A role of investment in intangibles: How can IT make it?[1]

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Abstract

The purpose of this paper is to demonstrate that the Japanese economy has fumbled their chance to reap the benefits of investment in information technology due to a reluctance to carry out drastic corporate reforms in business processes and human resource management associated with the introduction of new technology. For this purpose, we first review Solow's productivity paradox and the new economy in the U.S., and then we compare these with the Japanese economy based on growth accounting analysis and an estimation of production function models. On top of that, we illustrate a series of firm-level questionnaire surveys to examine the decisive role of investment in intangibles, i.e., reforming organizational structures and human resource management, in line with IT investment. These analyses yield two observations. First, Japan's investment in IT has been stagnant over the last two decades in spite of its potential to contribute to productivity improvement and consequent economic growth. Second, there is a strong complementary relationship between drastic corporate reforms and positive outcomes from IT investment, which Japanese firms have been fumbling. The results of this research suggest that the inertia of Japan's integrated corporate system persists in the midst of innovation in information technology. Therefore, the Japanese private business sector needs to make an intense effort into investing in intangibles, i.e., a drastic redesign of business processes and human resource management in order to achieve the maximum effect of investments in information technology.

Keywords: Japanese economy, information technology, productivity, corporate reform, human resources, intangible, growth accounting, production function model, questionnaire survey

JEL Classification Code: D2, O3, O4, O5, L2, M2

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1. Introduction

For decades a pessimistic outlook for the Japanese economy has prevailed mainly due to the diminishing demographic trend[2]. On the other hand, most economists have globally acknowledged the advantages of innovation in information technology (IT) to improve productivity and consequent economic growth. Indeed, the rising tide of technology-driven economies has been supporting not only developed countries but also emerging and developing economies since the early 2000s[3]. In accordance with this global context, we could draw a slightly brighter outlook on the Japanese economy, as IT could produce a surge in productivity and consequent economic growth. Nonetheless, is this feasible? How can the economy achieve this? Moreover, if it is feasible, why has the economy not yet achieved the positive effects from IT despite its potential over the last two decades?

To address these questions, in this paper we first review the controversial argument of Solow's productivity paradox and the new economy in the U.S., and then we analyze the impact of investment in information technology on Japanese productivity growth, conducting a growth accounting analysis and estimating production function models. In addition, we demonstrate firm-level analysis based on a questionnaire survey to examine the decisive role of investment in intangibles, i.e., reforming business processes and organizational structures, and human resource management. Finally, we consider the implications of these analyses and clarify the significance of investment in intangibles for reaping the benefits of IT investment.

2. Productivity paradox and the new economy revisited

2-1. Lessons from the U.S. economy

Before we examine the Japanese economy with regard to the impact of IT investment and the associated significance of investment in intangibles, it will be useful to revisit the controversial argument of the productivity paradox and the new economy as an international comparison with the U.S. economy. As is well known, intensive studies on the economic impact of information technology have been conducted in the U.S., giving rise to Solow's famous quip[4], "we can see the computer age everywhere but in the productivity statistics." Some analysts have claimed that information technology never contributed to a surge in productivity and that this paradox surely existed, while others argue that the technology contributed a lot to enhanced productivity and made the U.S. economy transform into a "new economy."

When Solow made the above comment, there were many business executives who could not see any clear or concrete improvement in productivity in their businesses even though they had poured huge amounts of money into technology, so that they came to consider investing in

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[2] Take the Japan Center for Economic Research (2015) for example, it forecasts a base line growth rate at around 1% annually from 2014 to 2025.

[3] See Picot and Lorenz (2010) and UNCTAD (2011).

[4] See Solow (1987).

IT as just losing money. Table 1 represents one of the studies that proves the paradox in statistics from the early 1970s to the mid-1990s. Jorgenson et al. (2008) illustrates clearly that productivity slowed down from 1973 in both average labor productivity, or ALP, and multi (total) factor productivity, or MFP (TFP), whereas the capital deepening of IT (i.e. IT investment) had some gains. This is what Solow mentioned (i.e., the productivity paradox).

(Table 1)

On the other hand, table 1 also demonstrates that economic performance has made a drastic change since the mid-1990s with the remarkable boom in investment in information technology. Productivity in both ALP and MFP accelerated in accordance with considerable gains in IT capital deepening, which proves that the paradox disappeared and the new economy emerged in the mid-1990s. In other words, you can see the paradox before the mid-1990s but you do not see it anymore after the second half of the 1990s, which Solow himself agreed to[5]. Likewise, the results of many other empirical studies such as Baily (2002), Stiroh (2002), and Oliner et al. (2007) revealed that investments in information technology finally paid off. At last, an undisputed acknowledgement of the “new economy” in the U.S. has now taken root.

2-2. Neither a paradox nor a new economy in Japan

In this subsection, we analyze the contribution of IT to Japanese economic growth and its surge in productivity in comparison with the U.S. economy. It is readily apparent that a critical statistic in examining the impact of technology is the dataset of IT capital stock, because this is used for orthodox methodologies of growth accounting measurement and the estimation of the production function mode. Although an official statistic for IT capital stock is unavailable in Japan, we can measure and create a dataset of IT investment and consequent capital stock using a fixed-capital matrix in an input-output table, as formulated by Shinozaki (2011). A glance at figure 1 shows that Japan experienced a massive IT investment boom up to the late 1980s, and then a cyclical fluctuation in line with a downward trend since the investment boom ended in the 1990s, when new types of open-network technology prevailed throughout the world.

(Figure 1)

Based on the dataset of Japan’s IT capital stock, several empirical studies have been conducted to analyze the long-run economic performance and the contribution of information

[5] According to Uchitelle (2000), Solow said, “You can now see computers in the productivity statistics,” in an interview. In addition, Solow put it, “I feel better about the endurance of the productivity improvement after it survives its first recession,” with an academician’s prudence.

technology to productivity growth in Japan[6]. Table 2 illustrates one of these results, presenting the measurement of aggregate growth in the private sector, with labor productivity shown as hourly output, and capital deepening of IT, etc., since the second half of the 1970s. The substantial matter at issue is concentrated in the figures of periodic changes in IT capital deepening in terms of its contribution to fundamental productivity improvement in the last six columns of table 2. As this table shows, growth accounting analysis reveals the following facts. First, the Japanese economy enjoyed a powerful boom up to the 1980s and plunged into a long slump since the 1990s. Second, the contribution of IT capital deepening to the fundamental productivity trend increased in the 1980s, but disappeared or even decreased in the 1990s and later.

(Table 2)

The remarkable fact is that the changes in total factor productivity, or TFP, and the contribution of IT capital deepening ran in the same direction, rather than in opposite directions, until the mid-1990s. This characteristic differs greatly from that in the U.S. where they ran in opposite directions until the mid-1990s, and thus, "economists were puzzled as to why productivity growth was so slow despite the widespread use of information technology."[7] The Japanese economy is a case of contrast. Conversely, no manner of positive correlation has been shown between TFP and the contribution of IT since the 1990s. It follows that we can see neither a productivity paradox nor a new economy in Japan, while in the U.S. the paradox disappeared and a new economy emerged in the mid-1990s, as we discussed in the previous subsection.

2-3. Potential of Japanese IT investment

In light of the observations presented above, it might have seemed appropriate to conclude that Japan missed its chance to ride on the new economy, taking full advantage of innovation in information technology. To borrow the words of Chandler (2000)[8], it is considered that Japan failed to transform its economy from one of an "Industrial Age" into one that can compete in the "Information Age."

Although this may be the case, there is no need to be overly pessimistic about the potential of Japan's growth in productivity as driven by information technology. The reason for this is that if the economy has fumbled the chance of an investment boom, it still has enormous room for improvement. In other words, the Japanese economy could even now accelerate productivity

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6 See Adams, et al. (2008) and Shinozaki (2011).
7 See Baily (2002), p. 4.
8 See Chandler (2000), p.3. He considers that the U.S, economy transformed "from the Industrial into the Information Age in the last decades of the twentieth century."

and resultant economic growth if it were to embrace the "new economy" and take full advantage of the dynamism of the IT innovation, as the U.S. economy certainly did in the late 1990s.

The question is whether it is realistic to assume that IT investment has such a potential to revitalize the economy. To address this question, Shinozaki (2009) estimates a macro-level production function model of three types: a base model, an IT assets model, and a network effects model. Constant returns to scale are assumed in the base model and the IT assets model, whereas the network effects model allows increasing returns of scale. Moreover, Shinozaki et al. (2012) estimates similar models with cross-industry panel dataset.

Table 3 and Table 4 represent a summary of the estimation results, demonstrating that the IT assets model, where IT capital stock is explicitly incorporated, explains the economy better than the base line model, or non-IT model. Furthermore, the accumulation of IT capital stock significantly affects economic growth, identifying a positive network effect driven by information flow. Finally, information flows, as well as IT capital stock, plays an important role for growth. In all respects, similar results are shown in the analysis of cross-industry models.

(Table 3)

(Table 4)

These results suggest that sluggish IT investment drove the economy into a lower growth path since the 1990s and that the economy, nevertheless, has the potentials to introduce the benefits of IT innovation if it achieves an investment boom in technology hereafter. Indeed, Shinozaki (2009) simulates a Japanese economic growth path based on three types of estimation results; a base line model, an IT assets model, and a network effects model, resulting in the IT assets model showing a half percentage point higher growth rate than the base line model. Furthermore, the network effects model proves that the economy would grow by 1.3% points faster than under the base line model.

3. Investment in intangibles associated with IT

3-1. Evidence from firm-level analysis

Here arises another puzzle: why has Japan's IT investment been stagnant over the last two decades in spite of its huge potential for the prosperity? Firm-level analyses based on a series of nation-wide questionnaire surveys provides some clues to solve this question, because several academic studies and business case studies in the U.S. ultimately reveal that investment in information technology paid off when it came along with investment in intangibles such as business process reengineering and human resource training and development[9].

[9] See Brynjolfsson, et al. (2002), Brynjolfsson and Hitt (2000), and Hammer and Champy (1993).

Taken in light of this research and these studies, it may be presumed that IT investment without corporate reforms results in failure, so that business executives consider investing in information technology as just losing money. If Japanese firms in general are extremely conservative about corporate reforms and they keep a negative attitude towards re-designing the existing organizational structures and human resource management, it is plausible that the economy overall would never see an IT investment boom.

A series of nationwide questionnaire surveys conducted in 2003, 2007, and 2012 reveals that reforms in organizational structures and human resource management affect the successful introduction of information technology. Taking the 2003 survey for example, the heights of the bar chart at the upper left of Figure 2 represents the outcome score of IT investment in the 3,141 effective respondent firms, divided into four categories; a group of intensive IT investment with aggressive reforms (3.6 score on the left side front row), intensive IT investment with poor reforms (2.6 score on the left side back row), less investment with aggressive reforms (3.0 score on the right side front row), and less investment with poor reforms (2.0 score on the right side back row).

(Figure 2)

This chart, as well as those of the 2007 and 2012 surveys, implies a strong complementary relationship between IT investment and corporate reforms in terms of achieving successful outcomes. The similar complementary relationship also appears between IT investment and enhancements in human resource management, as the bar charts at the bottom of Figure 2 show. In other words, the results of firm-level surveys definitely indicate that it would be quite difficult to obtain the positive outcomes from IT investment without investing in intangibles such as re-designing the existing organizational structures and human resource management.

3-2. Japan as an outlier in international comparisons

Here, we need international comparisons to distinguish the outstanding features of Japanese firms from those of other countries in order to elucidate the challenges and opportunities encountered by Japan. Based on a multinational survey of 18,500 firms in Japan, the U.S., Germany, and South Korea, it was revealed that in many aspects of corporate reforms, the percentage of Japanese firms that actually conduct reforms is significantly lower than that of firms in the U.S., Germany, and South Korea, especially with regard to re-designing decision-making processes by top management, changing business-to-business practices, and restructuring business units.

Due perhaps to their negative attitude to reforms, Japanese firms are considerably behind in the effective use of IT in the following two areas; firstly, agile and accurate decision-making, and secondly, the development of new markets and value chains. What should be stressed here is that there are less significant differences among firms in the U.S., Germany, and South Korea in terms of corporate reforms or the effective use of IT. In fact, the distribution charts in Figure 3 that illustrate the difference in the degree of corporate reforms from a minimum score of zero to a maximum score of seventeen, demonstrate well the marked reluctance of Japanese firms. As a consequence, it is clear that Japan appears to be an outlier among the four countries.

(Figure 3)

Having said this, a more in-depth analysis of the international questionnaire survey shows some opportunities for Japan towards a "new economy." When we divide effective respondent firms into the four categories as we did in the above subsection, similar complementary relationships between IT investment and corporate reforms are found in the other three countries. From this point we can go on a more detailed examination; firstly, international comparisons using a limited group of the survey data only from firms which conduct aggressive corporate reforms, secondly, comparisons of reformed firms with non-reformed firms in the respective countries.

Figure 4 illustrates one of the results of this examination, clarifying that the disadvantage of Japanese firms diminishes in terms of a limited respondent group of firms which conduct aggressive reforms. In addition, larger and clearer differences in performance are observed in Japan between aggressively reformed firms and less reformed firms. Therefore, we can deduce from the survey data that corporate reforms similarly affect the performance of IT investment in the U.S., Germany, and South Korea as well as Japan. Most Japanese firms, however, look more hesitant to invest in intangibles (i.e., corporate reforms) than firms in the three other countries, which caused a sluggish investment trend in Japan over the last two decades.

(Figure 4)

4. "Japan as number one" revisited

4-1. Strengths of the Japanese system in the industrial age

As we have discussed in this paper, it is intangibles that need to be paid more attention to when investing in information technology. Japanese firms, however, tend to plan sustainable progress rather than drastic reforms. This tendency implies that the inertia of Japan's "integrated system" persists in the midst of innovation. In this sense, it may still be necessary for Japanese private business sectors to continue their intensive efforts for drastic business reforms that will lead to their transformation into the "new economy."

It is obvious that before information technology began to deeply affect economic performance globally, Japan enjoyed a far better economic performance than other countries around the world, being praised as "number one."[10] Why were the implications of information technology lost on Japanese management? It is necessary to reexamine the strengths of the Japanese corporate system in its matured stage of the industrial age of the 1980s, and then to consider how those strengths became weaknesses in the emerging information age since the 1990s.

According to the Economic Planning Agency (1990), Corporate Japan had several striking features in its organizational structure: firstly, shared business information through informal face to face communications based on an intimate and intensive human network; secondly, some overlap in jobs under a flexible organizational structure and unrestricted job descriptions; thirdly, the extension of these characteristics to transactions between firms and the creation of long-term relationships in industrial organizations. The set of these features is referred to as an "integrated system," which is quite appropriate for technological improvement through "learning by doing," because invisible and tacit skills can be shared and transferred easily among employees or an exclusive group of companies and are assimilated within the membership day by day. Therefore, Corporate Japan had performed well through continuous improvements such as *kaizen* or total quality management in its production lines.

(Figure 5)

In contrast, Corporate U.S.A. has different features in its organizational structure, which we refer to here as a "modular system."[11] In a modular system, formal job descriptions define the mission of each job position. Moreover, borders that separate job units are much clearer than in an integrated system, although a modular system sometimes make it difficult to share information and the activities of other job units. To resolve this difficulty, the standard format of an open interface is created, which promotes smooth formal communication among units. This common interface and simple protocol eases communication, even with newcomers or participants outside the organization. This is in sharp contrast to communication carried out in an integrated organization.

4-2. Transformation of Economies in the information age

It seems reasonable to assume that innovation in information technology causes dynamic

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10 The title of the book, *Japan as Number One*, written by Harvard University professor Ezra Vogel represents this well.

11 Langlois and Robertson (1992) argues the nature of modularity.

changes in economies from those favoring an integrated system to those favoring a modular system because "network effects" and "economies of alliance" have emerged with the prevalence of open networks and digital technology.

Table 5 clarifies the notion of "economies of alliance" and incorporates it into other concepts of economies; "economies of scale," "economies of scope," and "network effects." Economies of alliance are the obverse of economies of scope just as network effects are the obverse of economies of scale.[12] Under economies of alliance, economic benefits arise from resources outside the organization, rather than from in-house resources under economies of scope, inducing the synergy effect of dynamic "new combinations," which is the key concept in what Joseph Schumpeter refers to as the driving force of innovation.

(Table 5)

With open networks and digital technology prevailing, modularity has come to gain an advantage over integrality, where some of the strengths of an integrated system turn into weaknesses. The reason for this is that information technology has progressed and changed its nature from simple high-performance automatic transaction machinery to an effective business communications tool. This will enable modular organizations to easily adapt the technology to a standard format of formal communication and reap the benefits of technological change in the form of productivity resurgence.

In contrast, integrated organizations tend to be unsuccessful at adapting technology. Their intimate human networks have traditionally performed so efficiently and dependably that their management is not attuned to the importance of using new technology and thereby pays less attention to formulating responses to technological change. It therefore takes a while for integrated organizations to fully implement new technology as a communication tool, which results in them losing their advantage over time. Furthermore, even if integrated organizations recognize the importance of using a given technology, they would need drastic business process reengineering and business unit restructuring in order to gain the benefits of the technology.

From the results of these analyses it is reasonable to conclude that appropriate investment in intangibles, i.e., redesigning business processes and human resource management, has a decisive role opening a narrow window of opportunity through which Japanese firms achieve significant improvements in productivity.

5. Conclusions

[12] Network effects represent the scale merits of the demand-side (consumption), whereas economies of scale represent those of the supply-side (production). Katz and Shapiro (1985) argue the nature of network externalities.

In this paper we implemented a comprehensive analysis of the impact of information technology and the associated significance of investment in intangibles on Japan's productivity growth under a diminishing demographic trend. We first revisited the arguments of Solow's productivity paradox and the new economy, and then we applied these to the Japanese economy, conducting a growth accounting analysis and estimating several production function models that incorporate IT capital stock explicitly. In addition, we investigated the significant role of corporate reforms to achieve effective outcomes from investment in IT based on a series of firm-level questionnaire surveys.

The main findings of this research are as follows; firstly, in the U.S. the productivity paradox disappeared and a new economy emerged during late 1990s and early 2000s, while in Japan we can see neither a productivity paradox nor a new economy. Secondly, the estimation of production function models, however, demonstrates that IT capital stock and information flows have considerable potential to contribute to Japanese economic growth. Thirdly, firm-level analyses based on a series of questionnaire surveys show that corporate reforms, such as re-designing existing organizational structures and human resource management play a decisive role in the positive outcomes of investment in information technology, although most Japanese firms tend to hesitate in implementing drastic reforms, which has led to a sluggish investment trend since the 1990s.

From these analyses, we can conclude that Japanese IT investment has been stagnant over the last two decades in spite of its potential, and that there is a strong complementary relationship between drastic corporate reforms and positive outcomes from IT investment, which Japanese firms have been fumbling. Since the inertia of Japan's integrated corporate system seems to persist in the midst of innovation, it is necessary for the private business sector to continue intensive efforts into investment in intangibles, i.e., drastic redesign in business processes and human resource management in order to reap the great benefits of new technology.

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Tables and figures

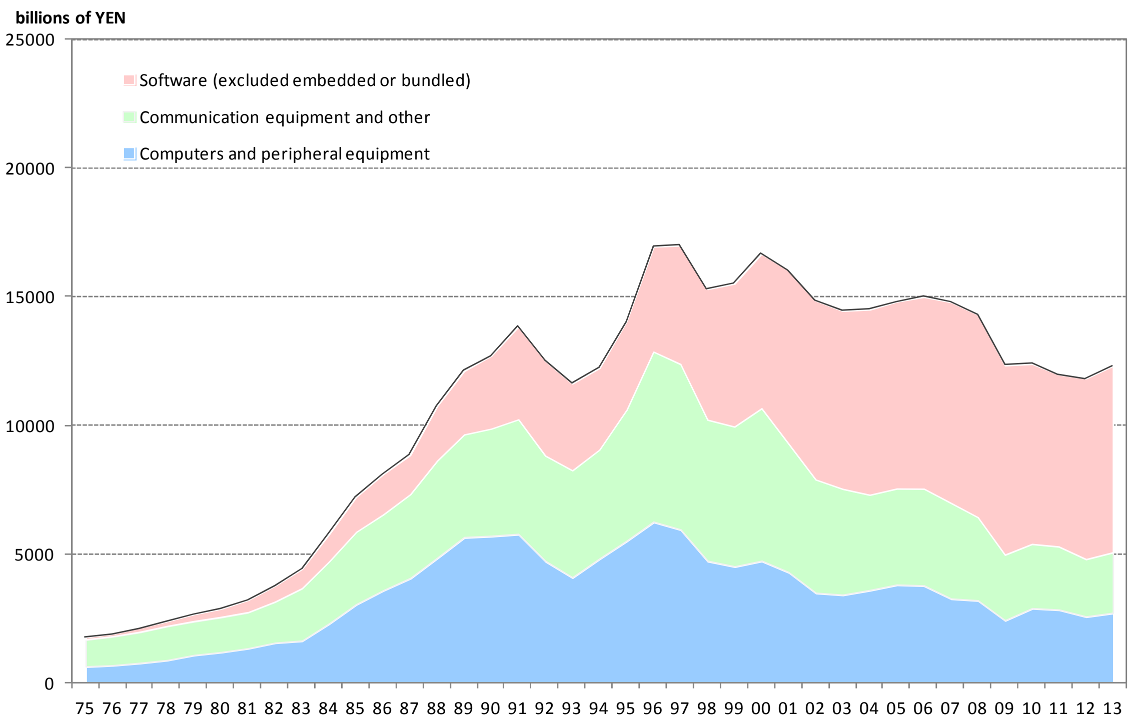
Table 1. Acceleration of the U.S. economy and the contribution of IT assets

	1959–73 (a)	1973–95 (b)	1995–2006 (c)	95–2000 (d)	Difference (b)–(a)	(c)–(b)	(d)–(b)
Output per hour	2.8	1.5	2.6	2.7	-1.3	1.1	1.2
Capital deepening	1.4	0.9	1.4	1.5	-0.5	0.5	0.6
of IT assets	0.2	0.4	0.8	1.0	0.2	0.4	0.6
Labor quality	0.3	0.3	0.3	0.2	0.0	0.0	-0.1
Total factor productivity	1.1	0.4	1.0	1.0	-0.7	0.6	0.6

Source: Jorgenson et al. (2008).

Note: Figures might not sum precisely because of rounding.

Figure 1. Nominal investment in information equipment and software in Japan



Source: Estimated extension based on Shinozaki (2011) and InfoCom Research (2013).

Table 2. Economic growth, labor productivity, TFP, and the contribution of IT

	76-80	81-85	86-90	91-95	96-00	01-05	06-09	changes from previous five years					
	a	b	c	d	e	f	g	b-a	c-b	d-c	e-d	f-e	g−f
Private output	4.8	3.3	5.0	1.3	0.8	1.5	-0.7	-1.5	1.7	-3.7	-0.5	0.8	-2.2
Hours worked	1.4	0.9	1.3	-0.2	-0.5	-0.6	-0.0	-0.5	0.4	-1.5	-0.3	-0.1	0.6
Output per hour	3.4	2.4	3.7	1.5	1.3	2.1	-0.7	-1.1	1.3	-2.1	-0.2	0.8	-2.8
Business cycle effect	1.2	-0.0	0.3	-0.8	0.1	0.2	-1.6	-1.2	0.3	-1.1	0.9	0.2	-1.9
Fundamental trend	2.2	2.4	3.4	2.4	1.2	1.9	1.0	0.2	1.0	-1.0	-1.1	0.7	-0.9
Capital deepening	1.7	1.5	1.7	1.5	1.0	0.7	0.5	-0.2	0.2	-0.2	-0.6	-0.3	-0.2
of non IT-assets	1.7	1.4	1.4	1.3	0.7	0.4	0.3	-0.3	0.0	-0.1	-0.6	-0.3	-0.1
of IT assets	0.0	0.1	0.3	0.3	0.3	0.2	0.1	0.1	0.2	-0.1	0.0	-0.0	-0.1
Labor quality	0.3	0.4	0.3	0.3	0.4	0.3	0.2	0.1	-0.1	-0.0	0.1	-0.0	-0.2
Total factor productivity	0.3	0.5	1.3	0.5	-0.1	0.9	0.4	0.3	0.8	-0.8	-0.6	1.0	-0.6
[Income shares (percentage)]													
share Ko (α)	32.1	30.5	30.7	26.6	23.4	23.3	23.3	-1.5	0.2	-4.1	-3.3	-0.1	0.1
share Ki (β)	2.0	1.8	2.5	2.9	3.5	4.5	4.9	-0.2	0.7	0.4	0.6	0.9	0.4
share L (γ)	66.0	67.7	66.8	70.5	73.1	72.3	71.8	1.7	-0.9	3.7	2.7	-0.8	-0.5
[Annual growth rate of inputs]													
dKo	6.6	5.5	5.9	4.5	2.4	1.3	1.4	-1.2	0.5	-1.4	-2.1	-1.1	0.1
dKi	3.9	7.0	13.8	8.7	7.6	4.8	3.0	3.1	6.8	-5.1	-1.1	-2.8	-1.8
dedu	0.4	0.6	0.5	0.4	0.5	0.4	0.2	0.2	-0.1	-0.1	0.1	-0.1	-0.2

Source: Shinozaki (2011).

Note: Figures might not sum precisely because of rounding.

Table 3. Results of macro-level estimation

	Base model		IT assets model		Network effect model	
	coefficient	t-statistics	coefficient	t-statistics	coefficient	t-statistics
C	-2.303 **	-16.010	-0.888	-1.814	-1.542 **	-5.341
Kall/eduL	0.537 **	23.510			0.359 **	6.056
Ko/eduL			0.229 *	2.250		
Ki/eduL			0.149 **	3.725		
ubq*Ki					0.018 *	2.189
AR(1)	0.570 **	3.316	0.662 **	3.008	0.952 **	17.315
Labor share	0.463		0.622		0.641	
Capital share	0.537		0.378		0.359	
(of non-IT)			0.229			
(of IT)			0.149			
$_{adj}R^2$	0.994		0.996		0.993	
D.W.	1.728		1.654		1.519	
growth rate	%		%		%	
(2010-20)	1.6		2.4		2.7	
(2010-25)	1.6		2.1		2.6	

Source: Shinozaki (2009).

Note: A variable of ubq represents the volume of information flow.

Table 4. Results of industry-level estimation

Model1

Dependent Variable: ln(Y)	Pool OLS		Fixed		Random	
	Estimated Coefficient	t-statistics	Estimated Coefficient	t-statistics	Estimated Coefficient	z-statistics
ln(Kall/L)	0.5034	[13.85]***	0.4457	[15.36]***	0.4493	[15.70]***
Ki/L	0.0150	[6.10]***	0.0045	[4.24]***	0.0045	[4.28]***
_cons	1.2712	[7.63]***	1.6646	[12.27]***	1.6466	[8.34]***
Diagnostic Test						
Number of observation	484		484		484	
Number of groups	22		22		22	
R-sq: within	-		0.5162		0.5162	
between	-		0.4941		0.4941	
overall	0.5058		0.4917		0.4917	
F test that all u_i=0:			F(21, 460) = 361.96		Prob > F = 0.0000	
sigma_u			0.6909		0.6798	
sigma_e			0.1627		0.1627	
rho			0.9474		0.9458	
Breusch and Pagan Lagrangian multiplier test for random effects			chi2(1) = 4260.59		Prob > chi2 = 0.0000	
Hausman specification test			chi2(2) = 3.38		Prob>chi2 = 0.1845	

* p<0.1, ** p<0.05, *** p<0.01

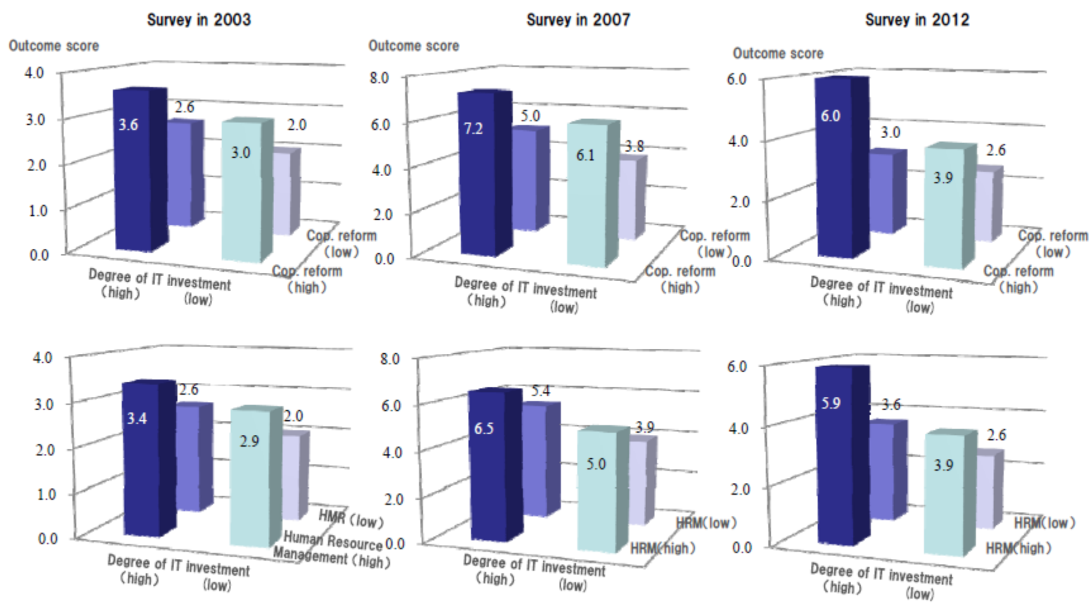
Model2

Dependent Variable: ln(Y)	Pool OLS		Fixed		Random	
	Estimated Coefficient	t-statistics	Estimated Coefficient	t-statistics	Estimated Coefficient	z-statistics
ln(Kall/L)	0.6739	[21.96]***	0.3781	[15.73]***	0.3875	[16.34]***
Ki/Ko	1.4233	[5.65]***	1.8637	[12.02]***	1.8219	[11.87]***
_cons	0.4767	[2.99]***	1.8832	[16.83]***	1.8407	[9.94]***
Diagnostic Test						
Number of observation	484		484		484	
Number of groups	22		22		22	
R-sq: within	-		0.6174		0.6173	
between	-		0.4509		0.4589	
overall	0.5007		0.4456		0.4533	
Log Likelihood	-		-		-	
F test that all u_i=0:			F(21, 460) = 468.53		Prob > F = 0.0000	
sigma_u			0.7439		0.6947	
sigma_e			0.1447		0.1447	
rho			0.9635		0.9584	
Breusch and Pagan Lagrangian multiplier test for random effects			chi2(1) = 4457.98		Prob > chi2 = 0.0000	
Hausman specification test			chi2(2) = 19.15		Prob>chi2 = 0.0001	

* p<0.1, ** p<0.05, *** p<0.01

Source: Shinozaki, et al. (2012).

Figure 2. Outcome scores of IT investment by different categories of corporate reforms



Note: Size of outcome scores cannot be compared with those in different years due to differences in questionnaire items and the methodology of scoring in each survey.

Figure 3. Distribution of firms by degree of corporate reforms

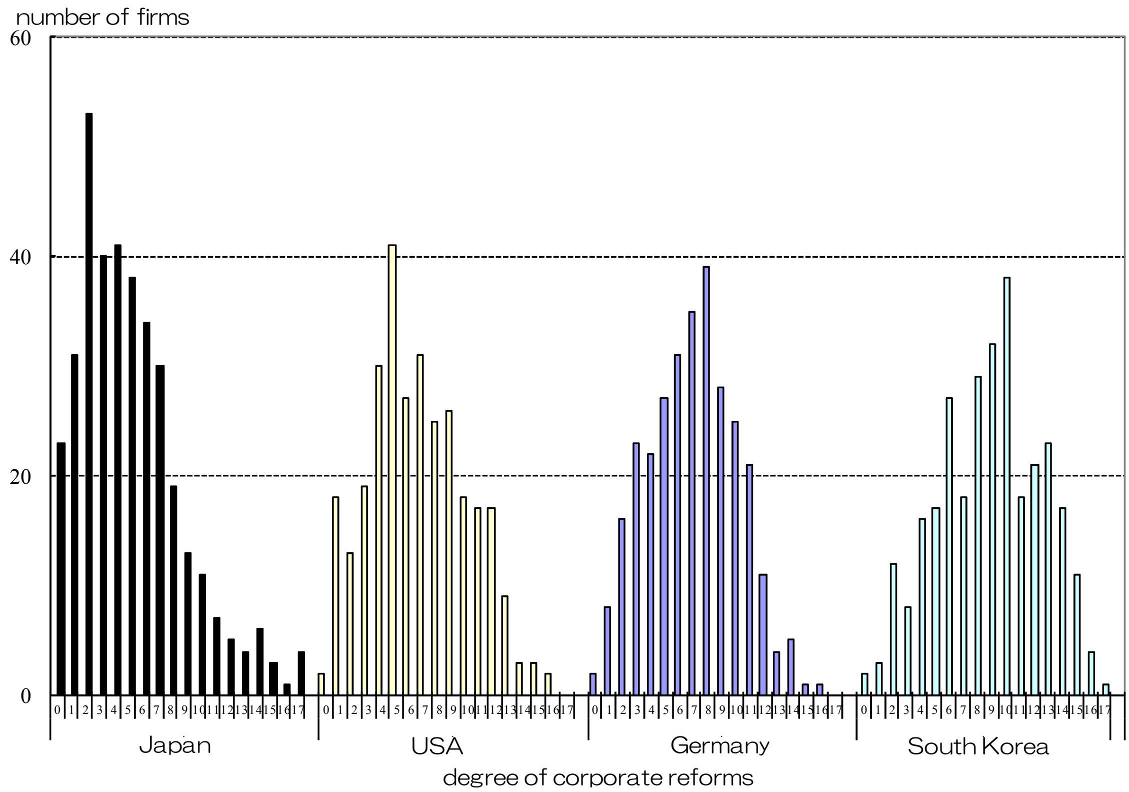


Figure 4. Comparisons of reformed firms with all respondent firms

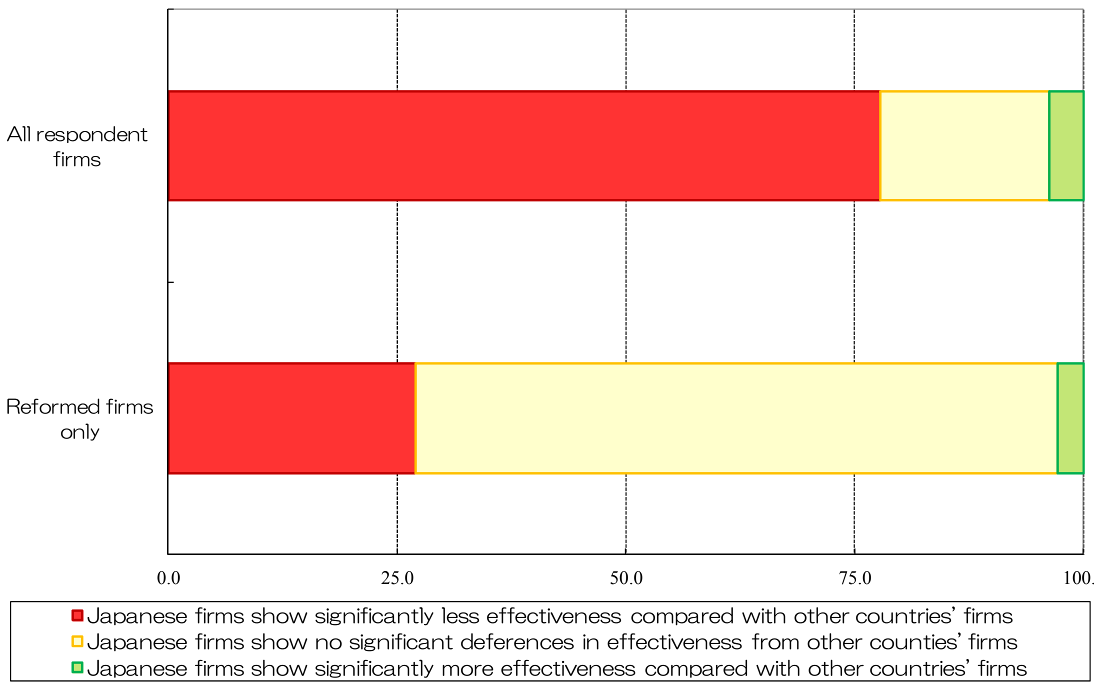
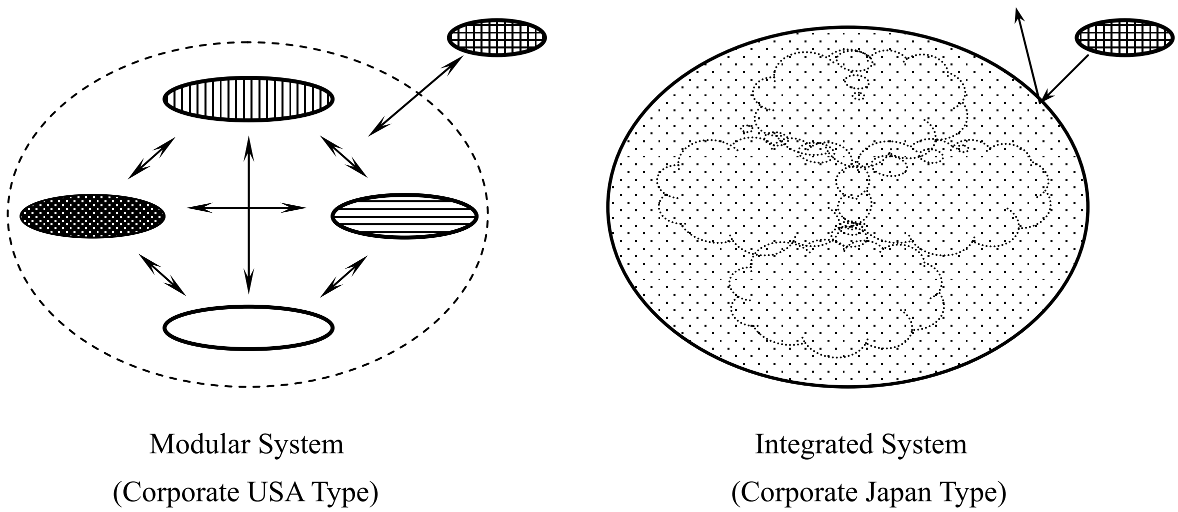


Figure 5. Modularity versus Integrality



Source: Adams, et al. (2007) Figure 8.1, p. 64, with modifications.

Table 5. Economies in the information age and the industrial age

Types of Merit	Emerging Information Age	Matured Industrial Age
Scale Merit	Network Effects (Externalities) - consumers' scale merit	Economies of Scale - producers' scale merit
Resource Merit	Economies of Alliance (Outsourcing) - outside resources - multiple organizations - synergy effect - innovations (new combinations)	Economies of Scope - in-house resources - single integrated organization - cost saving - learning by doing
Desirable Industrial Organization	Multiple small players Competitive market Compatibility Modularity	Larger organization Oligopoly, or monopoly Continuity Integrality

Source: Adams, et al. (2007) Table 8.1, p. 65, with modifications.