Does Intangible Investment Contribute to a Recovery in the Rate of Return on Capital?

-An Empirical Study Using Japanese KLEMS (JIP) Database-

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Abstract

Since the collapse of the bubble economy, economic growth rates in Japan have slowed down as a result of low capital accumulation. In this study, we focus on the low rate of return on capital, which led to this slow capital accumulation. Using the Japanese KLEMS (JIP) database, we find that the increase in the capital/output ratio and low capital share led to the low rate of return on capital. Not only has the rate of return on capital declined, but its variance has grown and the number of industries with negative rates of return has increased. Then, we estimate a profit function using industry-level data. In our estimation, the profit rate is explained not only by the real wage but also by intangible investments. Estimation results show that investment in IT and human resources leads to an increase in the profit rate. We also find complementary effects among intangibles on the increase in profitability. In particular, in the IT sector, the combination of IT and human resources is a key factor for productivity and profitability. Our study implies that the government should adopt a comprehensive innovation policy including improvements in IT, human resources and organizational structure as well as R&D investments to revitalize capital formation in Japan.

Keywords: Rate of return on capital, Capital/output ratio, Capital share, Intangibles

JEL classification numbers: D22, D24, E22, O33

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1. Introduction

Since the Global Financial Crisis, many advanced countries have suffered from slow growth. In his lecture at the IMF in 2013, Professor Lawrence Summers of Harvard University warned that the US and advanced countries in Europe might follow a similar path as the Japanese economy and suffer from long-term stagnation -- as Japan has seen since the collapse of the bubble economy in the 1990s.[1] He and his followers emphasized that the decline in capital formation and the real interest rate have led to the slow growth rate in advanced countries.[2]

As Summers pointed out, we do observe the slowdown in GDP and capital formation in Japan after the Global Financial Crisis. Figure 1 shows the movements in GDP and private capital formation in the 2000s. While GDP in the period from 2000 to the Global Financial Crisis increased by 40 trillion yen, the increase in GDP is only 20 trillion yen after the Global Financial Crisis. The growth in private capital formation is slower than that in GDP. Compared to the capital formation in the first quarter of 2008, the increase in capital formation in the fourth quarter in 2016 is only 2 trillion yen.

(Place Figure 1 around here)

Before Summers pointed out the issues with the falling real interest rate and corporate profit rate, Japanese economists argued that the inefficiency of capital led to the low real interest rate and profit rate. Ando, Christelis, and Miyagawa (2003) and Hayashi (2006) were critical of the fact that corporate savings in Japan were used for inefficient capital formation that induced low corporate profit. Based on the arguments by Ando, Christelis, and Miyagawa (2003) and Hayashi (2006), Saito (2007) argued that over-investment crowds out consumption and generates welfare loss. Fukao et al. (2016) also confirmed that the over-investment in the 1980s and the 90s led to a high capital/output ratio and a low rate of return on capital. Miyagawa (2004, 2005) suggested that the low

[1] See also Summers (2015)

[2] Solow (2014) also discussed secular stagnation induced by the low capital accumulation at the IMF website (http://www.imf.org/external/pubs/ft/fandd/2014/09/nobels.htm).

corporate profit rate in the 1990s was caused by a high labor share and low TFP growth.[3]

However, the discussions on the falling rate of return on capital have changed since the Global Financial Crisis. According to the Japanese KLEMS (Japan Industrial Productivity, JIP) Database, the real capital stock in Japan has fallen since the Global Financial Crisis despite the historically low interest rate and expanding monetary policy. Thwaites (2015) argued that the decline in nominal investment under the falling real interest rate for the past two decades in the industrialized economies is caused by the following three factors. First, the price of capital has fallen rapidly. Second, households have increased their debt for holding residential assets and for consumption. Third, firms invest in intangibles more than in tangibles. Murase and Ando (2014) showed the possibility of a steady state where firms hold liquid financial assets such as money and government bonds instead of capital because they are afraid that the labor share will rise again. This allows for low capital formation under a zero interest rates. Benigno and Fornaro (2015) also show an equilibrium that represents a secular stagnation by combining a standard short-run Keynesian model and an endogenous growth model. In this equilibrium, underemployment and low potential growth coexists under zero interest rates and pessimistic expectations for future growth.

These studies in the 2010s imply that factor shares and innovations induced by R&D and other intangibles play crucial roles in falling real rates of interest or corporate profit rate. Then, we focus on the long-term movements in rate of return on capital by using the JIP Database and examine whether the wage rate and innovation factors affect rate of return on capital by estimating a modified factor price frontier model.[4]

Movements in the rate of return on capital are broken down into capital/output ratio and capital share. We find that the capital/output ratio is on an upward trend as Fukao et al. (2016) found. In particular, the capital/output ratio in the service sector is very high. Although capital share in the 2000s recovered from that in the 1990s, it was still lower than that in the 1980s. In addition, the relative variance of the average rate of return on capital in the service sector has become larger and the number of industries where we find negative rate of return has increased.

[3] Measuring the equilibrium interest rate in Japan, Kamata (2009) did not find clear evidence that the rate fell. As for the measurement in the long-term equilibrium interest rate in the US, see Hamilton, Harris, Hatzius, and West (2015).
[4] Many studies on investment behavior in Japan suggest that the profit rate (or Tobin's Q indicating future profitability) is the most important determinant of capital formation. See Hayashi (2000).

To be more precise, we estimate a profit function that incorporates intangibles to the standard model by using industry-level data and examining what kind of factors affect the rate of return on capital. Estimation results show, first, that the increase in the wage rate has a negative impact on the rate of return on capital as we would expect in the standard cost minimizing firm. Second, greater investments in IT and human resources lead to higher rate of return on capital. Third, in the IT sector, the complementary effects of investments in IT and human resources are significant. These results lead to the policy implication that the government should conduct comprehensive innovation policies that not only stimulates investment in R&D but also promotes firms to utilize IT and human resources more effectively.

In the next section, we examine the movements in the rate of return on capital, capital/output ratio and capital share by using the JIP Database. In the third section, we estimate a profit function to examine the determinants of the profit rate. In the last section, we summarize our results and present some policy implications.

2. Why has the Rate of Return on Capital Declined?

We show two types of real gross rate of return on capital in the market sector in Figure 3 by using the JIP database.[5] The first measure is the average real rate of return on capital. We obtain this measure by dividing the sum of the operating surplus and consumption of fixed capital by real capital stock.[6] The second measure is the marginal rate of return on capital (marginal product of capital = MPK), which is obtained by the following equation:

$$(1)\quad MPK = \frac{\partial Y}{\partial K} = \alpha * \frac{Y}{K}$$

Y represents value added or output, K represents capital stock, and α represents capital share. Then, we measure the marginal rate of return on capital by dividing capital share

[5] The JIP database is published on the website of the Research Institute of Economy, Trade and Industry. (http://www.rieti.go.jp/en/database/JIP2015/index.html)
[6] Operating surplus and consumption of fixed capital are deflated by the investment deflator by industry.

by capital/output (value added) ratio.[7][8]

(Place Figure 2 around here)

Figure 32 shows that both rates of return on capital in the 2000s were lower than those in the 1980s. However, the average rate of return reverted to previous levels in the 2000s after its fall in the 1990s, although the marginal rates of return have been on a downward trend since the collapse of the bubble economy. Hence, the gap between the average and the marginal rates of return has widened in the 2000s. This gap implies that Japanese firms have concentrated on businesses that earn high profits by restructuring after the financial crisis in Japan, while the rate of return on new investment has declined.

Following Equation (1), we break down the marginal rate of return into capital/output ratio and capital share. Figure 3 shows movements in capital/output ratio. Not only the capital/output ratio in the market sector but also the capital/output ratio in the manufacturing and the service sectors have been on an upward trend as Fukao et al. (2016) pointed out.[9] We find that the increase in the capital/output ratio in the service sector after the collapse of the bubble economy has led to an increase in the capital/output ratio in the market economy.

(Place Figure 3 around here)

Figure 4 shows movements in capital share. Capital share in the market sector was greater than 30% in the 1980s. However, it has been on a downward trend since and marked around 30% in the 2010s as Ando, Christelis, and Miyagawa (2002), and Miyagawa (2004, 2005) pointed out. Capital shares in each sector show a different kind of movement from that in the market sector. The capital share in the manufacturing sector

[7] The KLEMS type database like the JIP database assumes that the marginal rate of return on capital in each asset is captured as the capital service of this asset. This assumption implies that each capital is utilized efficiently. However, as Basu and Fernald (2001), and Miyagawa, Sakuragawa, and Takizawa (2006) showed, the capital utilization rate fluctuates in the short-run. .In addition, Jorgenson et al. (2007), and Fukao et al. (2012) showed that there is a gap between the rate of return on capital at the aggregate level and at the industry level due to the misallocation of capital input.

[8] In Figure 3, Y is measured by value added.

[9] The service sector in our paper consists of the non-manufacturing industries except agriculture, forestry, fishing, and mining industries in the market sector.

seems to be cyclical. It was restored in the 2000s after its fall in the 1990s. On the other hand, the capital share in the service sector shows an upward trend. This upward trend may be generated by the rising share of irregular workers whose wages are lower than regular workers.[10]

(Place Figure 4 around here)

Figure 5 shows the marginal rates of return on capital by industry in 1980 and 2012. We find not only that the number of industries with negative rates of return has risen, but also that there are vast differences in rates of return on capital by industry. [11] We show variances and relative standard deviations (=standard deviation/mean) in the average rate of return on capital in Table 1. In Table 1, we observe that variances in the rates of return in the service sector have become larger in the 21st century, while those in the market and the manufacturing sectors have decreased as the rates of return fall. The relative standard deviations in the service sector also have increased, which affect the increase of the relative standard deviations in the market economy.

(Place Figure 5 and Table 1 around here)

3. Estimation Results

In this section, we examine how the rates of return fluctuate empirically. Taking the log in Equation (1), we obtain the following equation:

$$\ln r_t = \ln \alpha + \ln(Y_t / K_t) \quad (2),$$

where r is the marginal rate of return on capital. When we assume a Cobb-Douglas function ($Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$), Y is value added. L is labor input, K is capital input, and A is a technological factor. Equation (2) leads to:

[10] Capital share in the market sector is lower than in the manufacturing and service sectors. This implies that the capital shares in agriculture fishery, fishing, and mining industries are very low.

[11] Nomura (2004) also found large variances in rates of return on capital by industry. As we use the JIP database, the rate of return on capital is measured by activity base. Firms combine some of the activities listed in JIP database.

$$\ln r_t = \ln \alpha + \ln A_t + (1-\alpha)\ln(L_t / K_t) \quad (3)$$

When firms minimize their costs, (L/K) is negatively correlated with relative factor price (w/r). Arranging Equation (3) with respect to ln r, we obtain:

$$\ln r_t = const. + aw_t + bA_t. \quad (4)$$

When we assume that the technological factor is positively correlated with intangibles such as IT, R&D and other intangibles, equation (4) can be rewritten as follows.

$$\ln r_{jt} = const. + a_1 \ln w_{jt} + a_2 \ln(\frac{IT_{jt}}{K_{jt}^{IT}}) + a_3 \ln(\frac{RD_{jt}}{K_{jt}^{RD}}) + a_4 \ln(\frac{HR_{jt}}{K_{jt}^{HR}}) + a_5 \ln Y_{jt} + \mu_j + \eta_t + \varepsilon_{jt} \quad (5)$$

In this expression, *IT* and K^{IT} account for the capital formation (i.e., investments) in information technology and its capital stock, respectively, while *RD* and K^{RD} denote the capital formation in R&D and its capital, respectively.[12] Furthermore, *HR* and K^{HR} are used to include the capital formation in human resources and its capital stock. Y is the log of value added by industry as a control variable. Subscripts j and t denote the industry and time while μ_j and η_t denote industry and year fixed effects. [13][14]

As a proxy for a productivity variable in Equation (5), IT, R&D & human capital investments are used. Such presumptions based on the discussion in Corrado et al. (2009) indicate that the contribution of intangible capital deepening, especially that of IT capital, to labor productivity growth is high in the U.S. In order to verify this presumption, we

[12] Note that the "IT investments" used in the estimations do not account for investment in hardware associated with IT but only for the investments in software.

[13] In order to explicitly focus on the rate of return on tangible capital, we subtract the contribution of custom software from the rate of return on capital, which originally includes the contribution of intangibles.

[14] According to the Monthly Labor Survey compiled by Ministry of Health, Labor and Welfare, real wage has been declining since 2000. Contrary to this widely used statistic, the data series accounting for real wage used in the present paper that is obtained from JIP database, shows a growing trend. The discrepancy between these data series is partly due to the inclusion of income associated with the self-employed in the JIP database.

study the effects of intangibles on the rate of return on tangible capital through the estimation of the equation above.

In Equation (5), we are able to examine the contribution of a single intangible asset on the rate of return on capital. However, the Economic Report of the President in 2007 emphasized that complementary effects between intangibles improve productivity. Then, we add the cross terms between IT and R&D and between IT and human capital to Equation (5) and estimate the following equation.

$$\begin{aligned}\ln r_{jt} = const. + a_1 \ln w_{jt} + a_2 \ln(\frac{IT_{jt}}{K_{jt}^{IT}}) + a_3 \ln(\frac{RD_{jt}}{K_{jt}^{RD}}) + a_4 \ln(\frac{HR_{jt}}{K_{jt}^{HR}}) \\ + a_5 \ln(\frac{IT_{jt}}{K_{jt}^{IT}}) \ln(\frac{RD_{jt}}{K_{jt}^{RD}}) + a_6 \ln(\frac{IT_{jt}}{K_{jt}^{IT}}) \ln(\frac{HR_{jt}}{K_{jt}^{HR}}) + a_7 \ln Y_{jt} + \mu_j + \eta_t + \varepsilon_{jt}\end{aligned} \quad (6)$$

Given the presumption that an increase in labor share (decline in capital share) would lead to a decrease in the rate of return on capital, we predict the sign of the coefficient as $a_1 < 0$. Then, $a_2 > 0, a_3 > 0, a_4 > 0$ can also be predicted because an increase in intangible investments is expected to improve productivity Thus, intangibles have positive effects on the rate of return on tangible capital. If estimation results show $a_5 > 0, a_6 > 0$, we find there to be complementary effects among intangibles.

The data we use in the present study is obtained from the JIP 2015 database. Note that our analysis focuses on the market economy over the periods from 1985 to 2012, and consists of 92 industries. Appendix 1 provides a more detailed description of our data set. Table 2 shows the summary statistics for the variables used in our analysis.

(Place Table 2 around here)

For the rate of return on capital -- that we use for our dependent variables -- both the marginal and average rates of return are employed. Table 3 shows the results of the industry-level fixed-effect estimation for the market economy. A dependent variable in columns (1) to (4) is the marginal rate of return on capital and a dependent variable in columns (5) to (8) is the average rate of return on capital. First, we can see that the

coefficient on wage is negative and significant in all estimations, which is consistent with our expectations. Second, the coefficient on the IT investment ratio is positive and significant in almost all estimations. Third, the coefficient on the R&D investment ratio is negative and significant when we estimate Equation (5). However, when we estimate Equation (6), it turns to be positive. Fourth, the coefficient on the human resource (HR) investment ratio is positive and significant, suggesting that larger investments in HR in fact lead to higher rates of return on capital.

Cross terms between intangibles show positive coefficients in all estimations. In particular, the coefficient on the cross term between IT and R&D is positive and significant in all estimations. The results show the complementary effects among intangibles on productivity.

(Place Table 3 around here)

Given these baseline results, we implement an additional subsample analysis. That is, we have divided our sample into the IT sector and the non-IT sector.[15][16] In Table 4, we show the estimation results in the IT sector. The coefficient of real wage in the IT sector is negative and significant as in Table 3. The coefficient on IT shows positive and significant signs, while that in R&D shows negative signs in all estimations. We find expected and significant signs on human capital when we estimate Equation (6). Compared to the results in Table 3-1, the coefficients of IT and human resources in the IT sector are larger than those in the market sector. The results suggest that the capital formation in IT and human resources contribute to productivity improvement in the IT sector more than that in the market sector. The results on cross terms are different from those in Table3. While the cross term between IT and R&D is positive and significant in the market sector, we find positive and significant coefficients on cross term between IT and human capital. The estimation results suggest that intangibles, in particular the combination between IT and human resources are crucial factors for profitability

[15] We define the industry whose ratio of IT assets to total assets is above the median value in 2005 as the IT industry. The industry classification of the IT sector and the non-IT sector is described in Appendix 2.

[16] We also conduct regressions in the manufacturing and non-manufacturing sectors. While capital formation in IT and human resources and cross terms between IT and R&D, and between IT and human resources lead to increases in productivity and profitability in the manufacturing sector, we find no significant effects of intangibles on productivity in the non-manufacturing sector.

improvements in the IT sector.

(Place Table 4 around here)

In Table 5, we show the estimation results in the non-IT sector. As in Tables 3 and 4, we find negative and significant signs on real wage. However, in contrast with the results in Table 4, the contribution of IT investment is ambiguous. Instead, R&D investment leads to a significant increase in profitability when we estimate Equation (6). The cross term between IT and R&D also increases profits significantly, while the coefficient on the cross term between IT and human resources is positive but insignificant. The results suggest R&D investment is a key factor for the improvement in productivity and profitability in the non-IT sector. When the IT investment and R&D investment increase at the same time, the positive effect of R&D investment on profitability increases further.

(Place Table 5 around here)

4. Conclusion and Policy Implications

Since the collapse of the bubble economy, the Japanese economy has suffered from long-term stagnation. Advanced countries in the US and Europe are following the Japanese experience after the Global Financial Crisis. One of the main issues on long-term stagnation is the low growth rate induced by a stagnant capital formation under low interest rates. In this paper, we focus on the movements in the real rate of return on capital to understand secular stagnation by using the Japanese KLEMS (JIP) database.

First, we break down the rate of return on capital into the capital/output ratio and the capital share. We find that the capital/output ratio has an upward trend. In particular, the capital output ratios in the service sector are very high, which indicates that service industries have accumulated inefficient capital stock. These findings are consistent with the argument in Fukao, et al. (2016) On the other hand, the capital share seems to be cyclical, but the capital share in the 2000s is lower than that in the 1980s as Ando, Christelis, and Miyagawa (2002) and Miyagawa (2004, 2005) pointed out. The

downward trend in the rate of return on capital leads to an increase in the number of industries with negative profit rate. In addition, the greater relative standard deviation in the service sector indicates that industry-level factors affect the dispersion of the rate of return on capital in this sector.

Based on these findings, we estimate a profit function where the profit rate is affected by factor prices and productivity. As determinants of productivity, we choose some intangibles such as IT investment and R&D investment. As an important feature associated with the Japanese economy, while the level of IT investment and R&D investment are relatively high in Japan, the rate of return on capital, which could potentially benefit from such high investments, is low. In order to clarify the mechanism governing this feature, we include a couple of intangible assets in the estimated equation.

From the obtained estimate results, first, we can see that a higher real wage is associated with a lower rate of return as expected from the cost-minimizing behavior of the firm. This might imply that a policy measure intended to directly increase wages does not necessarily stimulate capital formation. Second, strong positive effects on the rate of return on capital associated with investment in IT and human resources can be seen in the results for the market economy. It is important to note that such a result is confirmed despite the rapid decline in investments on human resources since 2000 in Japan, shown in Figure 8[17]. Third, the most significant result is that the complementary effects among intangibles contribute to the increase in profitability. In particular, the complementary effects between IT and human resources are crucial factors for the improvement in productivity and profitability.

Our estimation results provide us with important policy implications. The Japanese government supports specific investment such as IT investment and R&D investment individually. However, our study shows that some combinations among intangibles are more effective to improve productivity and profitability than each intangible investment separately. In particular, the comovement of IT investment and human resource investment is crucial. Unfortunately, as seen in Table 8, investment in human resources in Japan has decreased drastically since the collapse of the bubble

[17] Fukao and Otaki (1993), Otaki (1995) provided a model where conventional capital formation is associated with human capital accumulation. Otaki and Yaginuma (2014) emphasized that skill in human capital is crucial for firm growth.

economy, while IT investment has increased, thanks to the support from the government. Our study implies that the positive effect of government support to IT investment leading to productivity improvement is offset by the decrease in human resource investment. If the government wants to implement policies to enhance productivity in the Japanese economy, it should support intangibles comprehensively.

(Place Figure 8 around here)

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Table 1 Variances and Relative Standard Deviations in the Average Rate of Return on Capital

		1990	2000	2012
Market economy	**Variance**	**1197.8**	**652.3**	**453.2**
	Relative SD	**1.3**	**1.4**	**1.7**
Manufacturing	**Variance**	**1535.0**	**786.1**	**191.2**
	Relative SD	**1.3**	**1.4**	**1.1**
Service	**Variance**	**837.0**	**566.3**	**953.2**
	Relative SD	**1.1**	**1.3**	**2.0**

Table 2 Summary Statistics: Market Economy 1985-2012

Variables	Definitions	Mean	Std. Dev	Min	Max	Obs
r_marginal	Marginal rate of return on capital	22.674	26.287	0.022	237.888	1,762
r_average	Average rate of return on capital	22.431	30.083	0.027	385.338	1,762
w	Wage	3.438	3.194	0.456	34.304	1,762
IT/K_{IT}	Capital formation in IT over IT capital stock	0.360	0.061	0.144	0.609	1,762
RD/K_{RD}	Capital formation in R&D over R&D capital stock	0.185	0.069	0.034	0.577	1,762
HR/K_{HR}	Capital formation in Human Resources over Human Resources capital st	0.378	0.061	0.195	0.560	1,762
Y	Value added	3781351	5651996	47902.62	3.87E+07	1,762
ln r_marginal	Log of marginal rate of return on capital	-1.899	0.954	-8.422	0.867	1,762
ln r_average	Log of average rate pf return on capital	-1.921	0.947	-8.208	1.349	1,762
ln w	Log of wage	1.044	0.547	-0.785	3.535	1,762
ln IT/K_{IT}	Log of capital formation in IT over IT capital stock	-1.037	0.170	-1.939	-0.495	1,762
ln RD/K_{RD}	Log of capital formation in R&D over R&D capital stock	-1.752	0.374	-3.386	-0.550	1,762
ln HR/K_{HR}	Log of capital formation in R&D over R&D capital stock	-0.987	0.164	-1.635	-0.580	1,762
ln Y	Log of value added	14.455	1.164	10.777	17.472	1,762

Notes: All the variables are converted into values in constant prices for the year 2000. We obtain the data from JIP2015 database.

Table 3-1 Basic Estimation Results in the Market Economy

Dependent variable: Marginal rate of return on capital								
	(1)		(2)		(3)		(4)	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
ln w	0.491	0.052 ***	-0.664	0.058 ***	0.487	0.052 ***	-0.678	0.057 ***
ln IT/K_{IT}	0.071	0.103	0.147	0.083 *	1.504	0.579 ***	2.081	0.468 ***
ln RD/K_{RD}	-0.181	0.051 ***	-0.176	0.041 ***	0.241	0.234	0.464	0.189 **
ln HR/K_{HR}	0.361	0.116 ***	0.205	0.094 **	1.155	0.649 *	1.146	0.524 **
ln IT/K_{IT}*ln RD/K_{RD}					0.401	0.220 *	0.611	0.178 ***
ln IT/K_{IT}*ln HR/K_{HR}					0.764	0.613	0.907	0.495 *
ln Y			1.412	0.048 ***			1.424	0.048 ***
Constant	-2.954	0.206 ***	-21.851	0.663 ***	3.128	0.625 ***	-15.412	0.799 ***
	Fixed-effects model		Fixed-effects model		Fixed-effects model		Fixed-effects model	
Number of obs	1,773		1,762		1,773		1,762	
Number of groups	70		70		70		70	
Prob > F	0		0		0		0	
R-sq:								
within	0.3174		0.5534		0.3206		0.5596	
between	0.2334		0.0077		0.2351		0.0075	
overall	0.2323		0.0525		0.2337		0.052	

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 3-2 Basic Estimation Results in the Market Economy

Market economy								
Dependent variable: Average rate of return on capital								
	(5)		(6)		(7)		(8)	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
ln w	-0.131	0.053 **	-1.211	0.060 ***	-0.133	0.053 **	-1.222	0.060 ***
ln IT/K_{IT}	0.168	0.103	0.239	0.087 ***	1.081	0.582 *	1.612	0.488 ***
ln RD/K_{RD}	-0.141	0.051 ***	-0.136	0.043 ***	0.282	0.236	0.489	0.197 **
ln HR/K_{HR}	0.438	0.116 ***	0.295	0.098 ***	0.669	0.652	0.658	0.546
ln IT/K_{IT}*ln RD/K_{RD}					0.405	0.222 *	0.598	0.186 ***
ln IT/K_{IT}*ln HR/K_{HR}					0.223	0.616	0.353	0.515
ln Y			1.320	0.050 ***			1.330	0.050 ***
Constant	-1.863	0.206 ***	-19.523	0.689 ***	3.679	0.628 ***	-13.640	0.832 ***
	Fixed-effects model		Fixed-effects model		Fixed-effects model		Fixed-effects model	
Number of obs	1,773		1,762		1,773		1,762	
Number of groups	70		70		70		70	
Prob > F	0		0		0		0	
R-sq:								
within	0.3095		0.5171		0.3115		0.5213	
between	0.1964		0.0001		0.1929		0.0001	
overall	0.0747		0.0235		0.075		0.0234	

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 4 Estimation Results in the IT Industries

Dependent variable: Marginal rate of return on capital								
	(1)		(2)		(3)		(4)	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
ln w	0.553	0.074 ***	-0.599	0.081 ***	0.556	0.075 ***	-0.612	0.081 ***
ln IT/K_{IT}	0.287	0.150 *	0.357	0.123 ***	1.423	0.816 *	2.308	0.672 ***
ln RD/K_{RD}	-0.251	0.070 ***	-0.268	0.058 ***	-0.767	0.451 *	-0.202	0.371
ln HR/K_{HR}	0.157	0.159	-0.003	0.131	2.230	0.920 **	1.968	0.754 ***
ln IT/K_{IT}*ln RD/K_{RD}					-0.494	0.421	0.054	0.346
ln IT/K_{IT}*ln HR/K_{HR}					2.011	0.879 **	1.914	0.720 ***
ln Y			1.421	0.065 ***			1.429	0.065 ***
Constant	-3.187	0.303 ***	-22.241	0.909 ***	2.551	0.886 ***	-15.750	1.102 ***
	Fixed-effects model		Fixed-effects model		Fixed-effects model		Fixed-effects model	
Number of obs	1,051		1,040		1,051		1,040	
Number of groups	41		41		41		41	
Prob > F	0		0		0		0	
R-sq:								
within	0.3331		0.4194		0.3367		0.5597	
between	0.2438		0.0003		0.2432		0.0429	
overall	0.2847		0.0267		0.2856		0.0761	

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 5 Estimation Results in the non-IT Industries

Dependent variable: Marginal rate of return on capital								
	(1)		(2)		(3)		(4)	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
ln w	0.522	0.076 ***	-0.620	0.080 ***	0.524	0.076 ***	-0.620	0.080 ***
ln IT/K_{IT}	-0.108	0.140	-0.031	0.108	1.253	0.862	1.581	0.666 **
ln RD/K_{RD}	-0.111	0.072	-0.076	0.056	0.540	0.265 **	0.558	0.205 ***
ln HR/K_{HR}	0.696	0.182 ***	0.419	0.142 ***	0.935	0.982	0.961	0.759
ln IT/K_{IT}*ln RD/K_{RD}					0.642	0.252 **	0.625	0.195 ***
ln IT/K_{IT}*ln HR/K_{HR}					0.222	0.918	0.510	0.709
ln Y			1.418	0.068 ***			1.420	0.067 ***
Constant	-2.668	0.285 ***	-21.760	0.939 ***	3.299	0.934 ***	-15.549	1.147 ***
	Fixed-effects model		Fixed-effects model		Fixed-effects model		Fixed-effects model	
Number of obs	722		722		722		722	
Number of groups	29		29		29		29	
Prob > F	0		0		0		0	
R-sq:								
within	0.3418		0.6041		0.3497		0.6125	
between	0.2686		0.0044		0.2592		0.0045	
overall	0.1973		0.031		0.1921		0.0306	

Figure 1

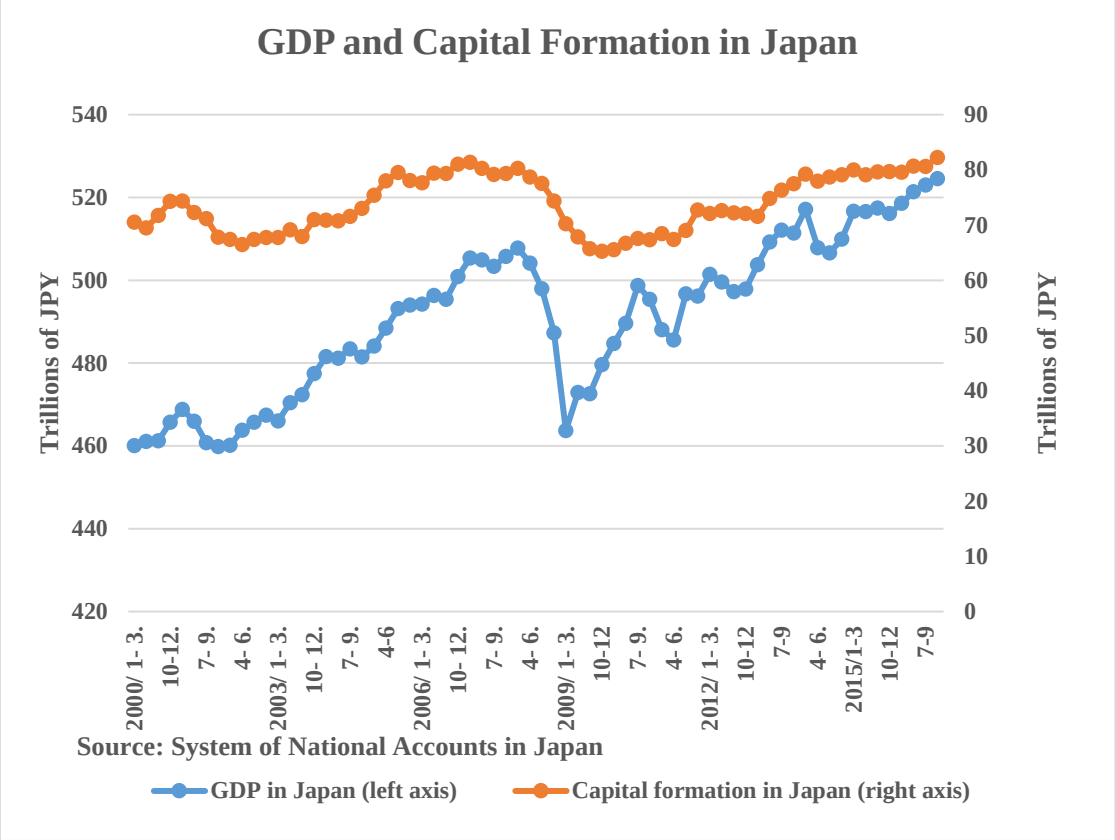

GDP and Capital Formation in Japan
Trillions of JPY
Trillions of JPY
540
520
500
480
460
440
420
90
80
70
60
50
40
30
20
10
0
2000/ 1- 3.
10-12.
7- 9.
4- 6.
2003/ 1- 3.
10- 12.
7- 9.
4-6
2006/ 1- 3.
10- 12.
7- 9.
4- 6.
2009/ 1- 3.
10-12
7- 9.
4- 6.
2012/ 1- 3.
10-12
7-9
4- 6.
2015/1-3
10-12
7-9
Source: System of National Accounts in Japan
GDP in Japan (left axis)
Capital formation in Japan (right axis)

Figure 2 Movements in Rate of Return on Capital

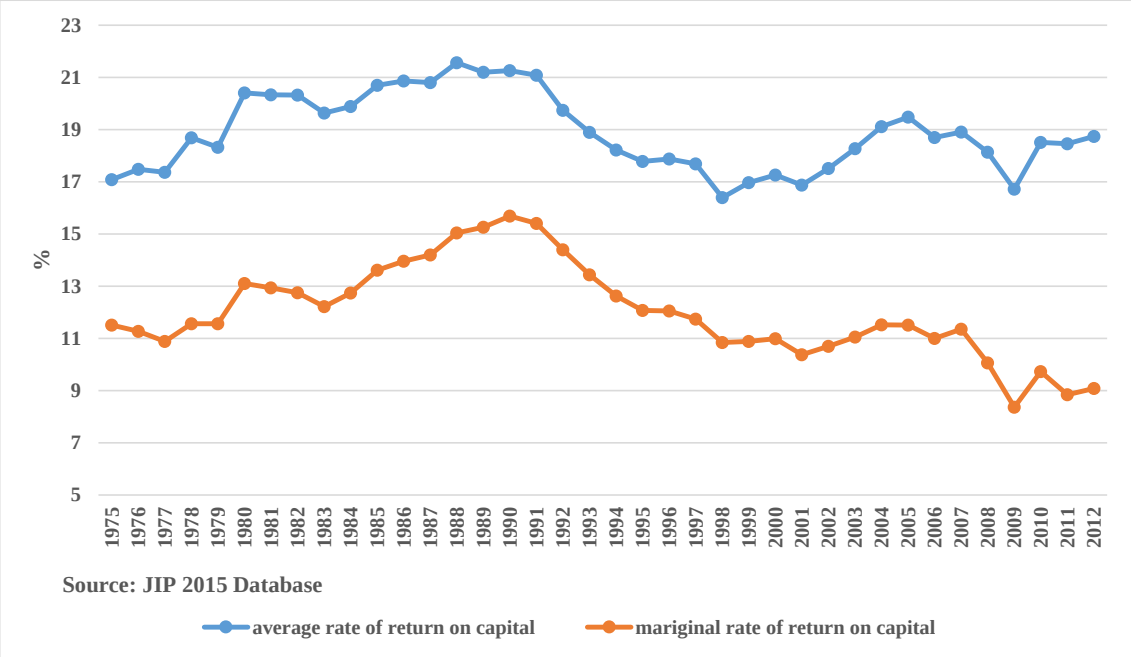


Figure 3 Capital/output Ratios in Japan

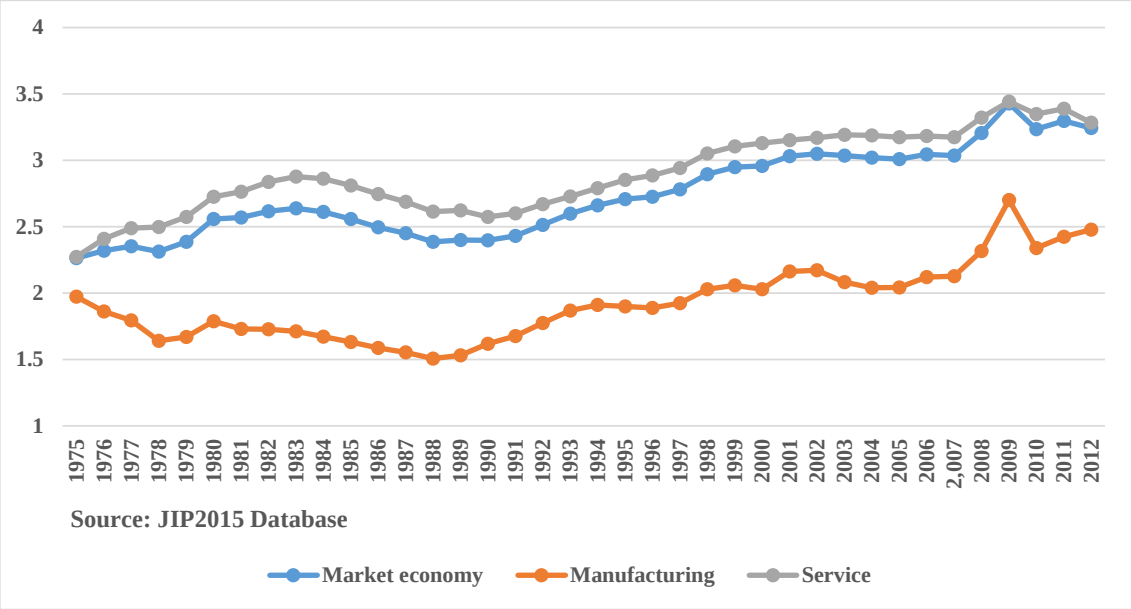


Figure 4 Capital Share in Japan

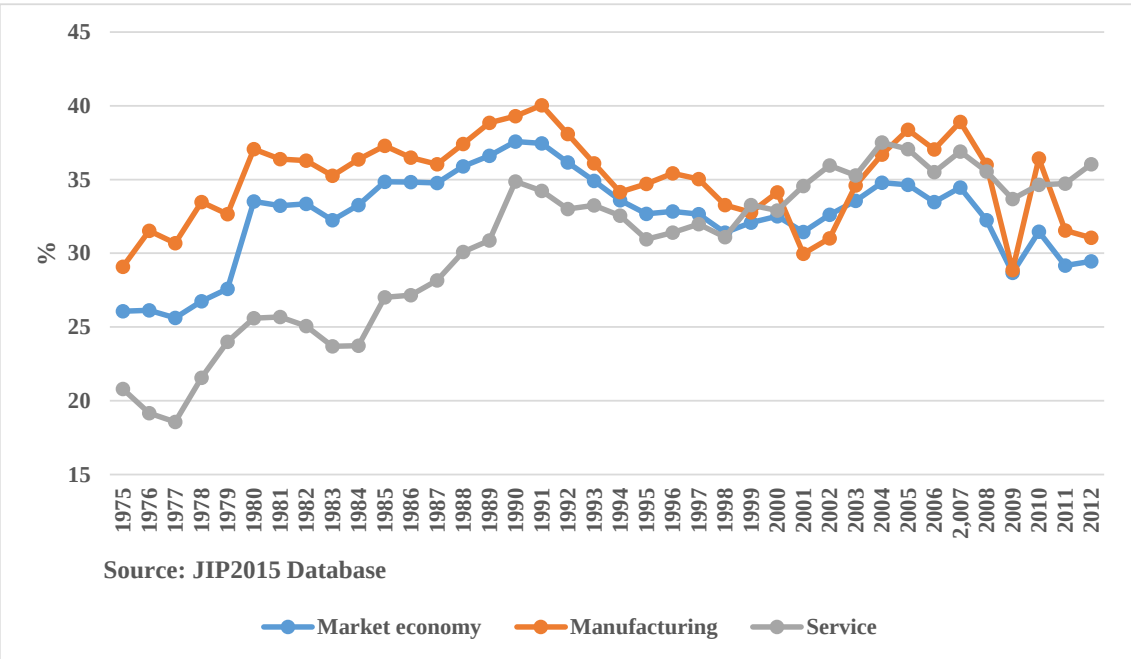


Figure 5-1 Marginal Rate of Return on Capital by Industry (1980)

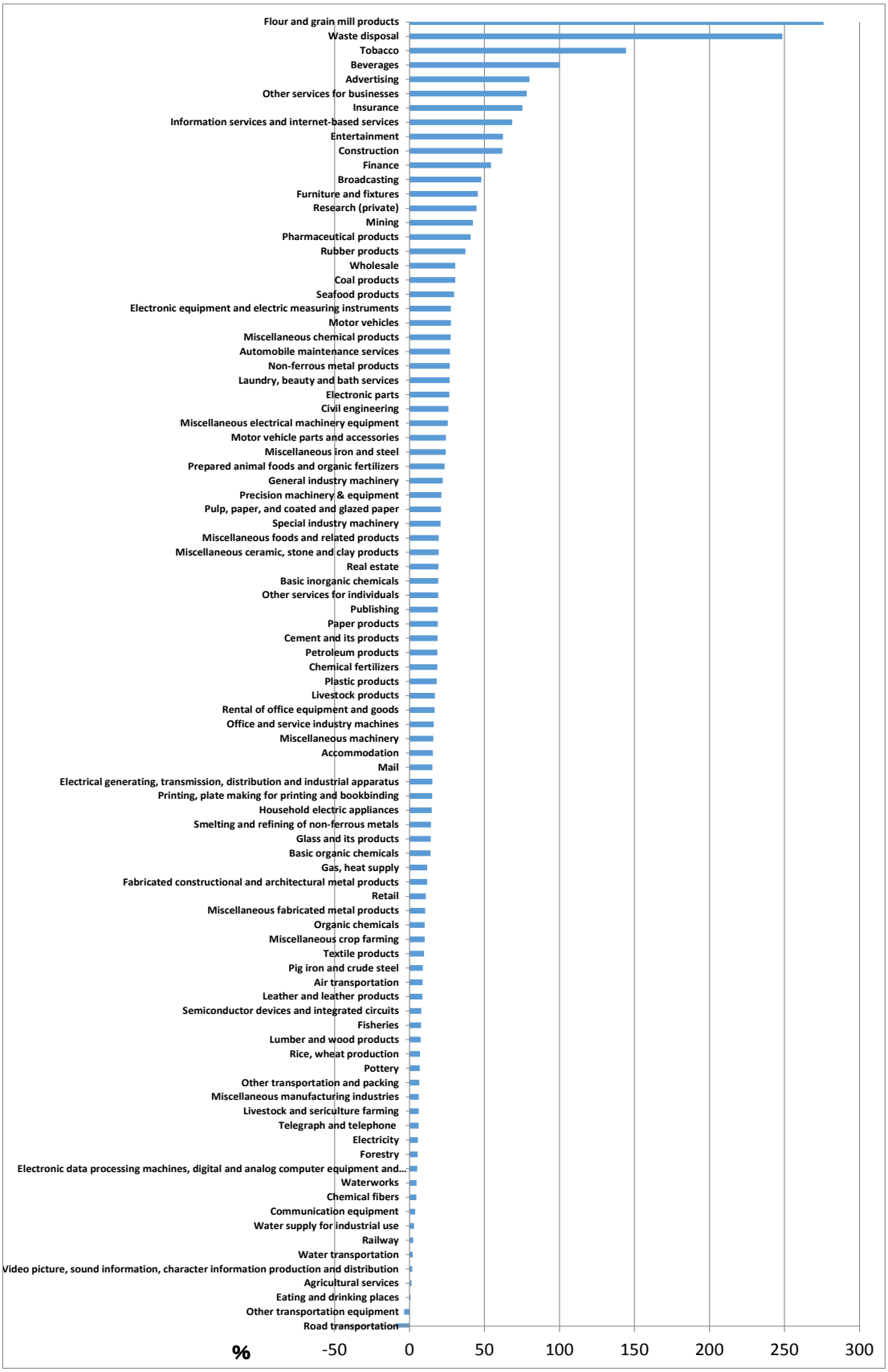


Figure 5-2 Marginal Rate of Return on Capital by Industry (2012)

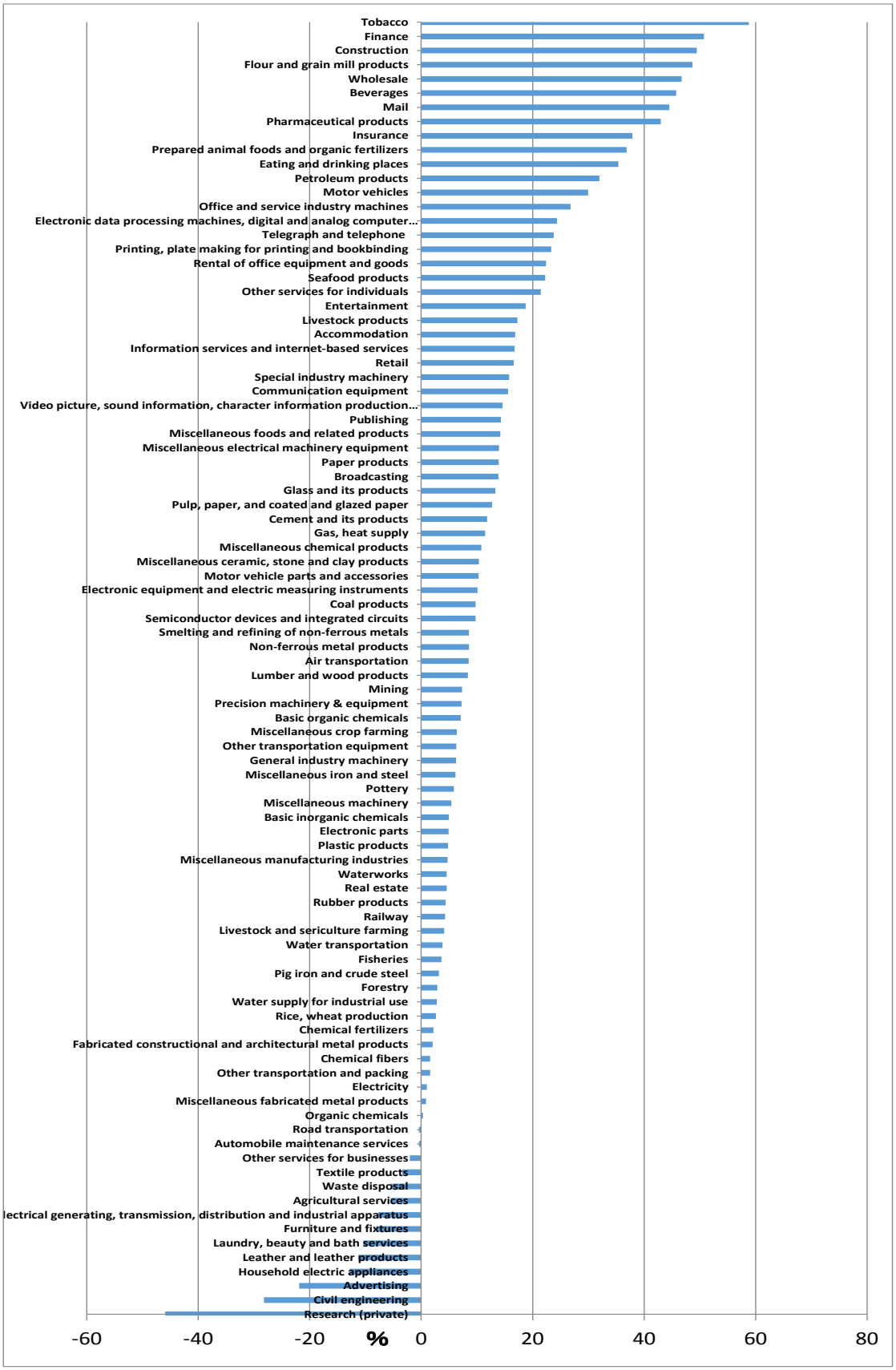
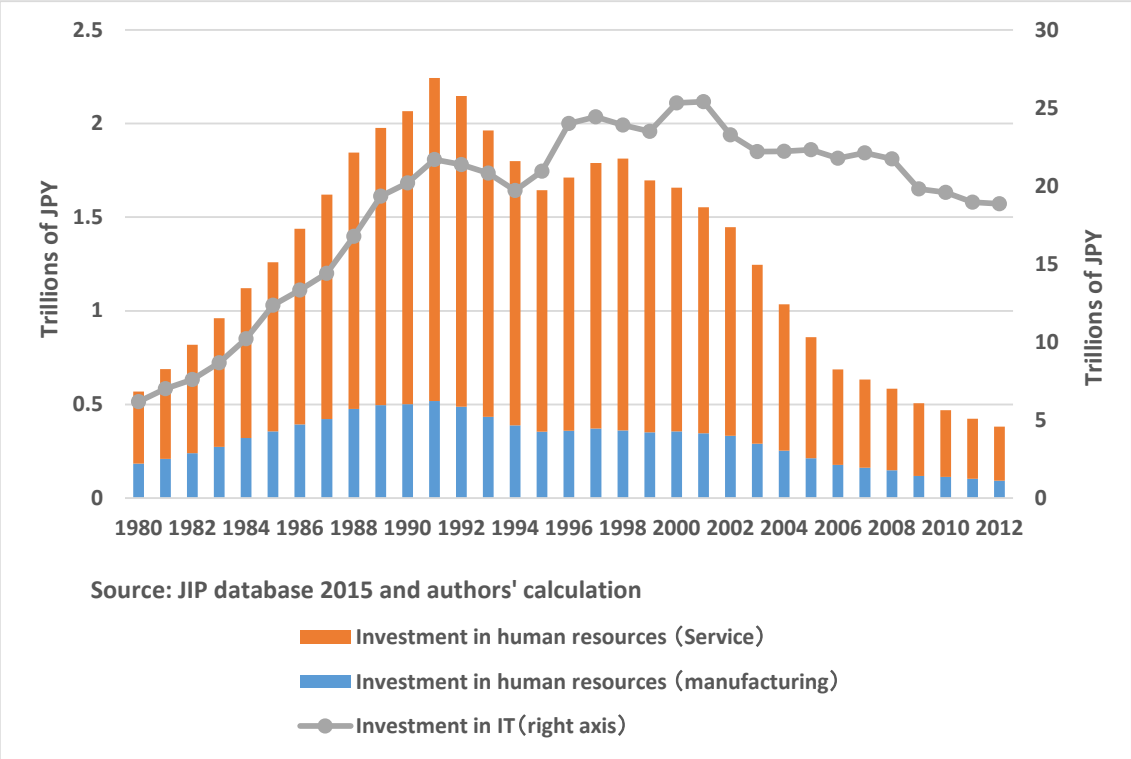


Figure 8 Investment in IT and Human Resources



Appendix 1 Data definitions

Variables	**Definitions**	**Constructions**
r_marginal	Marginal rate of return on capital	Capital share × (Value added / Net capital stock)
r_average	Average rate of return on capital	(Operating surplus +Consumption of fixed capital) / Net capital stock
w	Wage rate	Labor share×value added / Man-hours
IT	Capital formation in Information Technology (IT)	See Chun et al. (2015)
K_{IT}	IT capital stock	See Chun et al. (2015)
RD	Capital formation in R&D over R&D capital stock	See Chun et al. (2015)
K_{RD}	R&D capital stock	See Chun et al. (2015)
HR	Capital formation in Human Resources	See Chun et al. (2015)
K_{HR}	Human Resources capital stock	See Chun et al. (2015)

Notes: All the variables are converted into values in constant prices for the year 2000. We obtain the data from JIP2015 database.

Appendix 2

JIP Classification No.	IT industries
9	Seafood products
10	Flour and grain mill products
17	Furniture and fixtures
20	Printing, plate making for printing and bookbinding
21	Leather and leather products
22	Rubber products
23	Chemical fertilizers
24	Basic inorganic chemicals
25	Basic organic chemicals
27	Chemical fibers
28	Miscellaneous chemical products
29	Pharmaceutical products
34	Pottery
38	Smelting and refining of non-ferrous metals
40	Fabricated constructional and architectural metal products
41	Miscellaneous fabricated metal products
42	General industry machinery
43	Special industry machinery
44	Miscellaneous machinery
45	Office and service industry machines
46	Electrical generating, transmission, distribution and industrial apparatus
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
52	Electronic parts
53	Miscellaneous electrical machinery equipment
56	Other transportation equipment
57	Precision machinery & equipment
59	Miscellaneous manufacturing industries
63	Gas, heat supply
67	Wholesale
68	Retail
69	Finance
70	Insurance
78	Telegraph and telephone
79	Mail
81	Research (private)
85	Advertising
86	Rental of office equipment and goods
88	Other services for businesses
90	Broadcasting
91	Information services and internet-based services
92	Publishing
93	Video picture, sound information, character information production and distribution
96	Laundry, beauty and bath services

JIP Classification No.	Non-IT industries
1	Rice, wheat production
2	Miscellaneous crop farming
3	Livestock and sericulture farming
4	Agricultural services
5	Forestry
6	Fisheries
7	Mining
8	Livestock 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
18	Pulp, paper, and coated and glazed paper
19	Paper products
26	Organic chemicals
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
51	Semiconductor devices and integrated circuits
54	Motor vehicles
55	Motor vehicle parts and accessories
58	Plastic products
60	Construction
61	Civil engineering
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
87	Automobile maintenance services
89	Entertainment
94	Eating and drinking places
95	Accommodation
97	Other services for individuals