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Declining Rate of Return on Capital and the Role of Intangibles in Japan[1]

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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. We focus on the low rate of return on capital, which led to this slow capital accumulation. 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 also its variance has grown and the number of industries with negative rates of return has increased. Then, we estimate a modified factor price frontier model using industry-level data. In our estimations, the profit rate is explained not only by the real wage but also by intangible investments. Estimation results show that investment in human resources leads to an increase in the profit rate. However, the complementary effects between information technology (IT) or research and development (R&D) capital and tangible capital are indefinite as suggested by Chun et al. (2015). Our study implies that the government should take a comprehensive innovation policy including improvements in human resources and organizational structure as well as IT and R&D investments to revitalize capital formation in Japan.

Keywords: Rate of return on capital, Capital/output ratio, Capital share, Factor price frontier, 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 rate. In his lecture at IMF in 2013, Summers warned that the US and advanced countries in Europe might follow the Japanese economy and suffer from a similar long-term stagnation that 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 real interest rate have led to the slow growth rate in advanced countries.[2]

As Summers pointed out, the slowdown in capital accumulation in Japan has been dramatic. Figure 1 shows the growth rates in private capital formation in the first three years of the recovery period in the 2000s. We find that the growth rate has gradually slowed down and the growth rate during the 'Abenomics' period is the lowest of the three recovery periods.

(Place Figure 1 around here)

This slow capital accumulation led to stagnated growth in Japan. In particular, the gap in economic growth between Japan, the US, and East Asian countries in the 2000s is not a result of the gap in the contributions in labor input but of the gap in contributions in capital input as shown in growth accounting in Figure 2.

(Place Figure 2 around here)

Before Summers pointed out the issues on the falling real interest rate and corporate profit rate, Japanese economists argued that it was the inefficiency of capital which 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 (2012) 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 corporate profit rate in the 1990s was caused by a high labor share and low TFP growth.[3]

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[1] See also Summers (2015)

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

[3] Measuring the equilibrium interest rate in Japan, Kamata (2009) did not find clear evidences that the rate fell. As for the measurement in the long-term equilibrium interest rate in the US, see Hamilton, Harris, Hatzius, and West

However, the discussions on the falling rate of return on capital have changed since the Global Financial Crisis. According to the Japan Industrial Productivity Database, the real capital stock in Japan has fallen since the Global Financial Crisis despite the historically low interest rate and expanding monetary policy. Thwates (2015) argued that the decrease 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 steady state where economic agents hold money instead of capital under weak governance. This allows for a high labor share and a zero interest rate. 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 expectation on 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 long-term movements in rate of return on capital by using the Japan Industrial Productivity (JIP) Database and examine whether wage rate and innovation factors affect rate of return on capital by estimating a modified factor price frontier model.[4]

Movements in 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 (2012) found. In particular, the capital/output ratio in the non-IT industries 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 was very large in 2012 and the number of industries where we find negative rate of return has increased.

To be more precise, we estimate the modified factor price frontier model, which incorporates intangibles to the standard model, by using industry-level data and examine what kind of factors affect rate of return on capital. Estimation results show, first, that the increase in wage rate has negative impact on the rate of return on capital as we expect in the standard factor price frontier. Second, larger investment in human resource leads to higher rate of return on capital. Third, on the other hand, the effects of investments in IT and R&D on the rate of return on capital are ambiguous, which is consistent with the arguments in Chun et al. (2015),

(2015).

[4] Many studies on investment behavior in Japan suggest that profit rate (or Tobin's Q indicating future profitability) is the most important determinant of capital formation. See Tanaka and Miyagawa (2011).

especially in non-IT industries. These results suggest and policy implication that the government should conduct comprehensive innovation policy which not only stimulates investment in human resources but also promotes firms to utilize IT and their knowledge acquired by R&D investment more effectively.

In the next section, we examine the movements in rate of return on capital, capital/output ratio and capital share by using the JIP Database. In the third section, we estimate modified factor frontier model to examine the determinants of the profit rate. In the last section, we summarize our results and show 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 theJIP 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) $$MPK = \frac{\partial Y}{\partial K} = \alpha * \frac{Y}{K}$$

Y represents value added or output, K represents capital stock, and □ represents capit

Then, we measure the marginal rate of return on capital by dividing capital share by capital/output (value added) ratio.[7][8]

(Place Figure 3 around here)

Figure 3 shows that both rates of return on capital in the 2000s were lower than those in the 1980s. However, the average rate of return was restored in the 2000s after its fall in the 1990s, although the marginal rate of return have been on a downward trend since the collapse of

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5 The JIP database is published at the website of 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.

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), 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 rate of return on capital at the aggregate level and that at the industry level due to the misallocation of capital input.

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

the bubble economy. Hence, the gap between the average and the marginal rate of return has widened in the 2000s. This gap implies that Japanese firms have concentrated on the 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 4 shows movements in capital/output ratio. Not only the capital/output ratio in the market sector but also the capital/output ratio in each sector has been on an upward trend as Fukao (2012) pointed out. In particular, the capital/output ratio in the non-IT sector has increased rapidly after the collapse of the bubble economy. The high capital/output ratio in the non-IT sector implies that this sector holds inefficient capital.

(Place Figure 4 around here)

Figure 5 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 and it was around 30% in the 2010s as Ando, Christelis, and Miyagawa (2002), Miyagwa (2004, 2005) pointed out. Capital shares in each sector show a different movement from that in the market sector. The capital share in the manufacturing sector was restored in the 2000s after its fall in the 1990s. The capital share in the IT sector had been on an upward trend until the Global Financial Crisis. On the other hand, the capital share in the non-IT sector was the lowest in the 2010s, although it was over 40% in the late 1980s.

(Place Figure 5 around here)

The above findings in Figure 5 tell us that there are some variances in rate of return on capital among industries. Figure 6 shows the marginal rate 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 increased but also there are vast differences in rate of return on capital by industry. [9] We show variances and relative standard deviations (=standard deviation/mean) in rate of return on capital in Table 1. In Table 1, variances in the rates of return have decreased as the rates of return falls. However, the relative standard deviations have not declined as much. In particular, the relative standard deviation in the rate of return has increased despite the fall in the rate of return since 1990. These findings suggest that specific factors at the industry level as well as

[9] 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.

aggregate factors may affect the movements in rate of return on capital. Then, we will examine some factors that affect rates of return on capital through estimation using industry level data.

(Place Figure 6 and Table 1 around here)

3. Estimating the Factor Price Frontier

In this section, in order to establish the factors affecting the rates of return on capital, we empirically examine the Factor Price Frontier (FPF). Although Bruno and Sachs estimated the FPF considering material inputs to examine the effects of changes in oil price on the macroeconomy, we assume the following simple production function.[10]

$$Y = F(L, K; T)$$

Y is value added. L is labor input, K is capital input, and T is a technological factor.

When we assume that the production function is linearly homogeneous in factor inputs and firms minimize their costs, the following equation is obtained:

(2) $\ln r = a' - (\frac{\alpha}{\beta}) \ln w + \lambda t + \delta j$.

In this expression, α and β are labor income share and capital income share, respectively. $\ln r$, and $\ln w$ denote the log of the real rate of return on capital, and the log of the real wage respectively. In order to account for the time-series components affecting $\ln r$, the model also contains t as the technology factor and j as the cyclical factor.

When we assume that the technological factor is positively correlated with intangibles such as IT, R&D and other intangibles, equation (2) is rewritten as follows.

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

In this expression, IT and K^{IT} account for the capital formation (i.e., investments) in

[10] The simple FPF theory is explained in Chapter 2 in Bruno and Sachs (1985).

information technology and its capital stock, respectively while *RD* and K^{RD} denote the capital formation in R&D and its capital, respectively.[11] Furthermore, *HR* and K^{HR} are used to include the capital formation in human resources and its capital stock as the additional factors affecting FPF. Subscription j and t correspond to the industry and the time while μ_j and η_t denote industry and year fixed effects.[12][13]

We include the additional variables in the right hand-side of the equation due to our presumption that productivity growth pushes up the FPF. As a proxy for productivity, 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 veify this presumption, we study the effects of intangibles on the rate of return on tangible capital through the estimation of the equation above.

Given the presumption that an increase in labor share (decline in capital share) would decrease the rate of return on capital, we predict the sign of a 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 shift up the FPF. Thus intangibles have positive effects on the rate of return on tangible capital.

The data we use in the present study is obtained from the Japan Industrial Productivity (JIP) 2015 database. Note that our analysis focuses on the market economy over the periods from 1985 to 2012, which consists of 92 industries. Appendix 1 provides a more detailed description of our data set and Appendix 2 shows the industrial classification. 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. We use the marginal rate of

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

12 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.

13 According to 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, which is obtained from JIP database, shows the increasing trend over the period. The discrepancy between these data series is partly due to the inclusion of the income associated with self-employed in the JIP database.

return on capital in this estimation. First, from the column (1) of Table 3, we can see that the coefficient on wage is positive and significant, which is opposite to our expectation. One potential source of this controversial result is an insufficient list of control variables (e.g., output level), which we examine later. Second, the coefficient on the IT investment ratio is not significant. Third, the coefficient on the R&D investment ratio is negative and significant, suggesting that R&D investments do have negative impacts on the rate of return on capital, which is highly counter-intuitive. Forth, nonetheless, the coefficient on the Human Resource (HR) investment ratio is positive and significant, suggesting that larger investment in HR in fact lead to higher rates of return on capital.

Given the conjecture that the somewhat puzzling result associated with the positive coefficient on wage could be due to the insufficient list of control variables, we add the log of value added by industry to specifically control for the output level. The estimate results are summarized in the column (2) of Table 3. The sign of the estimated coefficient on wage is negative, which means that a higher real wage is associated with lower rate of return on capital as in the standard factor price frontier.

We should note that another puzzling result in the abovementioned estimation, i.e., the negative coefficient on the R&D investment, is still obtained while the coefficients on IT and HR investment ratio are positive and significant. This implies that under correct specification, which includes the output level as an independent variable, the two intangible assets contribute to higher rate of return on tangible capital.

(Place Table 3 and 4 around here)

Table 4 shows the fixed-effect estimation results for the market economy. We are using the average rate of return on capital as the dependent variable. As a baseline case, first, the column (1) shows that the coefficient on wage is negative but not significant. Second, the R&D investment ratio is negative and significant, thus providing no support for the positive relationship between the R&D investment and the rate of return on capital. Other results associated with IT investment and investment on human resource are qualitatively the same as in the column (1) of Table 3.

Given these baseline results, we implement an additional subsample analysis. Namely, we have divided our sample into IT industries and Non-IT industries. Table 5 and 6 show the results for IT industries using the marginal and average rate of return, respectively. Although almost all of the results provide the same implication as in the Table 3 and 4, the coefficients on

HR investment ratio are not significant for the case of IT industry.

(Place Table 5 and 6 around here)

Table 7 and 8 show the results for non-IT industries using marginal and average rate of return, respectively. The coefficient on the IT investment ratio is not significant, suggesting that IT investment does not contribute to a higher rate of return on capital. On the other hand, the coefficient on the HR investment ratio turns out to be positive and significant in Table 7 and 8 as in the baseline case (i.e., Table 3 and 4).

(Place Table 7 and 8 around here)

As a seemingly puzzling result first, the estimate results based on the samples covering whole market economy and that in IT industries show that the coefficients on R&D investment ratio (a_3) are negative. This means that R&D investments are not positively contributing to the rate of return on tangible capital, which is somewhat surprising. Second, the coefficients on the IT investment ratio (a_2) are not significant in the non-IT industries. This means that IT investments are not positively contributing to the rate of return on tangible capital. Regarding this result, Chun et al. (2015) examine the correlation between the dynamics of IT assets and intangibles and found that the dynamics of IT assets were not positively correlated with that of intangibles in Japan over 2000s. They claim that low productivity growth in Japan in the 2000s might be due to the lack of the synergy effects of IT assets. Given such discussion in Chun et al. (2015), we conjecture that the negative signs of and imply that capital formation in tangibles is not effectively associated with IT investment and R&D investment in Japan. This could lead to the implication that Japanese firms should put more effort on utilize complementary effects between tangibles and intangibles to raise rate of return on capital.

As one important result, the positive and significant sign of in IT industries implies that IT investments shift up the frontier in the case of IT industries. In other words, IT investments are likely to raise rate of return on tangible capital for the industries with larger accumulation of IT stock.

From the estimate results based on the sample covering the whole market economy and non-IT industries, we found that the coefficients on Human Resources investment ratio (a_4) are positive and significant. This suggests that growth in human resources is crucial for the rise of the rate of return on capital. Given Figure 7, which shows that the investments in human resources from 1980 to 2012 experienced the rapid decrease in investments in HR since 2000, we can conjecture that the rapid decrease in investments in HR might have led to the low rate of return on capital.

(Place Figure 7 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 experiences after the Global Financial Crisis. One of the main issues on long-term stagnation is the low growth rate induced by the stagnated capital formation under low interest rate. In this paper, we focus on the movements in the real rate of return on capital to understand secular stagnation by using the Japan Industrial Productivity (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 non-IT industries are very high, which indicates that these industries have accumulated the inefficient capital stock. These findings are consistent with the argument in Fukao (2012). 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 the number of industries with negative profit rate. In addition, the greater relative standard deviation indicates that industry-level factors affect the dispersion of rate of return on capital.

Based on these findings, we estimate a profit function based on the factor price frontier developed by Bruno and Sachs (1985). In factor price frontier theory, 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 empirically examine the factor price frontier through the estimation of the extended version of the model in Bruno and Sachs (1985).

From the obtained estimate results, first, we can see that higher real wage is associated with lower rate of return as expected from the shape of standard factor price frontier. This might imply that a policy measure intending to directly increase wages does not necessarily stimulate capital formation. On the other hand, the positive sign of value added suggests that the increase in aggregate demand through wage increase is likely to increase capital formation. Second, a puzzling result, IT and R&D investments have negative or not significant effect on the rate of return on tangible capital especially in the case of non-IT industries. This implies that firms might not be fully utilizing the performance of IT facilities and the stock of R&D investments in their production process. Thus, we could suggest that Japanese management should put more attention to how to incorporate advanced technologies to their work. Third, an important result, strong positive effects associated with human resources on the rate of return on capital 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 the investments on human resources since 2000 in Japan[14]. Such a result provides some supports for government to encourage expenditures in human resources.

The arguments by Benigno and Fornaro (2015) that we are not able to escape from aggregate demand policy and need aggressive innovation policy to escape from a stagnation trap are associated with policy implications from our estimation results. The aggregate demand policy implemented through an increase in wages, is insufficient to induce aggressive capital formation. We need a bold innovation policy that includes not only accumulation in human resource but also organizational reforms that vitalize the complementary effect between tangibles and intangibles.

[14] 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.

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Table 1 Variances and relative standard deviations in the rate of return on capital

		1980	1990	2000	2012
Mariginal rate of return	**Variances**	**1785.6**	**1026.3**	**909.3**	**290.9**
	Relative S.D.	**1.5**	**1.2**	**1.4**	**1.5**
Average rate of return	**Variances**	**3465.2**	**1303.8**	**652.9**	**461.0**
	Relative S.D.	**1.9**	**1.3**	**1.4**	**1.7**

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 pf 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 stock	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 Estimation results using the marginal rate of return on capital

Market economy						
Dependent variable: Marginal rate of return on capital						
	(1)			(2)		
	Coef.	Std. Err		Coef.	Std. Err	
ln w	0.491	0.052	***	-0.664	0.058	***
ln IT/K_{IT}	0.071	0.103		0.147	0.083	*
ln RD/K_{RD}	-0.181	0.051	***	-0.176	0.041	***
ln HR/K_{HR}	0.361	0.116	***	0.205	0.094	**
ln Y				1.412	0.048	***
Constant	-2.954	0.206	***	-21.851	0.663	***
	Fixed-effects model			Fixed-effects model		
Number of obs	1,773			1,762		
Number of groups	70			70		
Prob > F	0			0		
R-sq:						
within	0.3174			0.5534		
between	0.2334			0.0077		
overall	0.2323			0.0525		

Table 4 Estimation results using the average rate of return on capital

Market economy						
Dependent variable: Average rate of return on capital						
	(1)			(2)		
	Coef.	Std. Err		Coef.	Std. Err	
ln w	-0.131	0.053	**	-1.211	0.060	***
ln IT/K_{IT}	0.168	0.103		0.239	0.087	***
ln RD/K_{RD}	-0.141	0.051	***	-0.136	0.043	***
ln HR/K_{HR}	0.438	0.116	***	0.295	0.098	***
ln Y				1.320	0.050	***
Constant	-1.863	0.206	***	-19.523	0.689	***
	Fixed-effects model			Fixed-effects model		
Number of obs	1,773			1,762		
Number of groups	70			70		
Prob > F	0			0		
R-sq:						
within	0.3095			0.5171		
between	0.1964			0.0001		
overall	0.0747			0.0235		

Table 5 Estimation results using the marginal rate of return on capital

IT industries						
Dependent variable: Marginal rate of return on capital						
	(1)			(2)		
	Coef.	Std. Err		Coef.	Std. Err	
ln w	0.553	0.074	***	-0.599	0.081	***
ln IT/K_{IT}	0.287	0.150	*	0.357	0.123	***
ln RD/K_{RD}	-0.251	0.070	***	-0.268	0.058	***
ln HR/K_{HR}	0.157	0.159		-0.003	0.131	
ln Y				1.421	0.065	***
Constant	-3.187	0.303	***	-22.241	0.909	***
	Fixed-effects model			Fixed-effects model		
Number of obs	1,051			1,040		
Number of groups	41			41		
Prob > F	0			0		
R-sq:						
within	0.3331			0.4194		
between	0.2438			0.0003		
overall	0.2847			0.0267		

Table 6 Estimation results using the average rate of return on capital

IT industries						
Dependent variable: Average rate of return on capital						
	(1)			(2)		
	Coef.	Std. Err		Coef.	Std. Err	
ln w	-0.080	0.074		-1.131	0.084	***
ln IT/K_{IT}	0.431	0.149	***	0.495	0.128	***
ln RD/K_{RD}	-0.230	0.070	***	-0.244	0.060	***
ln HR/K_{HR}	0.207	0.159		0.063	0.136	
ln Y				1.297	0.068	***
Constant	-2.053	0.303	***	-19.432	0.945	***
	Fixed-effects model			Fixed-effects model		
Number of obs	1,051			1,040		
Number of groups	41			41		
Prob > F	0			0		
R-sq:						
within	0.3381			0.5232		
between	0.1202			0.0108		
overall	0.0972			0.0386		

Table 7 Estimation results using the marginal rate of return on capital

Non-IT industries						
Dependent variable: Marginal rate of return on capital						
	(1)			(2)		
	Coef.	Std. Err		Coef.	Std. Err	
ln w	0.522	0.076	***	-0.620	0.080	***
ln IT/K_{IT}	-0.108	0.140		-0.031	0.108	
ln RD/K_{RD}	-0.111	0.072		-0.076	0.056	
ln HR/K_{HR}	0.696	0.182	***	0.419	0.142	***
ln Y				1.418	0.068	***
Constant	-2.668	0.285	***	-21.760	0.939	***
	Fixed-effects model			Fixed-effects model		
Number of obs	722			722		
Number of groups	29			29		
Prob > F	0			0		
R-sq:						
within	0.3418			0.6041		
between	0.2686			0.0044		
overall	0.1973			0.031		

Table 8 Estimation results using average rate of return on capital

Non-IT industries						
Dependent variable: Average rate of return on capital						
	(1)			(2)		
	Coef.	Std. Err		Coef.	Std. Err	
ln w	-0.113	0.077		-1.215	0.084	***
ln IT/K_{IT}	-0.065	0.142		0.009	0.114	
ln RD/K_{RD}	-0.046	0.073		-0.012	0.058	
ln HR/K_{HR}	0.864	0.185	***	0.598	0.149	***
ln Y				1.368	0.071	***
Constant	-1.537	0.289	***	-19.959	0.985	***
	Fixed-effects model			Fixed-effects model		
Number of obs	722			722		
Number of groups	29			29		
Prob > F	0			0		
R-sq:						
within	0.3069			0.5559		
between	0.1911			0.0356		
overall	0.0985			0.0112		

Figure 1 Annual growth rate in capital formation in the recovery periods in Japan

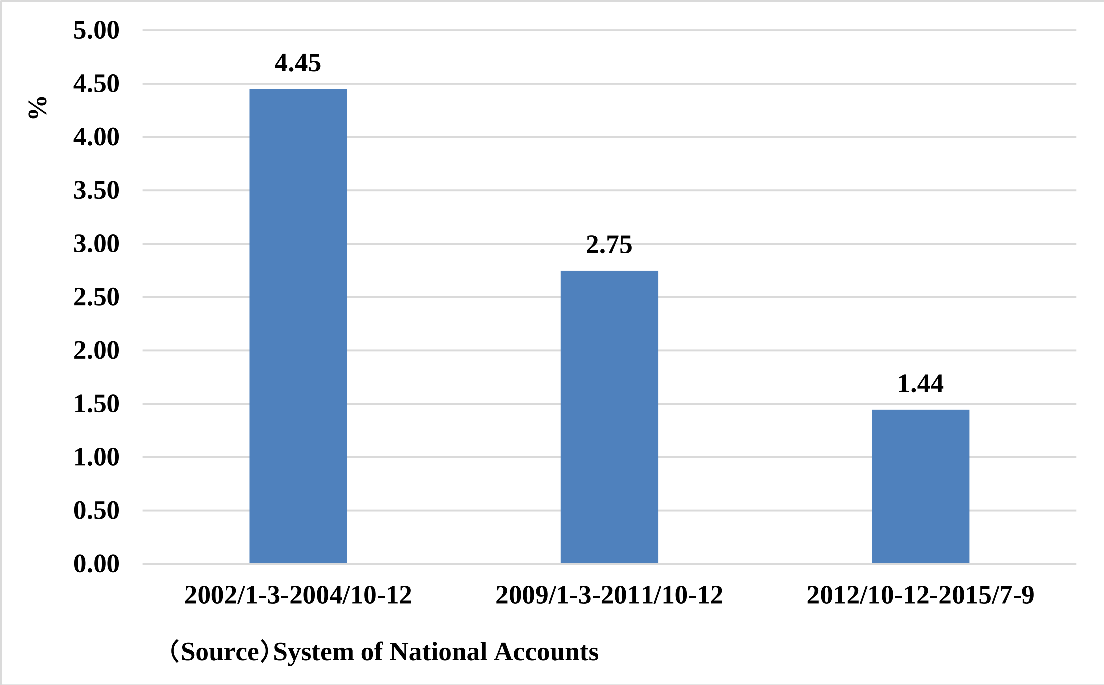


Figure 2-1 Growth accounting in Japan

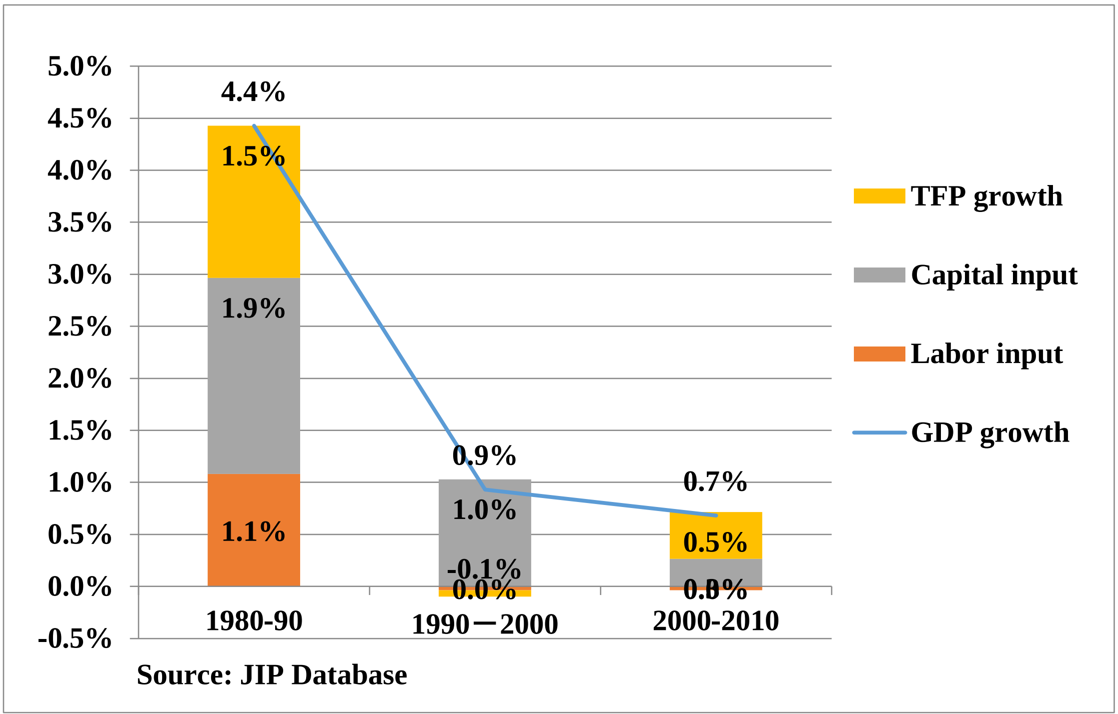


Figure 2-2 Growth accounting in the US

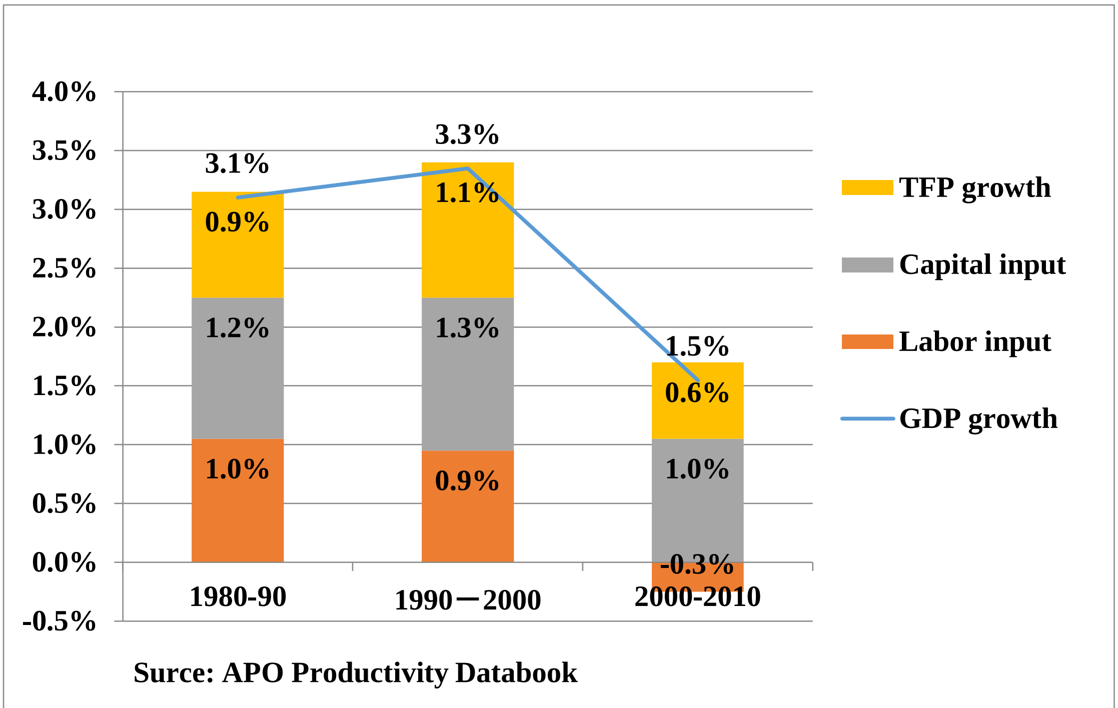


Figure 2-3 Growth accounting in Korea

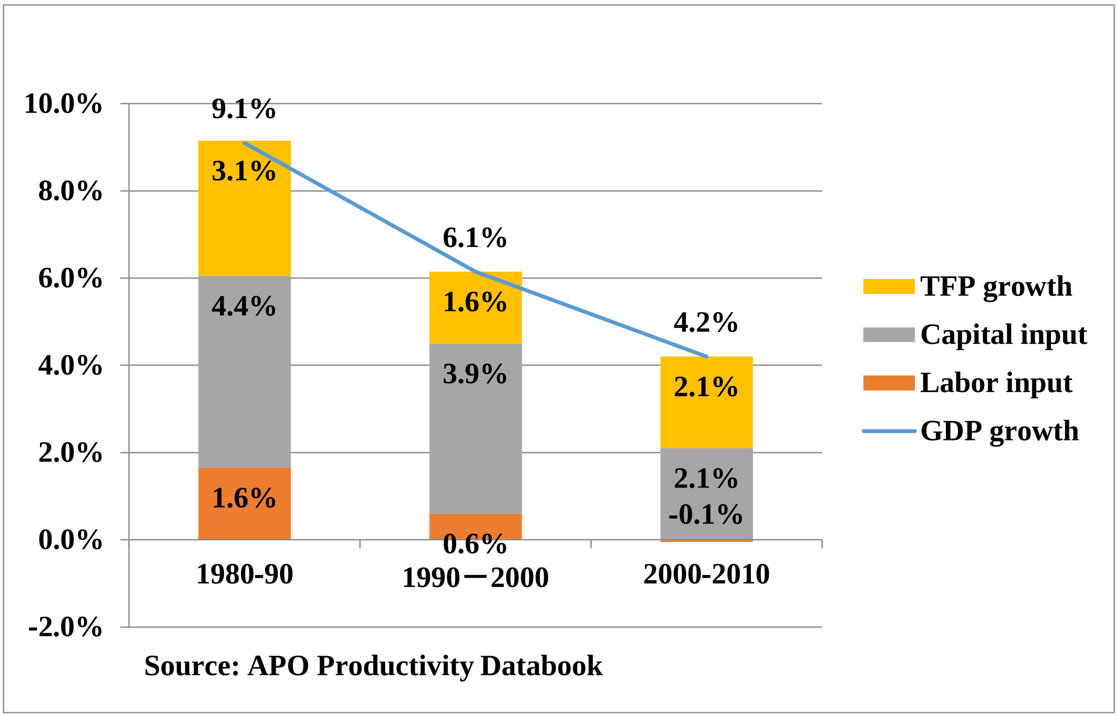


Figure 2-4 Growth accounting in Republic of China

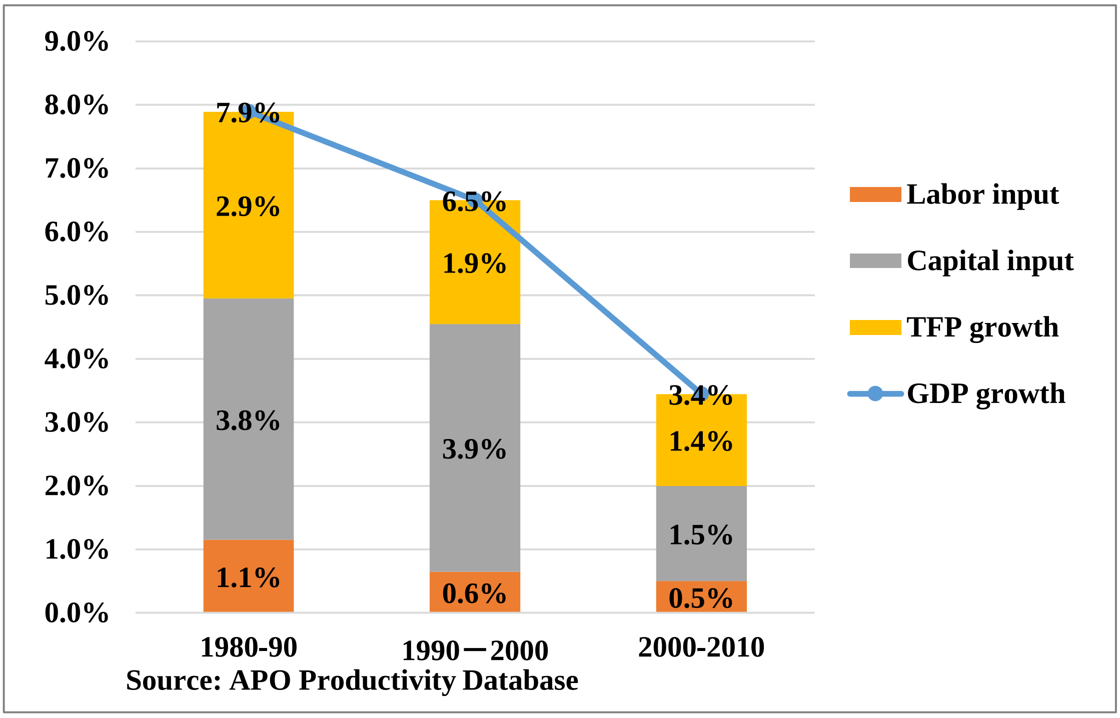


Figure 3 Movements in rate of return on capital

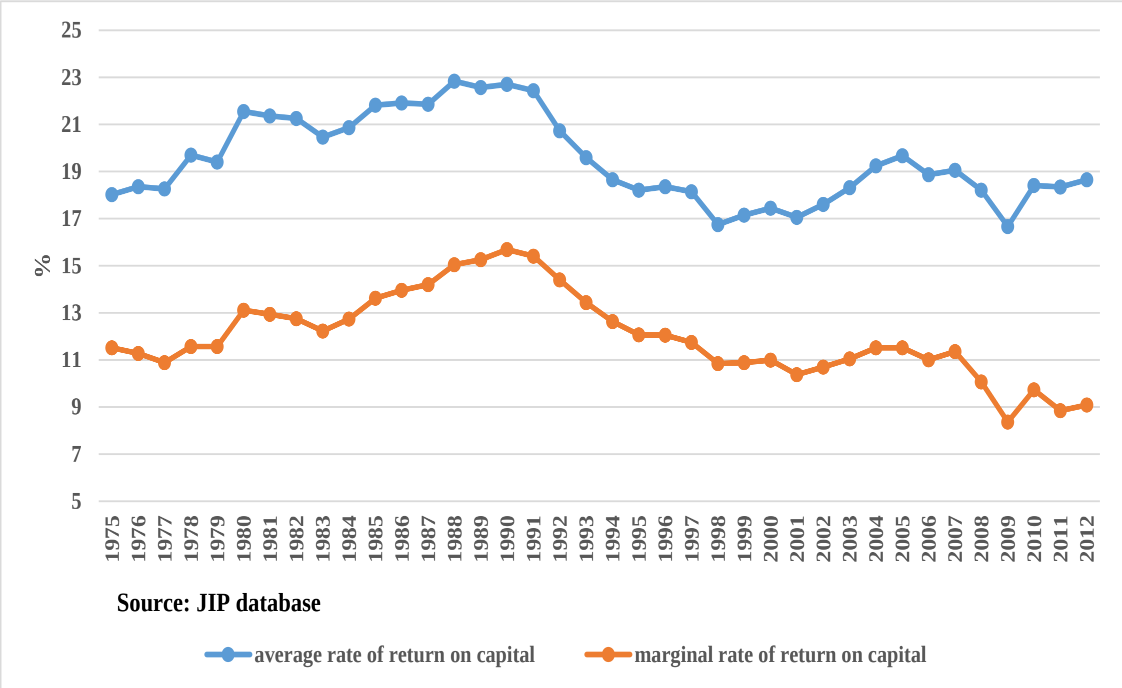


Figure 4 Capital/output ratio in Japan

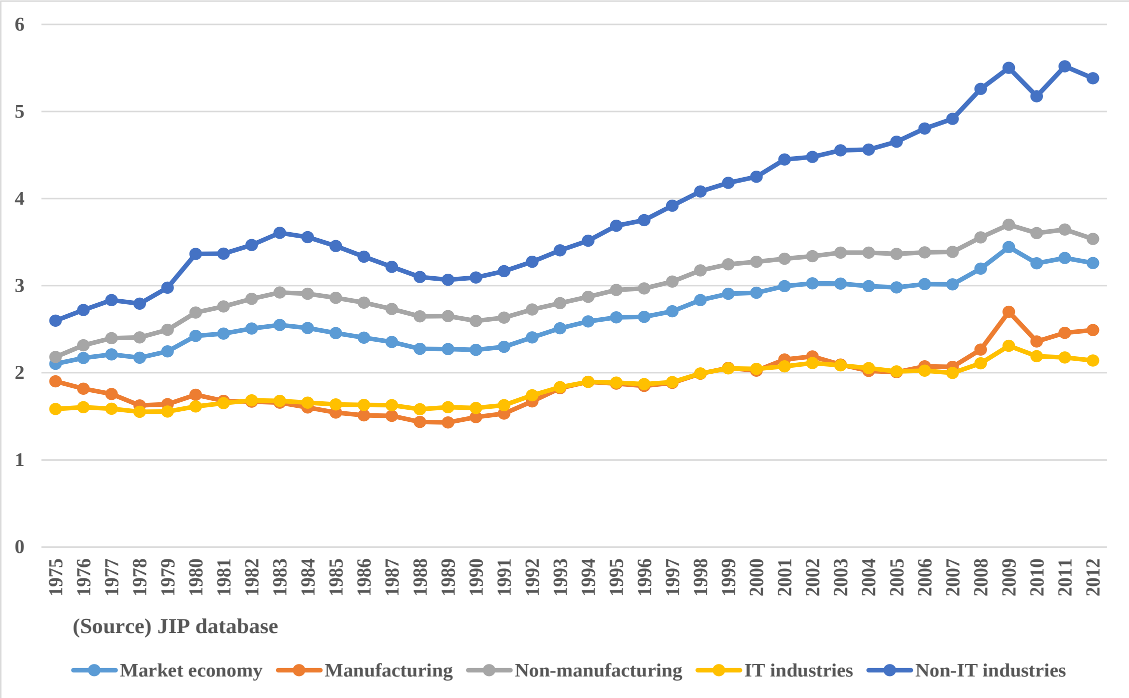


Figure 5 Capital share in Japan

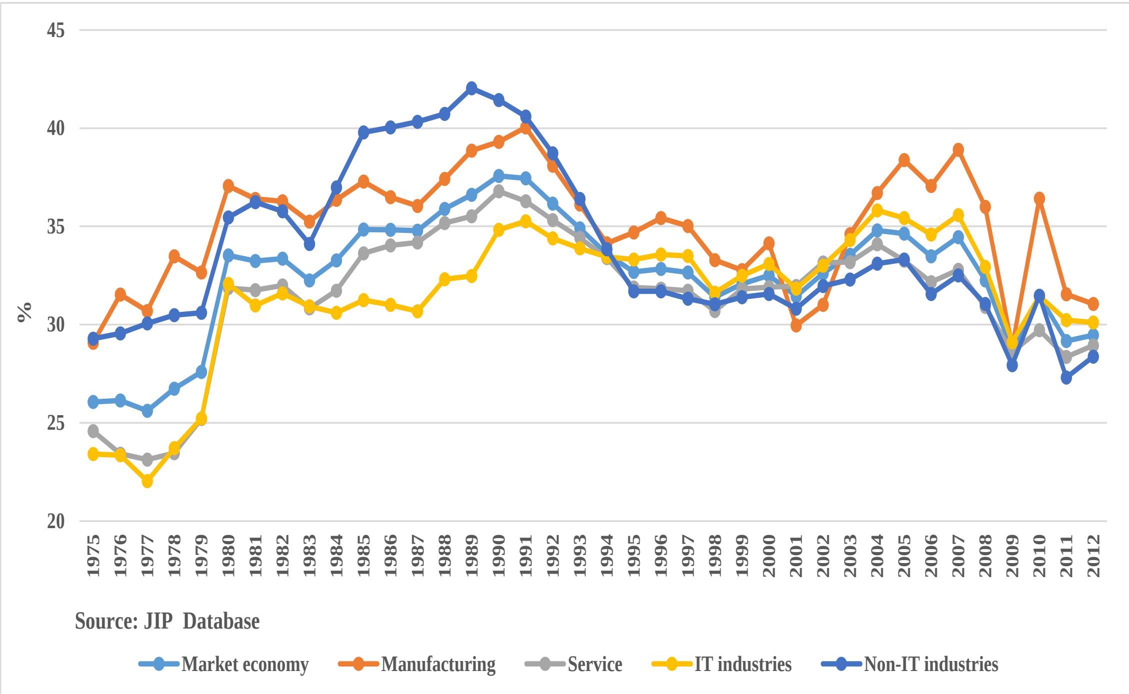


Figure 6-1 Marginal rate of return on capital by industry (1980)

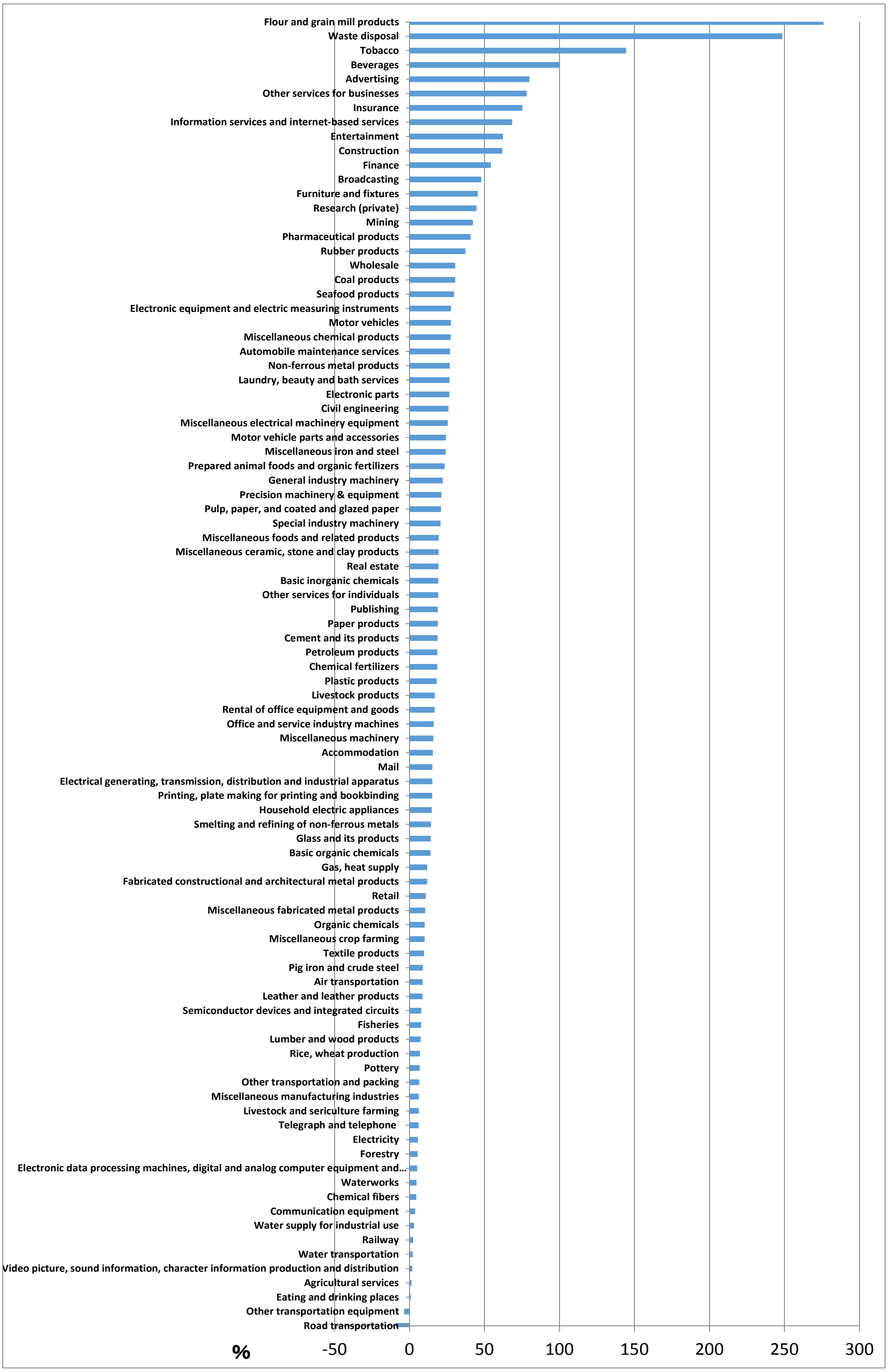


Figure 6-2 Marginal rate of return on capital by industry (2012)

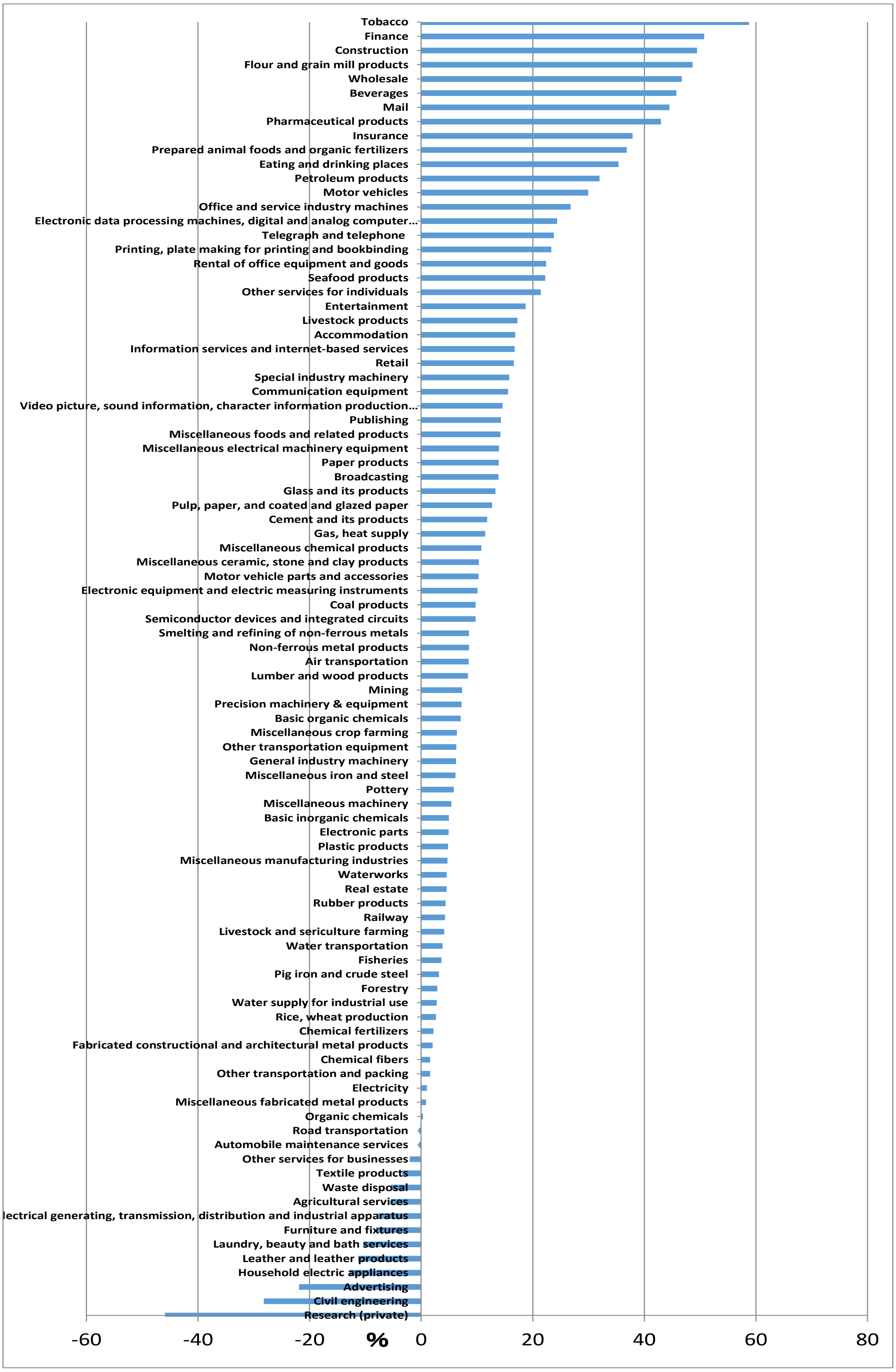
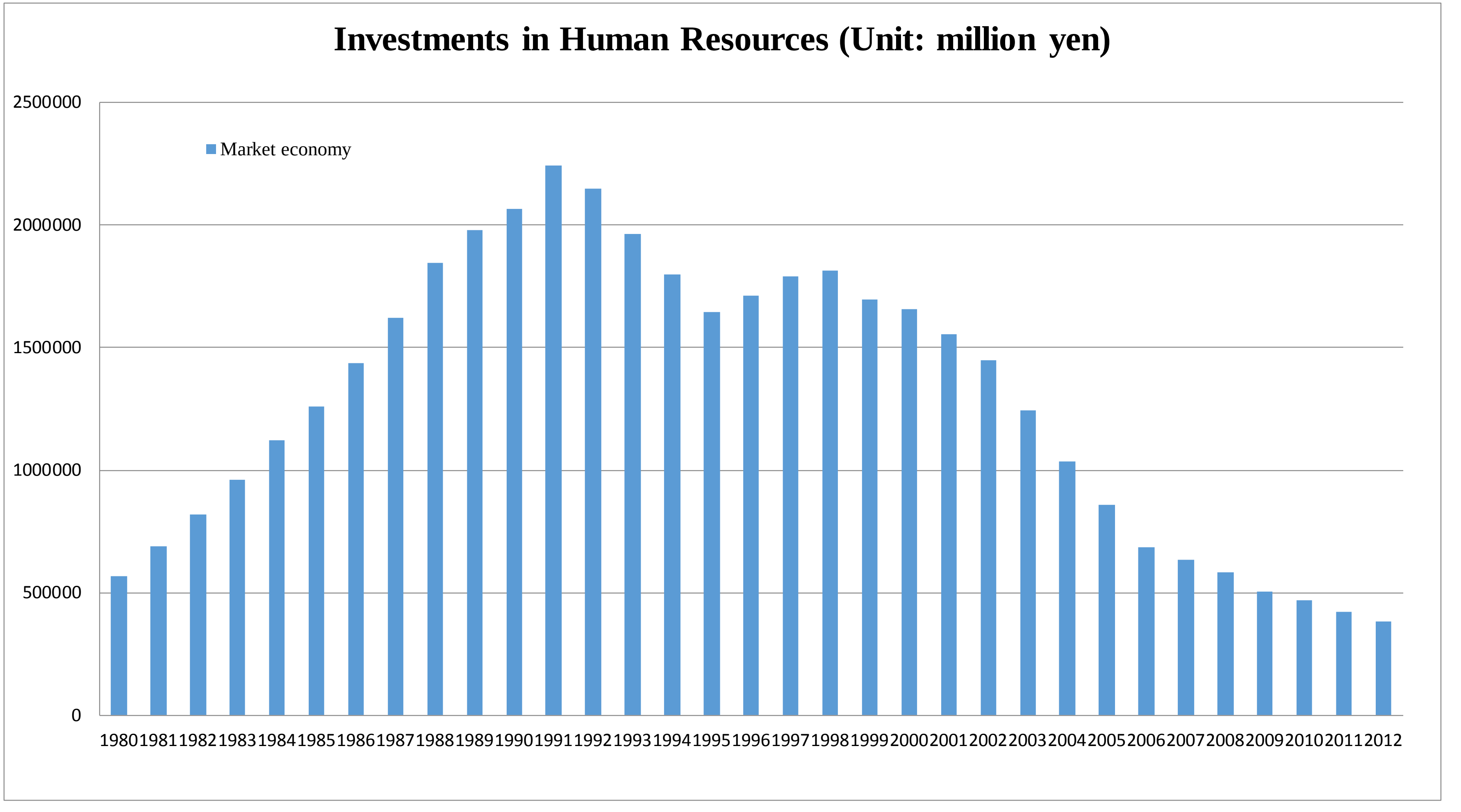


Figure 7 Investments in Human Resources 1980-2012



Source: Authors' calculation

Appendix 1 Data definition

Variables	Definitions	Constructions
r_marginal	Marginal rate of return on capital	Capital share × (Value added / Net capital stock)
r_average	Average rate pf 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 database industrial classification in the market economy

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

Appendix 2 (contd.)

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