RIETI Discussion Paper Series 06-E-032

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Centralization or Decentralization of Decision Rights? Impact on IT Performance of Firms

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Abstract

The effects of IT on the decision making structure of firms has been a topic of debate for decades. On the one hand, IT increases the information available to top management, and the coordination advantages that it provides may lead firms to centralize decision making. On the other hand, IT makes it possible to disseminate global information of the firm to line workers enabling them to make better decisions as well as enhances management's monitoring capability, favoring decentralization. In order to understand the economy wide effects of centralization and decentralization of decision rights on the productivity effect of IT, we conduct an empirical analysis to examine the change in the effects of IT performance in firms that changed its decision making structure, using a panel data set for 2,300 Japanese firms over 4 years. Our results indicate that both centralization and decentralization have a substantial productivity effect on IT for firms that changed its decision making structure and the productivity effects are more marked for firms that conducted radical change of decision rights. Moreover, we find evidence that changes in decision rights have a more pronounced productivity effect on large firms. Finally, our results show that productivity effects due to changes in decision rights are realized only in the non-manufacturing sectors. This paper sheds some light on the effects of decision rights on firms' IT performance and underscores the importance of organizational redesign accompanying IT investment.

1. Introduction

In the past decade, due to the swift technological progress of Information Technology (IT) coupled with its rapidly declining prices, IT has diffused broadly into many sectors of the economy. Several empirical studies report that IT has a positive impact on productivity of U.S. firms (Brynjolfsson and Hitt 1996, Lichtenburg 1995). Similarly in Japan, the contribution of IT has been recognized to be substantial at the firm-level (Motohashi 2006).

However, in order to fully reap the benefits of IT, several studies have stressed the importance of complementary workplace reorganization accompanying the adoption of IT. Brynjolfsson and Hitt (2000) point out that a key value of IT is its ability to enable complementary organizational investments such as business processes and work practices, which in turn increases productivity. Breshanan et al (2002) find empirical evidence of complementarities between IT and workplace organization, and report that the type of workplace organization complementary with IT is one with a decentralized decision making structure. Several case studies similarly report changes in work practices accompanying IT deployment (Hunter et al. 2000, Brynjolfsson et al. 1997).

Several empirical studies have investigated the joint effects of both workplace reorganization and IT on productivity. Black and Lynch (2001) examine the effects of different types of work practices, IT, and educational level of employees on labor productivity, and find that workplace practices positively affects productivity. Bresnahan et al (2002) report that firms that combine IT, workplace reorganization, and more skilled workers increases productivity. Bertschek and Kaiser(2004) examine the effects of complementarities between the various inputs including IT and workplace reorganization, and find that enhancement of group work and flattening of hierarchies increases labor productivity.

Although past studies provide some support for decentralizing decision rights accompanying IT investment, there is still a lack of quantitative studies compared with the plethora of case studies accentuating the importance of decentralizing decision rights to reap the benefits of IT. Moreover, since there is little quantitative evidence on the effects of centralization on IT performance, the productivity effects of centralization is unclear[1].

This paper attempts to fill this gap by providing quantitative evidence on the

[1] The study by the Economic Research Institute, Economic Planning Agency (2004) has shown that there is a positive correlation between the degree of using IT and performing of organizational reform, including centralization and decentralization of decision rights.

effects of reallocating decision rights on IT performance. Unlike past studies that have focused on the effects of "workplace reorganization", we examine the productivity effects of IT due to changing decision rights. Thus, we do not address issues such as the restructuring of organizational form (e.g. flattening of hierarchies), and instead focus on the change in decision rights, given an organizational structure (which is typically some form of hierarchy).

An important point to note is that our study focuses on Japanese firms. The decision making structure of a typical American and Japanese firm are different (Aoki 1986), so implications from past studies may not directly apply to Japanese firms, and the results of this study may not apply directly to Western firms. Since the decision making structure of Japanese firms has been more decentralized than Western counterparts, it is interesting to find whether the acclaimed effects of decentralization from past studies also has a positive productivity effect in Japan. Furthermore, since the decision making structure had been more decentralized, it may be the case in Japan that centralization is the solution to reap the benefits of IT.

Using panel data of 2,300 Japanese firms spanning 4 years, we examine the change in the productivity effects of IT in firms that centralized or decentralized its decision making structure, controlling for firm heterogeneity. Furthermore, our regression is conducted taking the degree of the change in decision rights into account, which reveals the differences in firm performance of firms that went through a radical change and those that experienced only minor changes. In order to find the type of change in decision rights that increases productivity for different types of firms, we grouped our sample by firm size and industrial classification.

Our major finding is that both centralization and decentralization of decision rights increases the productivity effects of IT. Furthermore, we find that bigger productivity effects are realized by firms that implemented a radical change in decision rights compared with firms that performed minor changes. In the sample grouped by firm size, we find some evidence that increases in the productivity effects of IT due to reallocation of decision rights are realized by large firms. Finally, in the sample grouped by industrial classification, we find that the impact of reallocating decision rights is heterogeneous among different sectors, and that positive productivity effects are realized only by firms in the non-manufacturing sectors.

The remainder of the paper is organized as follows: Section 2 presents the framework, Section 3 shows the empirical model, Section 4 explains the data used in the regression, Section 5 reports the results, and Section 6 concludes.

2. Framework

2.1 The Relationship Between IT and Decision Rights

The debate about whether IT would lead to centralization or decentralization of decision making stems back to 1958 when Leavitt and Whisler predicted, among others, that the introduction of IT in firms would lead to centralization of decision making (Leavitt and Whisler 1958). Over the years, many studies have attempted to address this issue, some pointing out to centralization, some indicating decentralization, while others reporting no effects at all[2].

Hayek (1945) stressed the importance of locating knowledge and decision rights together to improve organizational performance. Jensen and Meckling (1992) proposed two ways to collocate information and decision rights, which have been referred to as the *MIS solution* and the *organizational design solution* by Brynjolfsson and Mendelson(1993). The MIS solution transfers the information required to the decision maker using IT, whereas the organizational design solution moves decision rights to where the pertinent information is. The MIS solution is usually associated with centralization whereas the organizational design solution usually favors some form of decentralization (Nault 1998).

Gurbaxani and Whang (1991) presents a framework that explains why IT may lead to either centralization or decentralization of decision rights depending on the way IT impacts decision related costs that the firms face. On the one hand, IT provides the capability to improve the quality and speed of top management's decision making which has an effect of decreasing decision information costs, leading to centralization of decision rights. On the other hand, IT improves the monitoring capability of top management which reduces agency costs, leading to decentralization. Thus, the choice of centralization or decentralization depends on the specific cost structure of the firm.

2.2 IT and Centralization

A key reason that IT may lead to centralization is the coordination advantages that it provides by increasing the processing capacities of managers or decreasing communication costs which equips managers with more information. Leavitt and Whisler(1958) stresses the improved information processing capability by managers, which ensues in centralization. Bolton and Dewatripont (1994) presents a model which reveals that the reduction in communication costs caused by IT would lead to centralization due to the increased span of control by top management. Similarly,

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[2] Refer to George and King(1991) for an overview on this issue.

Gurbaxani and Whang(1991) point out that IT improves the quality and speed of top management's decision making process, which may lead to centralization.

Several anecdotal evidences report that Japanese firms have used IT to centralize decision rights. For example, Aeon, a large retail chain in Japan, introduced a real-time online system that enables the central office to access sales data and control the inventory. After the implementation of the new system, the head office now sets the minimum/maximum inventory and the ordering amount, which was previously decided by the person in charge at the local store (Nikkei Computer 2004). The case of Aeon clearly depicts how IT has engendered an opportunity to centralize decision rights by providing top management pertinent information for decision making.

The case of All Nippon Airlines (ANA) reveals the coordination advantages provided by IT. After the introduction of a new information system at ANA, the seat allocations which were delegated to each shop are now handled on a first come first serve basis, based on the slot optimized by the new system. This reduced the decision rights and degree of freedom of the sales division (Nikkei Information Strategy 2005).

2.3 IT and Decentralization

Various studies have indicated why it is advantageous for firms to decentralize decision rights with the advent of IT. Alleviation of information overload, increased sharing of global information at the floor level, and reduction in agency costs are some reasons that have been indicated in past studies that supports decentralization of decision rights accompanying the deployment of IT.

First, as IT gets deployed in a firm, the amount of available information increases abruptly, leading to a phenomenon of "information overload"(Brynjolfsson and Mendelson 1993). Decentralizing decision rights alleviates the burden on top management as well as cut unnecessary communication up and down the hierarchy. According to Van Zandt(2003)'s model, if IT speeds up the firm's strategic environment, other things being equal, this would lead to smaller and decentralized firms.

Second, IT has made it possible to disseminate and access information easily at the floor level, and as a consequence, employees can now make decisions using global information of the firm as well as their own specific idiosyncratic knowledge that they possess on the floor (Malone 1997). Anand and Mendelson (1997) models various coordination structures of a firm competing in multiple horizontal markets and shows that expected profits are generally the highest for firms with a decentralized decision making structure with access to global information. Similarly, Aoki and Okuno (1996) provides a model that explains how the introduction of IT affects decision making of

different divisions by enabling access to global information of the firm together with their division specific knowledge.

Third, IT may lead to decentralization is due to a reduction in agency costs. Gurbaxani and Whang (1991) point out that the enhanced monitoring capability provided by IT may lead firms to decentralize decision rights. The case of NTT Docomo, the largest mobile phone carrier in Japan, exemplifies how IT reduces agency costs. When NTT Docomo deployed a new information system "DREAMS", workers at the floor level were given autonomy to change budgets contingent upon the changing environment that they face. These changes in expenditure by the divisions are inputted to DREAMS which is accessible by top management. CFO Ugaki notes that the disclosure of expenditure by each of the divisions by DREAMS prevents questionable expenditures by the divisions (Nikkei Information Strategy 2006).

3. Empirical Model

We employ a production function approach to estimate the productivity effects of IT in firms that changed decision rights. In the baseline case for the whole sample, we estimate the following extended Cobb-Douglas production function:

$$\ln VA_{it} = \alpha \ln K_{it} + \beta \ln L_{it} + \gamma \ln IT_{it} + \delta \ln IT_{it} * DRR_i + \zeta \ln IT_{it} * DRM_i + \mu DRR_i * t + \eta DRM_i * t + \phi * t + u_{it} \quad (1)$$

where VA_{it} is value-added of firm i at time t, K is capital, IT is IT capital services, DRR_i is a dummy variable indicating that the firm changed its decision making structure radically, DRM_i is a dummy variable indicating that the firm made minor changes of its decision making structure. Finally, the error term u_{it} consists of the firm specific effect a_{it}, shocks that are exogenous to the firm e_{it}, and the error term ε_{it}:

$$u_{it} = a_{it} + e_{it} + \varepsilon_{it} \quad (2)$$

We estimate this equation using the linear fixed effects model, fixing and controlling for firm heterogeneity: i.e. $a_{it} = a_i$.

In the sample grouped by firm size and industrial classification, we collapse radical and minor change in decision rights into one binary variable:

$$\ln VA_{it} = \alpha \ln K_{it} + \beta \ln L_{it} + \gamma \ln IT_{it} + \delta \ln IT_{it} * DR + \mu DR_i * t + \phi * t + u_{it} \quad (3)$$

where DR_i is the binary variable representing whether the firm centralized or decentralized decision rights.

VA is calculated, K comes from the book value of capital stock, and L is data form the number of labor employees. VA and K are deflated using a 3 digit industry

deflator and deflator for investment respectively. The variable for IT is the amount of IT capital services which have been computed by deflating IT expenditure by the rental price of IT capital[3]. The regression is estimated over 4 years.

4. Data and Methodology

The data related to firm performance has been obtained from the Basic Survey on Business Structure and Activity (BSBSA), the Ministry of Economy Trade and Industry's (METI's) annual enterprise census survey. The BSBSA survey covers all firms in manufacturing, wholesale and retrial sector, and some business service sectors with more than 50 employees and 30 trillion yen of capital. The data relevant to the present study are the amount of tangible fixed capital, number of employees, amount of IT expenditure, and value-added which was calculated using double deflation, subtracting input from output (sales). Input was obtained by subtracting depreciation, wage, and IT expenditure from total cost. Output and input data used to obtain value-added are deflated using a 3-digit industry input and output deflator, and capital is deflated using a deflator of fixed assets averaged across all industries.

The data used in the present study is similar to that of Motohashi(2006), with the exception of using the method of double deflation to obtain value-added. Following Motohashi(2006), we deflated IT expenditure from the BSBSA by the rental price of IT capital services from Jorgenson and Motohashi (2005), to obtain a measure of IT capital service flow at the firm level[4].

Data on firm performance from the BSBSA were linked to data from METI's ICT Workplace survey, which is an annual survey that focuses on the use of IT by firms, surveying items such as the amount of IT investments in detailed classification and the type of network applications used for different business processes. From the survey in 2000, the survey sample was constructed using stratified random sampling from the list of firms in the BSBSA, making it possible to link detailed ICT data with firm performance measures.

The survey in 2002 includes a questionnaire on organizational change, asking the respondents whether the firm conducted a specific type of organizational change or business process reform during 2000-2002. The types of change or reform surveyed include flattening of hierarchy, reorganization of divisions, change in trade share, and increased outsourcing. The respondents circle one of the following for each type of organizational change: 1. Radically proceeded with the change 2. Performed minor

[3] Refer to Section 4 for details.

[4] Refer to Motohashi(2006) for details.

changes 3. Did not change. Respondents that circled 1 or 2 (i.e. firms that performed the specific type of organizational change) proceed to the next question that asks the effects of the change. The respondents circle one of the following: A. There was an effect B. Hard to say whether there was an effect or not C. There was no effect. Among the types of organizational change surveyed, the present study focuses on "Centralization of Decision Rights" and "Decentralization of Decision Rights". We used data on firms that radically performed change and firms that performed minor changes as the binary variables in the production function estimation.

Since the survey asks whether the firm performed a certain type of organizational change during 2000-2002, we linked this data on organizational change from the ICT workplace survey with firm performance measures of the BSBSA from 2000 to 2003[5]. Although the survey on organizational change ends in 2002, we include firm performance measures in 2003, since the effect of organizational change may not be instantaneous. After excluding firms that did not answer the ICT Workplace Survey question on decision rights and firms that could not be linked to the BSBSA or had missing observations in firm performance, we ended up with a balanced panel data set for approximately 2,300 firms spanning 4 years in the whole sample.

Table 1 gives some descriptive statistics of the whole sample regarding change in the decision making structure of firms. Approximately 5% of the firms radically centralized decision rights and 9% of the firms performed minor centralization, revealing that more firms performed minor modifications in decision rights accompanying IT investment. As regards to decentralization, 4% of the firms conducted substantial changes while 11% performed minor changes.

Table 2 shows the effects of the change in decision rights accompanying IT investment by the respondents in our sample. The responses may be interpreted as the perceived effects of changing decision rights by the firms. The figures reveal that over three quarters of firms that radically changed decision rights perceived an effect. As regards to firms that performed minor changes, the perceived effect of the change drops

[5] The data on 2003 is the latest one that is currently available.

to approximately 40% for both centralization and decentralization of decision rights. These qualitative figures indicate that firms that were able to use IT to radically centralize or decentralize generally experienced a positive effect, whereas not as many firms that performed only minor changes in decision rights perceived such an effect.

5. Results

Table 3 shows the results of the whole sample, which is a balanced panel spanning 4 years of approximately 2,300 firms[6]. First, the results report that the productivity effects of IT are larger for firms that changed decision rights accompanying IT investment. Furthermore, our results indicate that the productivity effects of IT are larger for firms that went through radical changes in decision rights compared with firms that performed minor changes, which is consistent with firms' perceived effects displayed in Table 2.

The results of the regression for firms that performed centralization indicate that the output elasticity of IT increases 8.2% for firms that radically centralized and 4.5% for firms that performed minor centralization. Furthermore, our results show that firms that radically centralized decision rights also increased total factor productivity (TFP) by 1.8%. With respect to the regression for firms that performed decentralization, the results report that the output elasticity of IT increases by 13.6% for firms that radically changed decision rights. The coefficient of the IT term interacted with minor decentralization is not statistically significant at the usual levels, although it is positive.

The result of decentralization of decision rights increasing the productivity effects of IT is consistent with Bresnahan et al. (2002). As IT enables the floor level to access global information of the firm or reduces agency costs by enhancing the monitoring capability of top management, decisions that are more aligned with the firm's strategic goals could be made at the floor level, which may be reflected as an increase in the elasticity of IT capital services. The result of centralization increasing the productivity effects of IT may be indicating the coordination advantages that IT provides by enhancing top management's decision making process. In both cases, the productivity effects of IT are larger for radical changes compared with minor changes,

[6] The number of firms in the centralization and decentralization sample differs slightly, since 2 more firms answered the survey question on decentralization.

indicating that firms that were able to use IT to radically change decision making gained substantial advantages and performed better.

Table 4 shows the results of the regression grouped by firm size. The sample was separated into two groups, divided by the median size of the firm in the mid-point of the sample[7]. In the sample separated into groups, both radical and minor changes were collapsed into one binary variable of whether the firm changed decision rights or not. The results of Table 4 reveal that the productivity effects of IT due to both centralization and decentralization is large and statistically significant for large firms, whereas the same effects are small and statistically insignificant in SME's. Thus, our results indicate that increases in the productivity effects of IT due to reallocating decision rights are realized only by large firms.

Since large firms intrinsically possess an intricate organizational architecture compared with SME's, it may be natural that the new advantages of reallocating decision rights enabled by IT has a larger effect in large firms. The coordination advantages enabled by IT are larger for large firms, simply because coordination costs increase with firm size. Thus the benefits of reducing coordination costs via centralization are larger for large firms. Similarly, as firm size increases, agency costs rise, the information overload problem becomes more severe, and the benefits of information sharing by line workers increase. Therefore, the benefits of IT in decentralizing decision rights are larger for large firms. Since these benefits of reallocating decision rights were not substantial in SME's, the productivity effects were miniscule.

Table 5 shows the results grouped by industrial classification. The whole sample was separated into manufacturing, wholesale/retail trade, and others. The sample of "others" consists mainly of the service sector (84%). The results indicate that productivity effects due to changing decision rights are realized only in the non-manufacturing sector. First, the results from the manufacturing sector report that

[7] The mid-point was chosen to be 2002, which is the year of the data on organizational change. The median number of employees is 277, and the number of firms in each group is approximately 1,170 firms.

both centralization and decentralization of decision rights does not affect the output elasticity of IT. Second, the results from the wholesale/retail sample reveal that only decentralization of decision rights increases the productivity effects of IT in wholesale and retail trade. Finally, in the service sector, the productivity effects of IT increase for both centralization and decentralization, and the increase is especially pronounced for centralization of decision rights.

Brynjolfsson et al.(1997)'s case study of a producer of medical products underscores the importance of complementary changes in organizational structure, including changes in decision rights, accompanying investment in computer integrated manufacturing in a factory to increase firm performance. However, our results indicate that changing decision rights does not change the productivity effects of IT in manufacturing firms. One speculation is that the decision making structure of Japanese manufacturing firms has always been one of its great strengths, and further changes in decision rights accompanying IT investment does not impact productivity.

Malone (1997) accentuates the importance of decentralizing decision rights, focusing on the revolution in retailing. In modern retail stores, such as at Wal-Mart, IT is used to enable local managers have access to global information of the firm (e.g. national sales data), that helps them make their decisions, together with the local idiosyncratic specific knowledge that they possess. The results indicating positive productivity effects by firms conducting decentralization of decision rights in the wholesale/retail sector may be reflecting these effects.

The sample of firms in the service sector consists of a wide variety of firms in disparate areas, ranging from finance to construction. One interpretation of the effects of both centralization and decentralization impacting productivity is that the effects reflect the disparate ways IT is used in different sectors, but indicates a positive effect overall in both directions of change in decision rights.

One important finding is that the productivity effects of changing decision rights are only realized in the non-manufacturing sectors. In manufacturing sectors, a production facility is also an important physical capital input. In this regards, the importance of IT capital stock to production process is relatively larger for non-manufacturing firms. In addition, IT plays a key role in business innovation in services sectors (Motohashi, 2001). Therefore, effectiveness in IT use in these sectors may have clearer effect on productivity performance, as compared to manufacturing sectors.

6. Conclusion

This paper examined the impact of centralization and decentralization of decision rights on the productivity effects of IT. Using panel data for 2,300 Japanese firms, the increase in the partial elasticity of IT due to changes in decision rights was estimated, and the results indicate that both centralization and decentralization of decision substantially increases the productivity effects of IT. Moreover, we find that larger gains in productivity are realized by firms that went through a radical change in decision rights.

Our sample grouped by firm size gives broad evidence that the productivity effects of IT due to reallocating decision rights is larger for large firms compared with SME's. The disparity in the IT coefficients between large and small firms may reflect the substantial advantages that large firms have gained by increased coordination or enhanced decision making of workers. In the sample grouped by industry, the results report that there are no productivity effects of IT due to reallocation of decision rights in the manufacturing sector, whereas productivity gains are realized by firms that performed decentralization in the wholesale/retail sector and firms that conducted centralization or decentralization in the service sector, indicating that changes in decision rights impacts the productivity effects heterogeneously in different sectors.

Our results that decentralization of decision rights affecting the productivity of IT is consistent with past findings by Bresnahan et al (2002), although their measure of decentralization includes several indicators of decentralization, whereas we focus on the effects of decentralizing decision rights on IT performance. Our study is one of the first studies that empirically revealed the positive effects of centralizing decision rights on IT performance of firms, which provides managers statistical evidence that using IT to centralize decision rights increases productivity, consistent with anecdotal evidences. Taken together, the results of this study underscore the importance of using IT to reallocate decision rights whenever possible in order to fully reap the benefits of IT.

An extension to our study is to examine the micro mechanism of the effects of changing decision rights, especially centralization on IT performance, through a detailed case study since the exact nature of the change in decision rights accompanying the adoption of IT is likely to be highly firm and situation specific. Another interesting research agenda is to investigate the effects of centralization of decision rights on the productivity effects of IT in U.S. firms and conduct an international comparison to find if there are any differences in the results due to inherent differences in the decision making structure of these two countries.

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Table 1: Percentage Share of Firms that Changed Decision Rights

		Firm Share(%)	Number of firms
Centralization	−Radical	4.78	112
	−Minor	8.67	203
Decentralization	−Radical	4.10	96
	−Minor	11.39	267

Table 2: Effects of Change in Decision Rights （% share of firms)

		Yes	Hard to Say	No
Centralization	−Radical	77	23	0
	−Minor	41	57	2
Decentralization	−Radical	76	24	0
	−Minor	41	58	1

Table 3: Productivity Effects in the Whole Sample

	Centralization			Decentralizaiton		
	coefficent	std.	t	coefficent	std.	t
α (Capital Elasticity)	0.064***	0.011	5.66	0.066***	0.011	5.78
β (Labor Elasticity)	0.445***	0.022	19.85	0.449***	0.022	20.06
γ (IT Elasticity)	0.071***	0.007	9.81	0.072***	0.007	9.86
δ (Radical Change*ln IT)	0.082***	0.029	2.84	0.136***	0.030	4.51
ζ (Minor Change*ln IT)	0.045**	0.023	1.98	0.024	0.020	1.18
μ (Radical Change*year)	0.018*	0.011	1.65	0.005	0.011	0.46
ν (Minor Change*year)	−0.012	0.008	−1.43	−0.003	0.007	−0.45
ϕ (year)	0.038***	0.002	15.25	0.038***	0.003	15.15
Number of Firms	2342			2344		
Number of Observations	9368			9376		

Key: ***- p<0.01, **- p<0.05, *- p<0.1.

Table 4: Productivity Effects Grouped by Firm Size

Large Firms					SME's			
	Centralization		Decentralizaiton		Centralization		Decentralizaiton	
	coefficent	std.	coefficent	std.	coefficent	std.	coefficent	std.
α (Capital Elasticity	0.070***	0.018	0.070***	0.018	0.063***	0.014	0.066***	0.015
β (Labor Elasticity)	0.435***	0.029	0.443***	0.029	0.450***	0.035	0.448***	0.035
γ (IT Elasticity)	0.058***	0.010	0.062***	0.010	0.083***	0.010	0.085***	0.010
δ (Change*ln IT)	0.082***	0.022	0.079***	0.022	0.032	0.033	0.021	0.021
μ (Change*year)	−0.002	0.008	0.002	0.008	−0.013	0.011	−0.011	−0.011
ϕ (year)	0.053***	0.003	0.053***	0.053***	0.024***	0.004	0.023***	0.004
No. of Firms	1171		1171		1171		1173	
No. of Observations	4684		4684		4684		4692	

Key: ***- p<0.01, **- p<0.05, *- p<0.1.

Table 5: Productivity Effects Grouped by Industry

Manufacturing					Wholesale and Retail Trade			
	Centralization		Decentralizaiton		Centralization		Decentralizaiton	
	coefficent	std.	coefficent	std.	coefficent	std.	coefficent	std.
α (Capital Elasticity	−0.008	0.027	−0.008	0.027	0.039***	0.018	0.040***	0.018
β (Labor Elasticity)	0.612***	0.038	0.614***	0.038	0.331***	0.032	0.333***	0.031
γ (IT Elasticity)	0.068***	0.011	0.067***	0.011	0.084***	0.013	0.073***	0.012
δ (Change*ln IT)	−0.009	0.035	−0.002	0.033	0.023	0.030	0.136***	0.034
μ (Change*year)	0.003	0.011	0.007	0.010	0.002	0.009	−0.002	0.009
ϕ (year)	0.027***	0.004	0.027***	0.004	0.089***	0.004	0.089***	0.004
No. of Firms	1048		1050		835		835	
No. of Observations	4192		4200		3340		3340	

Other(Mainly Service)				
	Centralization		Decentralizaiton	
	coefficent	std.	coefficent	std.
α (Capital Elasticity	0.086***	0.015	0.091***	0.016
β (Labor Elasticity)	0.420***	0.048	0.428***	0.048
γ (IT Elasticity)	0.079***	0.013	0.092***	0.013
δ (Change*ln IT)	0.128***	0.030	0.062**	0.025
μ (Change*year)	−0.012	0.013	0.010	0.012
ϕ (year)	−0.022***	0.005	−0.026***	0.006
No. of Firms	459		459	
No. of Observations	1836		1836	

Key: ***- p<0.01, **- p<0.05, *- p<0.1.