance
79	Mail
85	Advertising
86	Rental of Office equipment and goods
88	Other services for businesses
92	Publishers

JIP code	IT-producing manufacturing sector
47	Household electric appliances
48	Electronic data processing machines, digital and analog computer, equipment and accessories
49	Communication equipment
50	Electronic equipment and electric measuring instruments
51	Semiconductor devices and integrated circuits
52	Electronic parts
57	Precision machinery & equipment

JIP code	IT-producing non-manufacturing sector
78	Telegraph and telephone
90	Broadcasting
91	Information services and internet based services

JIP code	Non-IT intensive manufacturing sector
8	Livestock products
9	Seafood products
10	Flour and grain mill products
11	Miscellaneous foods and related products
12	Prepared animal foods and organic fertilizers
13	Beverages
14	Tobacco
15	Textile products
16	Lumber and wood products
17	Furniture and fixtures
18	Pulp, paper, and coated and glazed paper
19	Paper worked products
21	Leather and leather products
22	Rubber products
25	Basic organic chemicals
26	Organic chemicals
27	Chemical fibers
28	Miscellaneous chemical products
30	Petroleum products
31	Coal products
32	Glass and its products
33	Cement and its products
35	Miscellaneous ceramic, stone and clay products
36	Pig iron and crude steel
37	Miscellaneous iron and steel
39	Non-ferrous metal products
40	Fabricated constructional and architectural metal products
41	Miscellaneous fabricated metal products
43	Special industry machinery
44	Miscellaneous machinery
54	Motor vehicles
55	Motor vehicles parts and accessories
58	Plastic products

JiP code	Non-IT intensive non-manufacturing sector
62	Electricity
64	Waterworks
65	Water supply for industrial use
66	Waste disposal
71	Real estate
73	Railway
74	Road transportation
75	Water transportation
76	Air transportation
77	Other transportation and packing
81	Research(private)
87	Automobile maintenance services
89	Entertainment
93	Video picture, sound information, character information production and distribution
94	Eating and drinking places
95	Accommodations
96	Laundry, beauty and bath services
97	Other services for individuals

JIP code	Other Industries
1	Rice, wheat production
2	Miscellaneous crop farming
3	Livestock and sericulture farming
4	Agricultural Services
5	Forestry
6	Fisheries
7	Mining
60	Construction
61	Civil engineering

Source: Fukao et,al. (2012)