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**Does the Stock Market Evaluate Intangible Assets?  
An empirical analysis using data of listed firms in Japan**

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### Abstract

Following Corrado et al. (2009), we measure intangible assets at the listed firm level in Japan. Compared to the conventional Tobin's Q, the revised Q including intangibles is almost 1 on average, as suggested by Hall (2000 and 2001). The standard deviation of the revised Q is smaller than that of the conventional Q. Estimation results based on Bond and Cummins (2000) show that greater intangible assets increase firm value. In particular, in the IT industries, on average, Tobin's Q is higher than that in the non-IT industries, and the stock market reflects the value of intangibles in the IT industries. These results suggest that the government should adopt policies that promote investment, including intangibles in the IT industries, and change in the industry structure in Japan.

*Keywords:* Tobin's Q, Intangible assets, IT industries, Price cost margin, External finance dependence

*JEL classifications:* E22, G31, G32, L25, O30

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## 1. Introduction

In the 1990s, new types of firms such as Amazon and Google were founded and grew rapidly under the IT revolution. There are several characteristics of these firms. As Brynjolfsson (2004) pointed out, they developed new software, invested in human capital, and formed organizational structures that enabled faster decision-making. Due to the success of these firms, economists have paid attention to the role of intangible assets on firm performance and firm value. Corrado et al. (2009) measured comprehensive intangible investment including software investment, investment in human capital, and reform in organizational structure, and showed the significant contribution of intangible assets to US economic growth. Following Corrado et al. (2009), the positive effects of intangible assets on economic growth were found in the advanced countries.<sup>1</sup>

At the firm level, there have been several studies on the effects of R&D investment, which is a part of intangible investment on firm performances and firm value.<sup>2</sup> However, Hall (2000 and 2001) pointed out that after the IT revolution, the stock market may be evaluating not only R&D stocks but also other types of intangible assets positively. To examine the determinants of firm value after the IT revolution, we need to measure a broader concept of intangible assets beyond R&D assets like Corrado et al. (2009).

Thus, in our paper, we measure comprehensive intangible assets following Corrado, et al. (2009) by using data of Japanese listed firms. Based on our measurement, we examine the relationship between firm value and intangible assets, and estimate Tobin's Q using not only intangible but also tangible assets. From the above studies, we find that the mean value of Tobin's average Q becomes close to 1 and its variance becomes small when we consider intangible assets, as Hall (2000 and 2001) expected. We also find that intangible assets are

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<sup>1</sup> Intangible investment was measured at the aggregate level by Marrano, Haskel, and Wallis (2009) for the UK, Fukao et, al. (2009) for Japan, Delbeque and Bounfour for France and Germany, Hao, Manole, and Van Ark (2008) and Piekkola (2011) for the EU countries, Burns and McClure (2009) for Australia, and Pyo, Chen, and Rhee (2011) for Korea. At the sectoral Level, Miyagawa and Hisa (2013) measured intangible investment asnd showed positive effect on productivity growth.

<sup>2</sup> Griliches (2000) summarized a history of studies on the effects of R&D on firm performance and firm value.

positively correlated with firm value. The estimation results show that the accumulation of intangible assets significantly increases firm value. The effect is particularly pronounced and significant in the IT related industries.

Our paper consists of six sections. In the next section, we review the existing literature on the measurement of intangible assets and how intangible assets are evaluated in the stock market. In the third section, we explain how we measure intangible assets. In the fourth section, we examine several features of Tobin's Q that take intangible assets into account. In the fifth section, we examine the effects of intangible assets on firm value by estimating a standard average Tobin's Q. In the last section, we summarize our findings.

## **2. Intangible Assets and Firm Value: A Literature Review**

Hall (2000 and 2001) pointed out that the Tobin's Q in the US market consistently exceeded 1. He subsequently argued that these adjustment costs are accumulated as intangible assets within a firm, and the gap between Tobin's Q and 1 is accounted for intangible assets.<sup>3</sup> To examine Hall's proposition, Brynjolfsson, Hitt and Yang (2002) estimated firm value using non-IT capital and IT capital, and found that the coefficients of IT capital were much greater than those of non-IT capital. Then, they argued that these large coefficients were affected by intangible assets, complementary to IT capital. Cummins (2005) and Miyagawa and Kim (2008) estimated firm value using not only non-IT capital and IT capital but also with R&D capital and advertisement capital. Although Cummins (2005) did not find a higher than normal rate of return for intangible assets, Miyagawa and Kim (2008) obtained the opposite results to Cummings (2005).

Although Cummins (2005) and Miyagawa and Kim (2008) focused on R&D capital and advertisement capital, Lev and Radhakrishnan (2005) recognized a portion of sales, general and administrative expenditures as organizational capital. By estimating the difference between

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<sup>3</sup> Hall uses the term 'e-capital' instead of organization capital.

market value and book value using organizational capital, they found that organizational capital significantly contributed to market value. Hulten and Hao (2008) estimated firm value of pharmaceutical companies by R&D capital, and organizational capital measured from sales, general and administrative expenditures, and showed that both of these types of intangible assets contributed to increasing firm value.

Abowd et al. (2005) constructed their own measure with respect to quality of human capital from employer-employee datasets. They estimated firm value by obtaining Compustat data using the measure of quality of human capital, and found that their measure was positively correlated with the value of the firm. Bloom and Van Reenen (2007) also constructed their own management score taking organizational management and human resource management into account, using their interview surveys. They showed that this management score was positively correlated with Tobin's Q. Görzig and Görnig (2012) measured intangible assets by estimating the share of labor costs of IT, R&D, and management and marketing employees. Once they considered intangible assets, they showed that the dispersion of rate of return on capital was reduced dramatically.

### **3. Measurement of Intangible Assets in Japanese Listed Firms**

Although previous studies have shown the contribution of intangible assets to firm value, they did not capture comprehensive intangible assets like Corrado et al. (2009). Following Corrado (2009), therefore, we employ a broader concept of intangible assets compared to that of previous studies.<sup>4</sup> Corrado et al. (2009) classified intangible assets into three categories: computerized information, innovative property, and economic competencies.

The first category (computerized information) further consists of three types of software investment: custom software investment, packaged software investment, and own account

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<sup>4</sup> The measurement of tangible assets evaluated at replacement cost is also explained in Appendix 1.

software investment. The second category of intangible assets (innovative property) accounts for various items possibly including science and engineering R&D, mineral exploitation, copyright and license costs, and other product development, design, and research expenses. Due to the limitation of the information in *Basic Survey of Business Activities of Enterprises* (BSBAE), we have only R&D expenditures as the second item of intangible assets. The third category of intangible assets consists of brand equity, firm specific human capital, and organizational structure. As we detail later, the information in the DBJ Corporate Financial Databank is used to measure the three items (i.e., advertising, human capital, organization change) in this category of intangible assets. The methods we use to measure the five items mentioned above for each firm are as follows:

1) Software: First, the ratio of workers engaged in information processing to the total number of employee is multiplied by the total cash earnings in order to measure the value of software investment. Then, we add the cost of information processing to this number to find total software investment. We deflate this number by the deflator for software investment in the Japan Industrial Productivity (JIP) database.<sup>56</sup>

2) Research and Development (R&D): We subtract the cost of acquiring fixed assets for research from the cost of R&D (i.e., in-house R&D and contract R&D) to estimate the value of investment into R&D. The output deflator for research (private) in the JIP database is used to deflate this R&D investment.

3) Advertising: Advertising expenses in the DBJ Corporate Financial Databank are used as a proxy for investment into advertising. We use the output deflator for advertising in the JIP database as the deflator for advertising investments.

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<sup>5</sup> In this procedure, we were not able to measure purchased software investment, which is included in the capital expenditure in the balance sheets of each firm. We ignore this part due to data limitations on capitalized software in our data.

<sup>6</sup> The JIP database consists of 108 industries. The website of the database is <http://www.rieti.go.jp/en/database/JIP2011/index.html>. Fukao et al. (2007) explain how this database was constructed.

4) Human capital: First, we estimate each firm's investment on firm-specific skills by multiplying (i) the total labor cost in the DBJ Corporate Financial Databank with (ii) the industry-average ratio of total employee training cost to the total labor cost for each firm and (iii) the ratio of the on-the-job and off-the-job training costs for firm-specific skills to the total education cost (0.37).<sup>7</sup> In order to further consider the opportunity cost of the off-the-job training cost for skill improvement, we multiply the number computed in the abovementioned procedure to 2.51.<sup>8</sup>

5) Organizational change: Following Robinson and Shimizu (2001), who conducted a survey of the time-use of Japanese CEOs, we assume that 9% of board members' compensation -- which we can obtain from the DBJ Corporate Financial Databank -- accounts for investment in organizational change. This is deflated by the output deflator for education (private and non-profit) in the JIP database.

For all five investment category data detailed above, we employ the Perpetual Inventory (PI) method, in which we use FY1995 as the base year, to construct a data series of intangible assets from FY2000. All depreciation rates used for this computation follow that of Corrado et al. (2012).<sup>9</sup>

#### 4. Tobin's Q with Intangibles

The conventional Tobin's Q ( $Q_{it}^C$ ) at the firm level is measured as the ratio of firm value ( $V_{it}$ ) to the replacement value of tangible assets ( $(1 - \delta_k)K_{it-1}$ ) at the initial period of  $t$ .<sup>10</sup>

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<sup>7</sup> For the ratio of the job training costs for firm-specific skill to overall employee training costs, we use the results in Ooki (2003).

<sup>8</sup> Ooki (2003) estimates the ratio of the average opportunity cost of off-the-job training to the total employee training cost paid by firm (all industry) in 1998 as 1.51. Ooki (2003) uses the micro-data obtained from "The Japan Institute for Labor Policy and Training's Survey on Personnel Restructuring and Vocational Education/Training Investment in the Age of Performance-based Wage Systems" (Gyoseki-shugi Jidai no Jinji Seiri to Kyoiku/Kunren Toshi ni Kansuru Chosa).

<sup>9</sup> The depreciation rates of software, R&D, advertising, human capital and organizational change are 31.5%, 15%, 55%, 40% and 40%, respectively.

<sup>10</sup> As for the derivation of the conventional Q, we follow Bond and Cummins (2000).

$$(1) \quad Q_{it}^c = \frac{V_{it}}{(1 - \delta_{Kt})K_{it}}$$

where  $\delta_K$  is the depreciation rate of tangible assets. We measure the conventional Tobin's Q as follows:

The conventional Tobin's Q = (Stock value + Book values of commercial paper, corporate bond, and long-term debt)/(1- $\delta_K$ )\*(Replacement values of tangible assets + Inventory-Short-term debt).

As shown by Lindenberg and Ross (1981), and Hall (2000 and 2001) for the US and Tanaka and Miyagawa (2011) for Japan, the standard Q expressed by (1) has persistently exceeded 1. The mean value of the conventional Tobin's Q shown in Table 1-1 is also 1.40.

Lindenberg and Ross (1981) explained the gap between the measured conventional Q and 1 as being due to monopoly rents, although they knew that unmeasured intangibles affected this gap. When we measure the Tobin's Q considering intangible assets ( $N_{it-1}$ ) as measured in Section 3, the revised Tobin's Q ( $Q_{it}^R$ ) is expressed as follows:

$$(2) \quad Q_{it}^R = \frac{V_{it}}{(1 - \delta_K)K_{it} + (1 - \delta_N)N_{it}}$$

where  $\delta_N$  is the depreciation rate in intangible assets.

We show a revised Tobin's Q including intangible assets in Table 1-2. The mean value of the revised Tobin's Q is 0.99 which is almost equal to 1. The difference between the two mean values is significant. The standard deviation of the revised Q is smaller than that of the conventional Q, which is consistent with the results of Görzig and Görnig (2012), who showed



that the dispersion of profit rates when including intangible assets is smaller than that without intangibles. The distributions of two types of Tobin's Q are shown in Figure 1. We find that the revised Tobin's Q is distributed around 1 compared to the conventional one. The Kolmogorov-Smirnov test rejected the hypothesis that the two distributions are the same.

(Place Tables 1-1, 1-2 and Figure 1 around here)

We divide all samples into two sectors: IT sectors and non-IT sectors.<sup>11</sup> The mean value of Tobin's Q in IT sectors is higher than that in non-IT sectors in both cases. However, the mean value of the revised Q in the IT sectors is 1.13, which is much closer to 1 than the mean value of the conventional Q in the IT sectors. Also, the standard deviation of the revised Q in the IT sectors is reduced compared to that of conventional Q in the IT sectors.

(Place Tables 1-3, 1-4, 1-5, and 1-6 around here)

Arato and Yamada (2012) measured aggregate intangible assets based on DBJ data. Their estimated ratio of intangible assets to tangible assets is 0.47 in the 1980s. As shown in Table 2, the corresponding rate of our estimates is 0.45, which is similar to that of Arato and Yamada (2012). The result shows that the ratio of intangible assets to tangible assets has not changed in Japan.

(Place Table 2 around here)

## **5. Do Intangible Assets Explain the Overvaluation of Tobin's Q?**

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<sup>11</sup> The classification of IT industries and non-IT industries is shown in Appendix 2.

### 5-1 The Relationship of the Conventional Tobin's Q with Intangibles

Although the revised Q is almost equal to 1 on average, the Tobin's Q in each firm deviates from 1. Thus, we econometrically check the effects of intangible assets on the variation of Tobin's Q. As we introduced in Section 2, Brynjolfsson, Hitt and Yang (2002), Cummins (2005) and Miyagawa and Kim (2008) estimated the effects of intangible assets on firm value. However, these studies focused on fewer components of intangibles than those classified by Corrado et al. (2009). Therefore, we examine the effect of intangibles following the classification by Corrado et al. (2009) on firm value.

Following Bond and Cummins (2000), the profit function ( $\pi$ ) depends on tangible and intangible capital. Dividends at firm  $i$  ( $D_i$ ) are expressed as follows:

$$(3) \quad D_{it} = \pi(K_{it}, N_{it}) - I_{it} - O_{it} - G(I_{it}, K_{it}) - H(O_{it}, N_{it})$$

where  $I$  is investment in tangible assets,  $O$  is investment in intangible assets, and  $G$  and  $H$  are adjustment cost functions in tangible investment intangible investment, respectively.<sup>12</sup>

$$G(I_{it}, K_{it}) = \frac{a}{2} \left( \frac{I_{it}}{K_{it}} \right)^2 K_{it}$$
$$H(O_{it}, N_{it}) = \frac{b}{2} \left( \frac{O_{it}}{N_{it}} \right)^2 N_{it}$$

Capital accumulation in tangible assets and intangible assets is expressed as follows:

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<sup>12</sup> There are two types of adjustment cost functions. The first type of adjustment cost implies additional costs associated with gross investment. The second type of adjustment cost implies that gross investment includes adjustment costs associated with accumulation of capital. In our study, we use the first type of adjustment cost function.

$$K_{it} = I_{it} + (1 - \delta_K)K_{it-1}$$

$$N_{it} = O_{it} + (1 - \delta_N)N_{it-1}$$

We solve the optimization problems of firm  $i$  with respect to  $I$ , and  $O$ .

$$(4-1) \quad q_{Kt} = 1 + a\left(\frac{I_{it}}{K_{it}}\right)$$

$$(4-2) \quad q_{Nt} = 1 + b\left(\frac{O_{it}}{N_{it}}\right)$$

where  $q_K$  and  $q_N$  are Lagrange multipliers.

When the profit function is linear homogeneous, the firm value of firm  $i$  is expressed as a linear combination of each asset (Wildasin (1984) and Hayashi and Inoue (1991)).

$$(5) \quad V_{it} = q_{Kt}(1 - \delta_K)K_{it} + q_{Nt}(1 - \delta_N)N_{it}$$

From (5),

$$(6) \quad q_{Kt} = \frac{V_{it}}{(1 - \delta_K)K_{it}} - q_{Nt} \frac{(1 - \delta_N)N_{it}}{(1 - \delta_K)K_{it}}$$

Substituting (4-1) and (4-2) into (6), we obtain:

$$(7) \quad Q_{it}^C - 1 = a\left(\frac{I_{it}}{K_{it}}\right) + \left\{1 + b\left(\frac{O_{it}}{N_{it}}\right)\right\} \frac{(1 - \delta_N)N_{it}}{(1 - \delta_K)K_{it}}$$

$$= a\left(\frac{I_{it}}{K_{it}}\right) + \frac{(1 - \delta_N)N_{it}}{(1 - \delta_K)K_{it}} + b\frac{(1 - \delta_N)O_{it}}{(1 - \delta_K)K_{it}}$$

where  $Q_{it}^C = \frac{V_{it}}{(1 - \delta_{Kt})K_{it}}$  is the standard average Q at firm  $i$ .

Equation (7) implies that the gap between the conventional Q ratio and 1 is explained by the ratio of intangible assets to tangible assets, the gross tangible investment/tangible assets ratio, and the gross intangible assets ratio.

## 5.2 Estimation results

Based on Equation (7), we estimate the following equation:

$$(8) \quad Q_{it}^C - 1 = \text{const.} + \alpha_1 \left( \frac{N_{it}}{K_{it}} \right) + \alpha_2 \left( \frac{I_{it}}{K_{it}} \right) + \alpha_3 \left( \frac{O_{it}}{K_{it}} \right) + \sum_{j=1}^n \beta_j X_{jt} + \varepsilon_{it}$$

In Equation (8),  $X$  is a control variable. Lindenberg and Ross (1981) pointed out that monopoly rents explained the overvaluation of firm value. In addition, financial constraints may affect the gap between a standard Q and 1. Then, we also estimate Equation (8) with a price cost margin or external finance dependence as defined by Rajan and Zingales (1998). We expect that the coefficient of external finance dependence will be negative because a greater dependence on external finance reduces firm value. The basic statistics of the variables used in our estimation are summarized in Table 3.

(Place Table 3 around here)

First, we estimate Equation (8) by OLS. To avoid endogeneity, we take a one-year lag for all explanatory variables except firm age. The estimation results are shown in Table 4. In Column (1), we focus on the effect of intangible assets on the overvaluation of the conventional Q. In this estimation, the ratio of intangible to tangible assets significantly explains the overvaluation of the Q ratio. In Column (2), we regress firm value on three variables included in Equation (7). The estimation results show that all variables are positive and the ratio of intangible to tangible assets, and the tangible investment/tangible assets ratio are significant. Due to the strong correlation between intangible assets/tangible assets and intangible investment/tangible assets ratio, the coefficient of intangible investment/tangible assets ratio may be not significant.

In Columns (3) and (4), we estimate Equation (8) including control variables. In Column (3), all three variables in Equation (7) are positive and significant. In addition, the coefficient of external finance dependence is negative and insignificant, as we expected. In Column (4), the ratio of intangible assets to tangible assets and the price cost margin are positive and significant, while intangible and tangible investments are not significant.

(Place Table 4 around here)

Next, we estimate Equation (8) utilizing the instrumental variable method. Instruments are the ratio of white-collar to total workers, and external finance dependence. The results in Table 5 indicate that the ratio of intangible assets to tangible assets is positive and significant in all estimations. However, the intangible investment/tangible assets ratio is negative in Columns (2) and (3). It is possible that negative coefficients of intangible investment/tangible assets are caused by the multicollinearity between intangible assets and intangible investment.

(Place Table 5 around here)

We also conduct panel estimations. As the Hausman test suggests that the random effect estimation is better than fixed effect estimation, we show the results of random effect estimations in Table 6. Table 6 shows that the ratio of intangible assets to tangible assets is positive and significant in all estimations. As the coefficient of price cost margin is also positive and significant, monopoly rents also contribute to the valuation of firm, as Lindenberg and Ross (1981) suggested.

(Place Table 6 around here)

Brynjolfsson, Hitt and Yang (2002), Basu et al. (2003), and Cummins (2005) emphasized that intangible assets are complementary to IT assets. Miyagawa and Hisa (2012) found that intangible investment in the IT sectors improve TFP growth. In Section 4, we found that the Tobin's Q in IT sectors is higher than that in non-IT sectors. Then, we divide all samples into those in the IT sectors and non-IT sectors and estimate Equation (8) by the instrumental variable method in each sector. Table 7 shows that estimation results in IT sectors are similar to those in Table 5. The ratio of intangible to tangible assets is positive and significant in all estimations when the coefficients of intangible and tangible investments are not significant. However, in the non-IT sectors, the coefficients of the ratio of intangible to tangible assets are not necessarily significant, while the signs of the coefficients are positive in all estimations. The estimation results in Table 7 imply that only intangible assets in the IT industries contribute significantly to

the evaluation of firm value.<sup>13</sup> In addition, the price cost margin is positive and significant in the IT and non-IT sectors, as can be seen in Tables 5 and 6.

(Place Table 7 around here)

As explained in Section 3, Corrado et al. (2009) classified intangible assets into three components: computerized information, innovative property (R&D assets), and economic competencies. In Table 8, we examine what kind of assets the stock market assesses favorably. Estimation results in Table 8 show that the stock market assesses assets in computerized information favorably, while the assessments of innovative property and economic competencies are inconclusive. These results imply that the stock market does not necessarily consider all components of intangibles as positive.

(Place Table 8 around here)

## **6. Robustness Checks**

We confirm our results by checking robustness in two ways. First, we revise the adjustment cost functions of tangible and intangible investments and reexamine the effect of intangible assets on firm value. Second, we conduct an alternative estimation considering the cases where there are many observations far from the mean value.

There are two types of adjustment cost functions. The first type of adjustment cost implies additional costs associated with gross investment. The second type of adjustment cost depends on the accumulation of capital. While we assumed the first type of adjustment cost of

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<sup>13</sup> We also conduct OLS estimations in each sector. The estimation results are similar to Table 6. Although the ratio of intangible to tangible assets in the IT industries is positive and significant, the signs of this variable are inconclusive in the non-IT industries.

investment in the former section, we assume the other type of adjustment cost function in this section.

The second type of adjustment cost functions are expressed as follows;

$$G(I_{it}, K_{it}) = \frac{a}{2} \left( \frac{I_{it}}{K_{it}} - \delta_K \right)^2 K_{it}$$

$$H(O_{it}, N_{it}) = \frac{b}{2} \left( \frac{O_{it}}{N_{it}} - \delta_N \right)^2 N_{it}$$

Following the same procedure as in the former section, the estimating equation is

$$(8)' \quad Q_{it}^C - 1 = const. + \gamma_1 \left( \frac{N_{it}}{K_{it}} \right) + \gamma_2 \left( \frac{I_{it}}{K_{it}} - \delta_K \right) + \gamma_3 \left( \frac{O_{it}}{K_{it}} - \delta_N \right) + \sum_{j=1}^n \lambda_j X_{jt} + \varepsilon_{it}.$$

The estimation results of Equation (8)' are shown in Table 9. Estimation results in Table 9 are similar to those in Tables 4 and 5.<sup>14</sup> Intangible assets are viewed positively and significantly on firm value when we consider that the adjustment cost function depends on the accumulation of capital.

(Place Table 9 around here)

Figure 1 shows that the sample deviation from the mean value is not symmetric. In this case, quantile regression -- that estimates parameters based on the error measured as a deviation from the median value in each quantile -- is useful to check the robustness of our results. We separate the distribution of a conventional Tobin's Q into four quantiles and conduct quantile

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<sup>14</sup> In Table 9, we show results of Pooled OLS and instrumental variable estimations. However, we have also confirmed that the results of Random effects estimation and estimations by sector are similar to those to Tables 6 and 7.



regression. Table 10 shows the estimation results of quantile regression that correspond to the OLS estimations in Table 4. As in Table 4, the firm value reflects intangible values in all estimations. In addition, intangible investment also contributes positively and significantly to the increase in firm value (Column (2)), while the coefficient of this variable is not significant in Table 4. As a result, the above two alternative estimations confirm the positive and significant contributions of intangible assets to firm value.

(Place Table 10 around here)

## **7. Concluding Remarks**

The IT revolution has changed the growth strategy of firms. Software investment has become as important as tangible investment. Firms have focused on accumulation in human capital and restructured their organizations to be compatible with the new technology. Many economists such as E. Brynjolfsson, C. Corrado, R. Hall, C. Hulten, B. Lev, and L. Nakamura summarized these new types of expenditures as intangible investment and examined its effects on firm value. However, many studies have focused on the effects of specific components of intangible assets on firm value, because it is difficult to measure intangibles at the firm level.

Based on the classification of intangibles by Corrado et al. (2009), we measure a broader concept of intangibles than those in the previous studies using the listed firm-level data in Japan. The mean value of Tobin's Q including intangible assets is almost equal to 1, while the mean value of conventional Tobin's Q exceeds 1, as Hall (2000 and 2001) suggested. The standard deviation of the revised Q is smaller than that of the conventional Q, which is consistent with the results of Görzig and Görnig (2012). These results imply that stock prices reflect the value

of intangibles.

Although the results also imply that the market concludes that there are no growth opportunities of Japanese listed firms on average in the 2000s, there are still differences in Tobin's Q. The Tobin's Q in the IT industries is consistently higher than that in the non-IT industries. This difference in market value suggests that firms in the IT industries should expand their businesses, and firms in the non-IT industries should restructure their businesses. The result is consistent with Miyagawa and Hisa (2012), who argued that intangible investment improves productivity in the IT industries. The Japanese government should take growth strategies such as to promote investment including intangibles in the IT industries and to assist firms in the non-IT industries transform themselves to a business in a growth industry.

Using our measures, we examined the effects of intangibles on firm value. Estimation results following Bond and Cummins (2000) showed that greater intangible assets increase firm value. As these results are robust in the IT industries in particular, they support our policy implications. However, not all intangible assets are valued in the stock market. The values of innovative property and economic competencies are inconclusive. One possible reason for the long-term slump of the Japanese stock market is that investors are not valuing high level R&D investment and human resources in Japanese firms. The upcoming reform in accounting standards that will evaluate intangible assets will contribute to the revitalization of the Japanese stock market.

## **Appendix 1. Measurement of tangible capital stock**

### **Capital stock**

In reference to Hayashi and Inoue (1991), we created the dataset of capital stock by assets.

We employ the Permanent Inventory (PI) method, in which we use FY1980 or FY1990 as the base year.

We create firm level data of the capital stock using six assets, (1) non-house building, (2) construct, (3) machinery, (4) ship/vehicle/transportation equipment, (5) tool appliance equipment, and (6) other tangible assets as follows:

$$K_{it}^m = (1 - \delta_m)K_{it-1}^m + I_{it}^m$$

where  $K_{it}^m$  is the capital stock of asset  $m$  for firm  $i$  at time  $t$ ,  $I_{it}^m$  is real investment, and  $\delta_m$  is the depreciation rate. After calculating the capital stock of each asset, we estimate the real tangible capital stock,  $K_{it}$  by firm level, by adding them together as follows.

$$K_{it} = \sum_m K_{it}^m$$

In the following, we introduce the variables used in calculating the real tangible capital stock.

### **Nominal investments**

The nominal investment of each asset is defined as the amount of each acquisition credited against the retirement and decrease in the tangible asset by the sale of another one. While

Hayashi and Inoue (1991) used the retirement and decrease valued by replacement price, we use the book value.

### **Capital price by the type of capital goods**

In order to deflate nominal investments, we use the following price indices in "Corporate goods Price Index (CGPI)" by Bank of Japan.

"Construction material price index" for (1) non-house building and (2) construct

"Transportation equipment price index" for (4) ship/vehicle/transportation equipment

"Manufacturing product price index" for (6) other tangible assets

For (3) machinery or (5) tool appliance equipment, we use the relevant price indices in the CGPI. At first we calculate the industry level weight for each machinery or tool using the "Fixed Capital Formation Matrix" by the Cabinet office, of the Government of Japan. We calculate the weighted average price indices using the weights and the relevant price indices in CGPI for (3) machinery or (5) tool appliance equipment.

### **Base year**

As the analysis period in this work is after 2000, the base year for (1) non-house building and (2) structure (was "construct" earlier) is FY1980 and that for (3) machinery, (4) ship/vehicle/transportation equipment, (5) tool appliance equipment, and (6) other tangible assets is FY1990.

The base year for the companies that were newly listed after FY1980 or FY1990 is the very year when they were listed. As a benchmark, we took the book value of each tangible asset in the base year.

**Depreciation rate**

We use the depreciation rate that Hayashi and Inoue (1991) created using Hulten and Wykoff (1979, 1981). Specifically, the rates are the following: (1) non-house building, 4.7% (2) construct, 5.64% (3) machinery, 9.489% (4) ship/vehicle/transportation equipment, 14.7% (5) tool appliance equipment and (6) other tangible assets are both 8.838%.

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Table 1-1

Conventional Tobin's Q (All Sectors)	
Periods: FY2000-FY2009	
Mean	1.404
Median	1.056
Minimum	0.207
Maximum	6.933
Standard Deviation	1.146
Observations	2939

Table 1-2

Revised Tobin's Q (All Sectors)	
Periods: FY2000-FY2009	
Mean	0.990
Median	0.774
Minimum	0.142
Maximum	6.238
Standard Deviation	0.742
Observations	2939

Notes: 1) We drop the top and bottom 4% tails of the Conventional Tobin's Q.

2) Conventional Tobin's Q is calculated as follows:

Conventional Tobin's Q=(Stock value + Book value of Commercial paper and Corporate bond and Long-term debt) / ((1- $\delta_K$ )\*Replacement value of tangible assets+Inventory-Short-term debt)

3) Revised Tobin's Q is calculated as follows:

Revised Tobin's Q=(Aggregate market value + Book value of Commercial paper and Corporate bond and Long-term debt) / ((1- $\delta_K$ )\*Replacement value of tangible assets+(1- $\delta_N$ )\*Replacement value of intangible asset+Inventory-Short-term debt))

Figure 1. Density of Tobin's Q

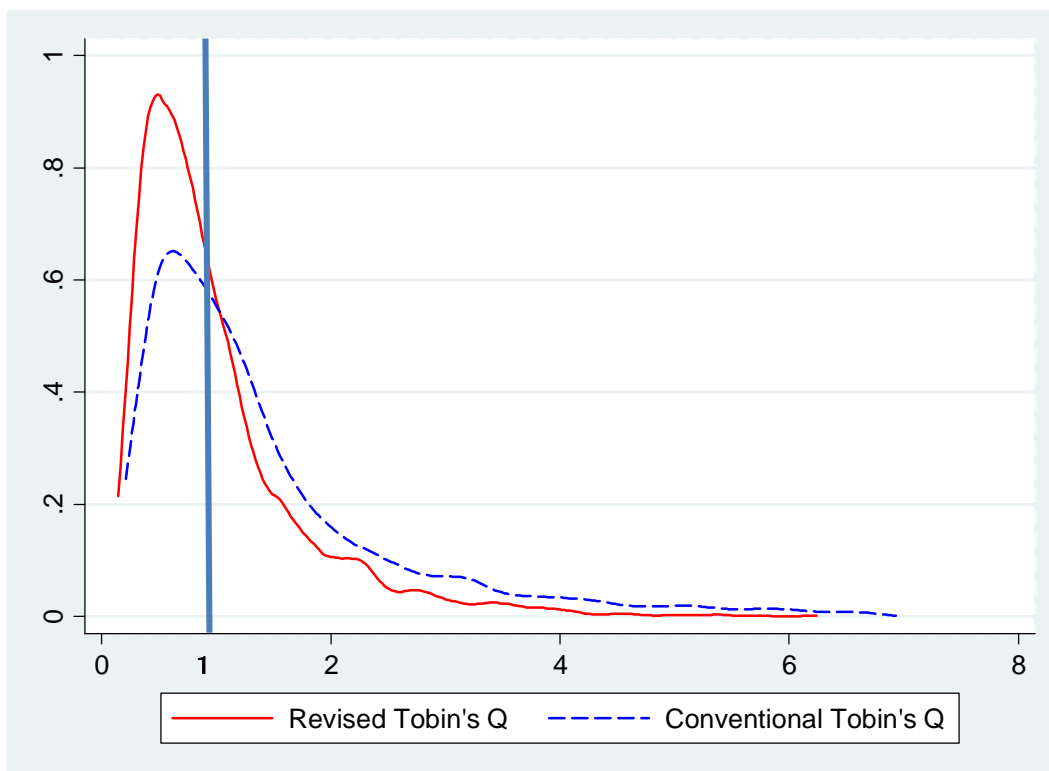


Table 1-3

Conventional Tobin's Q (IT Sectors)	
Periods: FY2000-FY2009	
Mean	1.710
Median	1.262
Minimum	0.207
Maximum	6.625
Standard Deviation	1.304
Observations	1089

Table 1-4

Revised Tobin's Q (IT Sectors)	
Periods: FY2000-FY2009	
Mean	1.129
Median	0.880
Minimum	0.162
Maximum	5.424
Standard Deviation	0.802
Observations	1089

Table 1-5

Conventional Tobin's Q (Non-IT Sectors)	
Periods: FY2000-FY2009	
Mean	1.224
Median	0.944
Minimum	0.208
Maximum	6.933
Standard Deviation	1.000
Observations	1850

Table 1-6

Revised Tobin's Q (Non-IT Sectors)	
Periods: FY2000-FY2009	
Mean	0.908
Median	0.711
Minimum	0.142
Maximum	6.238
Standard Deviation	0.692
Observations	1850

Table 2. Statistics of the ratio of intangible assets to tangible assets (N/K)

Periods: FY2000-FY2009	
Mean	0.442
Median	0.305
Minimum	0.013
Maximum	3.999
Standard Deviation	0.438
Observations	2939

Table 3. Statistics of the sample

Periods: FY2000-FY2009	Q-1	N/K	I/K	O/K	CC	PCM
Mean	0.404	0.442	0.103	0.129	0.130	0.036
Median	0.056	0.305	0.086	0.088	0.099	0.031
Minimum	-0.793	0.013	-0.019	0.004	-4.830	-0.469
Maximum	5.933	3.999	0.845	1.065	2.721	0.334
Standard Deviation	1.146	0.438	0.075	0.125	0.274	0.063
Observations	2939	2939	2939	2939	2026	2939

Notes:

N/K indicates the ratio of intangible to tangible assets.

I/K indicates the ratio of tangible to tangible assets.

O/K indicates the ratio of intangible to tangible assets.

CC indicates the measure of credit constraint.

We calculate this measure following Rajan and Zingales (1998) as follows:

$(\text{Capital expenditures (tangible + intangible)} - \text{Cash flow from operations}) / \text{Tangible capital stock}$ .

PCM indicates the price cost margin. The price cost margin is calculated as follows:

$(\text{Operating surplus} - \text{Interest expense}) / \text{Sales}$ .

Table 4. OLS estimates of determinants of conventional Tobin's Q-1

	(1)		(2)		(3)		(4)	
	All Sectors		All Sectors		All Sectors		All Sectors	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
N/K	0.619	0.053 ***	0.598	0.126 ***	0.390	0.143 ***	0.724	0.121 ***
I/K			0.571	0.236 **	1.036	0.292 ***	0.043	0.227
O/K			0.103	0.428	1.329	0.478 ***	-0.288	0.408
CC					-0.337	0.084 ***		
PCM							4.983	0.293 ***
Const.	-0.478	0.922	-0.575	0.922	-0.495	0.883	-0.723	0.878
Industry dummy	Yes		Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes		Yes	
Number of obs	2882		2882		2047		2882	
F	19.62		19.15		15.61		25.07	
Prob > F	0		0		0		0	
R-squared	0.312		0.313		0.3315		0.377	
Adj R-squared	0.296		0.297		0.3103		0.362	
Root MSE	0.918		0.917		0.87606		0.874	

Notes:

\*, \*\*, and \*\*\* indicate statistical significance at 10%, 5%, and 1%, respectively.

Dependent variable: Standard Tobin's Q-1

Explanatory variables: Nt/Kt indicates the ratio of intangible assets to tangible assets.

It/Kt indicates the ratio of tangible investments to tangible assets.

Ot/Kt indicates the ratio of intangible investments to tangible assets.

CC indicates the measure of credit constraint.

We calculate this measure following Rajan and Zingales (1998) as follows: (Capital expenditures (tangible + intangible) - Cash flow from operations)/Tangible capital stocks.

PCM indicates the price cost margin. Price cost margin is calculated as follows: (Operating surplus - Interest expense)/Sales.

Table 5. Instrumental variable (IV) estimates of determinants of conventional Tobin's Q-1

	(1)		(2)		(3)	
	All Sectors		All Sectors		All Sectors	
	Coef.	SE	Coef.	SE	Coef.	SE
N/K	0.518	0.212 **	3.413	0.763 ***	1.788	0.623 ***
I/K			0.924	0.315 ***	0.193	0.269
O/K			-9.934	2.768 ***	-4.146	2.261 *
PCM					6.005	0.356 ***
Const.	-0.759	0.171 ***	0.161	0.445	-0.670	0.371 *
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
Instrumented	N/K		O/K		O/K	
Instrumental Variables	Skilled labor ratio		Skilled labor ratio		Skilled labor ratio	
	CC		CC		CC	
Number of obs	2040		2040		2040	
F	52.06		12.27		20.75	
Prob > F	0		0		0	
R-squared	0.3196		0.1438		0.3767	
Adj R-squared	0.387		0.2286		0.4384	
Root MSE	0.8708		0.9769		0.8335	
Sargan statistic	9.624		0.488		0.409	
Chi-sq(1) P-val	0.0019		0.4847		0.5225	

Notes: See the notes in Table 4.

Skilled labor ratio indicates the ratio of white-color to total workers.

Table 6. Panel estimate (Random Effect) of determinants of conventional Tobin's Q-1

	(1)		(2)		(3)	
	All Sectors		All Sectors		All Sectors	
	Coef.	SE	Coef.	SE	Coef.	SE
N/K	0.613	0.082 ***	0.451	0.129 ***	0.595	0.125 ***
I/K			0.242	0.172	0.010	0.167
O/K			0.711	0.391 *	0.286	0.380
PCM					4.014	0.286 ***
Const.	-1.203	0.986	-0.558	0.987	-0.707	0.943
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
sigma_u	0.772		0.772		0.730	
sigma_e	0.600		0.599		0.581	
rho	0.623		0.624		0.612	
Number of obs	2882		2882		2882	
Number of groups	332		332		332	

	(1)		(2)		(3)	
	IT Sectors		IT Sectors		IT Sectors	
	Coef.	SE	Coef.	SE	Coef.	SE
N/K	0.666	0.110 ***	0.370	0.176 **	0.523	0.171 ***
I/K			0.563	0.344	0.155	0.337
O/K			1.108	0.481 **	0.666	0.469
PCM					4.860	0.565 ***
Const.	0.804	1.097	0.809	1.104	0.759	1.063
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
sigma_u	0.772		0.779		0.741	
sigma_e	0.738		0.733		0.712	
rho	0.523		0.530		0.520	
Number of obs	1211		1211		1211	
Number of groups	135		135		135	

Table 6. (Cont'd.)

	(1)		(2)		(3)	
	Non-IT Sectors		Non-IT Sectors		Non-IT Sectors	
	Coef.	SE	Coef.	SE	Coef.	SE
Nt/Kt	0.567	0.109 ***	0.319	0.155 **	0.453	0.149 ***
It/Kt			0.106	0.182	-0.082	0.176
Ot/Kt			1.148	0.498 **	0.714	0.481
PCM					3.961	0.318 ***
Const.	-0.721	0.752	-0.666	0.736	-0.799	0.682
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
sigma_u	0.669		0.649		0.593	
sigma_e	0.544		0.544		0.524	
rho	0.602		0.587		0.562	
Number of obs	1845		1845		1845	
Number of groups	202		202		202	

Notes: See the notes in Table 4.



Table 7. Instrumental variable (IV) estimates of determinants of conventional Tobin's Q-1 (IT or Non-IT sectors)

	(1)		(2)		(3)	
	IT Sectors		IT Sectors		IT Sectors	
	Coef.	SE	Coef.	SE	Coef.	SE
N/K	0.887	0.264 ***	3.233	1.127 ***	2.176	1.042 **
I/K			0.923	0.622	0.040	0.581
O/K			-7.598	3.691 **	-4.498	3.410
PCM					4.913	0.599 ***
Const.	-1.012	0.355 ***	-0.412	0.464	-0.820	0.429 *
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
Instrumented	N/K		O/K		O/K	
Instrumental Variables	Skilled labor ratio		Skilled labor ratio		Skilled labor ratio	
	CC		CC		CC	
Number of obs	777		777		777	
F	7.81		9.05		12.22	
Prob > F	0		0		0	
R-squared	0.307		0.2248		0.3432	
Adj R-squared	0.457		0.3927		0.4855	
Root MSE	0.9451		0.9996		0.92	
Sargan statistic	4.013		0.231		0.021	
Chi-sq (1) P-val	0.045		0.631		0.884	

Table 7. (Contd.)

	(1)		(2)		(3)	
	Non-IT Sectors		Non-IT Sectors		Non-IT Sectors	
	Coef.	SE	Coef.	SE	Coef.	SE
N/K	0.022	0.267	3.443	0.999 ***	1.369	0.752 *
I/K			0.753	0.370 **	0.304	0.299
O/K			-12.174	4.025 ***	-3.423	3.025
PCM					6.535	0.435 ***
Const.	-0.018	0.265	-0.078	0.307	-0.350	0.247
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
Instrumented	N/K		O/K		O/K	
Instrumental Variables	Skilled labor ratio		Skilled labor ratio		Skilled labor ratio	
	CC		CC		CC	
Number of obs	1269		1269		1269	
F	13.84		10.55		21.07	
Prob > F	0		0		0	
R-squared	0.3062		0.0653		0.3996	
Adj R-squared	0.3398		0.1106		0.4287	
Root MSE	0.8257		0.9584		0.7681	
Sargan statistic	3.634		1.081		0.156	
Chi-sq (1) P-val	0.057		0.298		0.693	

Notes: See the notes in Table 4.

Skilled labor ratio indicates the ratio of white-color to total workers.

Table 8. Instrumental variable (IV) estimates of determinants of Conventional Tobin's Q-1 (computerized information, innovative property and economic competencies)

	(1)		(2)		(3)	
	All Sectors		All Sectors		All Sectors	
	Computerized Information		Computerized Information		Computerized Information	
	Coef.	SE	Coef.	SE	Coef.	SE
N/K	3.676	2.050 *	73.826	35.946 **	47.953	23.001 **
I/K			0.891	0.553	0.089	0.384
O/K			-211.792	106.955 **	-133.847	68.346 *
PCM					7.444	0.854 ***
Const.	-0.890	0.398 **	-1.800	0.755 **	-1.747	0.531 ***
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
Instrumented	N/K		O/K		O/K	
Instrumental Variables	Skilled labor ratio		Skilled labor ratio		Skilled labor ratio	
	CC		CC		CC	
Number of obs	2040		2040		2040	
F	13.1		3.67		9.42	
Prob > F	0		0		0	
Centered R2	0.2913		-1.6073		-0.3055	
Uncentered R2	0.3615		-1.349		-0.1762	
Root MSE	0.8887		1.705		1.206	
Sargan statistic	12.95		0.466		1.149	
Chi-sq (1) P-val	0.0003		0.495		0.2838	

Table 8. (Cont'd.)

	(1)		(2)		(3)	
	All Sectors		All Sectors		All Sectors	
	Innovative Property		Innovative Property		Innovative Property	
	Coef.	SE	Coef.	SE	Coef.	SE
N/K	0.908	0.263 ***	2.797	1.334 **	-0.289	1.118
I/K			0.684	0.298 **	-0.016	0.266
O/K			-10.646	6.867	4.824	5.762
PCM					5.711	0.358 ***
Const.	-0.467	0.287	-0.598	0.309 *	-0.666	0.275 **
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
Instrumented	N/K		O/K		O/K	
Instrumental Variables	Skilled labor ratio		Skilled labor ratio		Skilled labor ratio	
	CC		CC		CC	
Number of obs	2040		2040		2040	
F	13.52		12.8		20.22	
Prob > F	0		0		0	
Centered R2	0.3062		0.2268		0.3877	
Uncentered R2	0.375		0.3034		0.4483	
Root MSE	0.8793		0.9283		0.8261	
Sargan statistic	4.561		4.747		2.564	
Chi-sq (1) P-val	0.0327		0.0293		0.1094	

Table 8. (Cont'd.)

	(1)		(2)		(3)	
	All Sectors		All Sectors		All Sectors	
	Economic Competeicies		Economic Competeicies		Economic Competeicies	
	Coef.	SE	Coef.	SE	Coef.	SE
N/K	-0.185	0.708	25.574	14.490 *	2.331	6.818
I/K			1.989	0.894 **	0.088	0.407
O/K			-55.305	32.712 *	-2.687	15.374
PCM					6.197	0.791 ***
Const.	-0.311	0.452	1.155	1.327	-1.131	0.629 *
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
Instrumented	N/K		O/K		O/K	
Instrumental Variables	Skilled labor ratio		Skilled labor ratio		Skilled labor ratio	
	CC		CC		CC	
Number of obs	2040		2040		2040	
F	12.72		7.54		20.49	
Prob > F	0		0		0	
Centered R2	0.2729		-0.2816		0.3951	
Uncentered R2	0.345		-0.1546		0.455	
Root MSE	0.9002		1.195		0.8211	
Sargan statistic	15.686		10.05		16.294	
Chi-sq (1) P-val	0.0001		0.0015		0.0001	

Notes: See the notes in Table 4.

Skilled labor ratio indicates the ratio of white-color to total workers.

Table 9. Robust estimations (1) Revising adjustment cost functions of tangible and intangible investments

	(1)		(2)		(3)		(4)	
	Pooled OLS		Pooled OLS		Pooled OLS (IV)		Pooled OLS (IV)	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
N/K	0.486	0.094 ***	0.576	0.090 ***	2.339	0.860 ***	1.882	0.763 **
I/K	0.448	0.212 **	-0.022	0.204	0.837	0.295 ***	0.229	0.263
O/K	0.479	0.417	0.103	0.397	-8.766	4.484 *	-6.610	3.985 *
PCM			5.018	0.293 ***			6.065	0.382 ***
Const.	-0.511	0.905	-0.713	0.861	-0.055	0.523	-0.510	0.463
Industry dummy	Yes		Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes		Yes	
Instrumented					O/K		O/K	
Instrumental Variables					Skilled labor ratio		Skilled labor ratio	
					CC		CC	
Number of obs	2832		2832		2012		2012	
F	18.42		24.37		12.26		18.94	
Prob > F	0		0		0		0	
R-squared	0.3086		0.3749		0.1613		0.3211	
Adj R-squared	0.2919		0.3595		0.2418		0.3862	
Root MSE	0.90097		0.85689		0.9511		0.8557	
Sargan statistic					1.589		0.078	
Chi-sq (1) P-val					0.2075		0.7799	

Notes: See the notes in Table 4.

Skilled labor ratio indicates the ratio of white-color to total workers.

Table 10. Robust estimations (2) Quantile regression of determinants of conventional Tobin's Q-1

	(1)		(2)		(3)		(4)	
	All Sectors		All Sectors		All Sectors		All Sectors	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
N/K	0.709	0.042 ***	0.575	0.086 ***	0.321	0.123 ***	0.553	0.075 ***
I/K			0.764	0.160 ***	1.026	0.247 ***	0.176	0.141
O/K			0.520	0.290 *	1.687	0.408 ***	0.403	0.253
CC					-0.218	0.071 ***		
PCM							4.081	0.181 ***
Const.	-0.309	0.063 ***	-0.441	0.061 ***	-1.885	0.431 ***	-0.468	0.054 ***
Industry dummy	Yes		Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes		Yes	
Number of obs	2882		2882		2047		2882	
Pseudo R2	0.1885		0.1907		0.2067		0.2333	

Note: See the notes in Table 4.

## Appendix 2. Classification of ICT sectors

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

<b>JIP code</b>	<b>IT-using non-manufacturing sector</b>
	63 Gas, heat supply
	67 Wholesale
	68 Retail
	69 Finance
	70 Insurance
	79 Mail
	82 Medical(private)
	85 Advertising
	86 Rental of office equipment and goods
	88 Other services for businesses
	92 Publishers

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

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



Appendix 2. (Cont'd.)

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

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