Economic Analysis of Information Network Use :
Organizational and Productivity Impacts on Japanese Firms

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Summary

This paper shows firm level micro analysis of information network use and its impact on firm's organization and productivity. New evidences on economic impacts of IT by type of its application are provided, based on MITI's firm level data of Japanese manufacturers and distributors. It is found that there are two types of application (direct business operation networks and back office supporting networks), which have distinct implications. A firm with business operation networks is likely to have higher share of white-collar workers, to outsource its production activities and to achieve higher productivity level. In contrast, back office supporting networks have relatively weak relationship with these variables. Differences in economic consequences of IT by its application types shed new light on mixed empirical evidences on economic impacts of IT investments, as is mentioned like Solow's Paradox.

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1. Introduction

Is information economy a driving force of recent productivity upward shift, observed in the United States and other counties? None can deny that dramatic technological progress is observed in IT. Computer price index drops more than 10% annually, and use of Internet has expanded explosively since 1995. This timing coincides with the kinked point of US labor productivity trend, i.e., after productivity slow-down in 1980's, called Solow's productivity paradox, US labor productivity trend has regained its speed in the late 1990's. Oliner and Sichel (2000) show that about two thirds of 1.5% productivity revival after 1995 can be attributed to the growth in IT investment. On the other hand, Gordon (2000) argues that recent US labor productivity growth is not structural shift but mere procyclical movement and that productivity growth is observed only in IT sectors, and IT user sectors cannot take advantage of benefit from IT investment.

To determine whether this is really new economy or not, it is important to analyze micro level evidences of IT usage. IT causes significant impact on production site by flexible manufacturing system, and our work places has changed dramatically with e-mail system and Internet. The question is whether these changes in the business style lead to productivity growth in the production site or our work places. At the firm level, IT investment is not simply the process of just buying computers and software. Workers have to be trained, and the introduction of a large computer system sometimes requires changes in a firm's business process or organizational structure.[1] One of major factors behind productivity paradox of information technology is the mismanagement of IT investment. (Brynjolfsson (1993)). It has been found that a firm, which does not achieve the expected payoffs from IT investments, does not have an appropriate

[1] A related point is raised by Hammer and Champy (1993), which stresses the importance of IT for business process re-engineering. The concept of "virtual corporation" by Davidow & Malone (1993) addresses the relationship between IT and inter firm organization. That is, an advance in IT enables a firm to change its activities flexibly and

organizational and human resource strategy (Brynjolfsson and Hitt (1996)).

This paper sheds new light on such black box IT investment with unique dataset for Japanese firms, called the Business Structure and Activities (BSBSA)[2]. BSBSA is conducted by MITI, and asks information network use by the type of its application, organizational characteristics such as supplier and customer relationship and business performance variables. Therefore, it is possible to analyze impact of information network use on firm's business organization and performance. In addition, this paper provides new findings on the different kinds of IT application, such as electric ordering system at the production site and financial management system at the corporate finance section, leading to different kinds of economic consequences. The next section provides literature survey on IT, organization and productivity, which is followed by data description and regression analysis parts. This paper concludes with policy implications and future research agenda.

2. Literature survey

IT and organization*:* There is no standard way to grasp firm's organizational characteristics, but one of typical method is to looks at worker's skill level at a firm. A number of studies analyze the relationship between IT investment and worker skills. An introduction of IT system changes work at the organization in such a way that manipulating the system may need higher skills. This skill biased technical progress is supported by empirical studies for IT investment. For example, computer investments lead to a greater share of white collar workers with higher educational achievement, (Berndt and Morrison (1990), Berndt et. al. (1992)) and create more well-paid jobs. (Krueger (1993), Doms et. al. (1997))

Some studies address innovative work practices, such as work teams (e.g. quality circle),

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even its boundaries as well, depending on customer needs.

employee stock ownership and flexible job assignment. (Ichniowski et. al. (1996)) In most cases, an ad-hoc survey on work practice is conducted, and it has been found that "high performance work systems" lead to higher performance for firms. (Ichiniowski et. al. (1996)) Brynjolffson and Hitt (1996) show that innovative work practices work well with information systems in a sense that improvement of communication efficiency by IT stimulates a worker's motivation in a decentralized decision making and incentive system.

As compared to such firm organization characteristics, measuring inter-firm organization, such as customer and supplier relationship is more difficult, and few statistical studies exist. However, there are substantial number of case studies related to the IT's impact on firm's external relationship. It is observed that IT stimulates strategic outsourcing and allows a firm to concentrate on its core activities, because IT improves communication efficiency with other firms. In addition, IT can be used for effective management of supplier and customer relationship as is discussed in the concept of SCM (supply chain management) or CRM (customer relationship management).

IT and productivity: Number of researchers have tried to solve 'Solow's Paradox', based on the famous quip of Robert Solow, "You can see computer everywhere, except in productivity paradox." Brynjolfsson (1993) has compared more than 20 papers on this topic, and concluded that traditional tools of productivity measurement are still inadequate, and researcher must come up with better measurements, which take into account intangible utilities associated with IT investments. In this sense, empirical studies on IT and productivity show a history of searching for a good indicator of IT investment and econometric sophistication to investigate IT's impact on

[2] Aggregate results are reported by MITI (1994).

productivity.

Many studies on IT and productivity are conducted by means of production function to estimate the rate of return of IT investment. Morrison and Berndt (1991) and Berndt and Morrison (1995), based on industry-aggregate data, show that US manufacturing industries over-invest in IT capital products, while Lichtenberg (1993) and Brynjolfsson and Hitt (1995), based on firm level micro-data, show that the marginal return of IT capital is significantly higher than that of other capital inputs. Such contradictory results between aggregate data and firm level data may be attributed to the firm level heterogeneity of IT. That is, firm level investigation into IT and productivity relationship picks up difference between 'good firm' and 'bad firm' in a sense of IT management, while such variation is slashed out in aggregate data.

It should be noted that positive co-relation between IT and productivity at the firm level does not provide clear explanation on causality of such relationship. Good productivity performance can be achieved by the firm's active investment in IT, but it may be also true that the firm invests in IT because its business performance is good. Such endogeneity problem associated with an explanatory variable (IT investment) in production function regression casts doubt on regression results in existing studies.[3] One of possible solutions is to apply instrumental variable regression. Brynjolffson and Hitt (1996) use firm's organizational variables as instrumental variables, and conclude that IT and firm's organization co-determine its productivity performance.

3. Information network use and organizational characteristics of Japanese firms

Statistical analysis in this paper is conducted by using the Basic Survey on Business Structure and Activities (BSBSA), for all firms with 50 or more employees and capital of at least 30 million yen in the manufacturing and distribution (wholesales and retails) sectors[4]. Its questionnaire covers a broad range of firm's activities, including international transactions, technological development, and information network use, which can be linked with performance measurements such as productivity. In this section, summary statistics of information network and organizational variables, used for the following analysis, are presented

Information network variables: The questionnaire on information network use consists of three types, as follows; The first one is whether or not a firm has introduced intra-firm information networks, inter-firm ones or both. The second one is the type of application type of IT networks. This is a multiple-choice question with 13 possible answers[5]. The last one is on the owner of information networks, out of 7 alternatives[6].

Of the 23,000 firms covered by BSBSA, 64.6% have introduced intra-firm information networks, and 43.8% have inter-firm one in 1991. This adoption rate does not vary much across industries, which shows "general purpose nature" of information technology.[7] Table 1 shows the percentage of firms, which adopted each type of information network by industry and size.[8] In contrast to industry distribution, firm size has a large effect on network adoption, i.e., the larger the firm is,

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[3] Endogeneity problem with explanatory variables in production function is extensively discussed and possible econometric solutions are provided in Griliches and Mairesse (1995).

[4] BSBSA also covers firms in service sectors, but the survey for them is not census style, in contrast to the complete enumeration (with cut-off points) for manufacturing and distribution. In addition, the sample size of the other sectors is too small to be analyzed by the 3-digit industry classification. Therefore, samples in the manufacturing and distribution sectors are used for this paper.

[5] The 13 options are as follows; (1) ordering and product transactions, (2) production management, (3) sales and inventory control, (4) distribution management, (5) technology information management, (6) accounting and financial management, (7) human resource management, (8) management planning, (9) customer information management, (10) financial transaction, (11) reservation and customer information service, (12) general information reference and (13) others.

[6] The 7 choices are as follows: (1) own firm or group, (2) product suppliers, (3) wholesalers, (4) retailers, (5) database providers, (6) VAN (Value Added Network) providers and (7) others.

[7] Detailed descriptive statistics can be found in Motohashi (1995) and OECD (1997a).

[8] 2 types of IT non specific network use ((12) general information reference and (13) others) are excluded from analysis, since the main objective of this paper is to evaluate the relationship between a particular type of information

the more likely it introduces information networks.[9] It is natural that larger firms, with their larger capital and human resources to cope with successful investments, are likely to be an early adopter of new technology as compared to smaller ones are.

Table 1. **Summary statistics on information network use**

	Ordering	Production	Sales&Inve	Distribution	Tech. mgt.	Accounting	Labor mgt.	Mgt. plan	Customer	Fin. Trans.	Resv&guide
(Industry)											
Food Products	60.5%	42.0%	56.9%	26.4%	3.7%	50.0%	34.0%	6.3%	16.1%	22.6%	1.5%
Texitiles & Apparel	50.0%	45.9%	55.3%	25.6%	5.7%	46.0%	27.7%	7.4%	8.5%	19.6%	0.9%
Lumber Wood & Paper	47.8%	42.4%	52.6%	20.6%	3.6%	46.0%	30.7%	6.7%	14.9%	21.9%	1.2%
Chemicals excluding Drugs	61.3%	56.8%	67.8%	38.5%	17.7%	60.2%	38.4%	9.1%	16.3%	25.2%	2.5%
Drugs	59.7%	58.8%	71.8%	45.8%	15.7%	59.7%	42.6%	12.5%	26.4%	33.8%	1.9%
Petroleum & Coal Product	58.3%	61.7%	66.7%	43.3%	28.3%	58.3%	40.0%	6.7%	16.7%	26.7%	3.3%
Plastics & Rubber	61.9%	49.7%	60.4%	28.2%	10.2%	46.0%	31.1%	5.2%	10.2%	22.3%	0.9%
Stone, Clay & Glass	43.2%	42.7%	55.5%	17.6%	6.3%	47.4%	30.0%	5.6%	8.6%	19.8%	1.0%
Primary Metals	58.9%	55.7%	59.9%	23.0%	8.9%	49.6%	33.7%	6.4%	9.1%	22.7%	1.0%
Metal Products	49.8%	50.2%	52.9%	18.0%	7.8%	47.4%	31.7%	4.8%	8.2%	20.3%	0.6%
General Machinery	51.3%	51.8%	50.7%	16.0%	16.1%	50.2%	33.1%	6.5%	16.6%	23.1%	1.7%
Office Equip. & Computer	61.2%	62.0%	56.9%	27.4%	25.8%	53.7%	36.2%	9.6%	16.2%	28.7%	5.3%
Electrical Machinery	60.2%	57.2%	49.0%	18.7%	15.2%	49.5%	34.3%	4.5%	10.4%	21.9%	1.5%
Electronic Supplies	65.7%	68.2%	63.1%	29.1%	21.5%	55.2%	41.0%	7.8%	9.4%	24.3%	2.1%
Communication Equipment	57.1%	63.2%	59.9%	23.1%	23.1%	52.7%	39.6%	13.2%	10.4%	26.4%	2.7%
Electrical Appliances	60.6%	60.3%	58.9%	28.1%	20.7%	52.9%	35.0%	7.7%	12.6%	23.4%	2.6%
Automobiles & Supplies	75.0%	61.4%	54.7%	26.8%	22.1%	50.6%	38.6%	9.4%	10.6%	27.5%	1.7%
Other Transport Equip.	45.9%	51.4%	47.3%	10.9%	14.1%	50.9%	34.5%	8.2%	9.1%	25.0%	1.4%
Optical Precision Machinery	55.8%	57.1%	54.5%	20.5%	17.3%	50.6%	34.6%	2.6%	9.0%	26.9%	0.6%
Other Precision Machinery	61.3%	56.8%	60.8%	20.6%	17.1%	51.8%	35.2%	6.5%	16.6%	24.1%	1.5%
Wholesale	67.0%	16.2%	72.9%	33.2%	5.1%	58.3%	28.8%	9.1%	27.7%	27.5%	2.0%
Retail	65.8%	8.8%	73.9%	27.3%	5.9%	62.0%	36.9%	12.2%	47.5%	26.4%	7.6%
(Size class by # of employees)											
-99	47.8%	23.0%	50.9%	16.3%	4.0%	41.2%	19.0%	5.1%	14.9%	19.4%	1.2%
100-199	58.2%	32.5%	61.0%	22.2%	6.6%	51.6%	27.8%	6.4%	19.7%	23.3%	1.8%
200-499	68.5%	42.7%	70.9%	31.5%	10.4%	60.2%	40.2%	9.8%	25.4%	27.0%	3.0%
500-999	79.1%	53.6%	83.0%	47.1%	17.4%	74.0%	56.4%	13.7%	30.6%	32.7%	3.7%
1000+	89.0%	64.0%	89.5%	65.8%	32.0%	82.8%	69.6%	22.2%	41.8%	42.2%	9.4%
All	60.8%	35.5%	63.6%	27.1%	9.1%	54.0%	32.7%	8.3%	21.7%	24.8%	2.5%

Aside from such a general discussion on industry and size distribution, there are some interesting points, as follows:

- The adoption rate of ordering and product transaction system is high in automobile and supply industry, due to the close linkage between assemblers and parts manufactures in their production system.

- The adoption rate of production control system is high in electronics supplies industry, since

network system and its economic consequences

[9] This is consistent with surveys in other countries, e.g. the U.S. (Dunne (1994)) and Canada (Baldwin et. al.(1995)).

control of production process is very important for high precision microelectronics parts such as semiconductors.

- Drug industry shows a high rate of adoption in sales and inventory system and customer information system, and presumably its reason is that pharmaceutical firms need to manage a lot of product lines and to keep close contacts with their institutional customers such as hospitals.

- Wholesalers and retailers show a high rate of adoption in both sales and inventory system and customer information system, their core activities.

Organization variables: To see how IT induces higher skill jobs at the firm, in the BSBSA, the number of employees by type of occupation is investigated. There are five types: (1) business planning, (2) R&D, (3) information processing, (4) sales and (5) production.

Information on the external relationship is also available in the BSBSA, such as outsourcing activities. Contract theory suggests that IT changes an equilibrium of the decision to make or buy, and a firm with information systems tends to outsource its production. (Brynjolfsson et. al. (1994)) It is interesting to test this hypothesis, by interacting these organizational variables with information network ones. The BSBSA has also variables on the relationship with suppliers and customers, such as the number of suppliers and of customers, and the share of transactions by each counterpart.

Table 2 provides the definitions and summary statistics of organizational indicators, based on the BSBSA, which are used for the following statistical analysis.

Table 2. **Organizational variables from BSBSA**

4. Regression analysis of IT, organization and productivity

Variable	Definition	Mean
intra-firm org.		
PLAN	Share of person engaged in business planning and research jobs	1.4%
R_D	Share of person engaged in R&D	2.1%
IP	Share of person engaged in information processing	1.3%
SALE	Share of person engaged in sales and distributions	31.5%
BC	Share of person engaged in production or business operations	63.8%
inter-firm org.		
OUTS	Share of firms outsourcing their part of business	43.5%
PR_N	Number of firms to which the production of final product is outsourced	6.88
PA_N	Number of firms to which the production of part is outsourced	18.57
HI_S	Herfindahl index by the transaction share of suppliers*	0.25
HI_C	Herfindahl index by the transaction share of customers*	0.21

Note: Since BSBSA asks only three major suppliers and customers, Herfindahl indices are constructed from large three firms.

Occupational structure: The large number of studies has addressed effects of IT investment on the structure of a firm's organization, particularly its occupation structure. More broadly, advance of new technology causes a relative shift in labor demand from unskilled workers to the skilled workers ("skill biased technical progress"). Presumably, new technology takes the place of jobs requiring low-level skills and/or enhances the skill level of existing jobs.

Substantial number of empirical studies supports this hypothesis in case of IT (Berndt et. al. (1992), Krueger (1993), Bartel and Lichtenberg (1987)), while one should be caucious in interpreting the results due to the difficulty in measuring the skill level of workers. Its methodologies include white collar / blue-collar comparison, more detail occupation classification, and using the educational attainments of workers.[10] It is found that IT affects worker's skill level in complicated way. For example, labor market polarization can be found not

[10] Recent studies by the OECD are based on data of the ISCO (International Standard Classification of Occupation) 1 digit level, and broke up into four types of workers: white collar high skilled, white collar low skilled, blue collar high skilled and blue collar low skilled. This is one way of combining the occupation mix and education attainment

only in white collar / blue collar distinction, but also within white-collar categories, such as the substitution of middle management jobs by computers. In addition, Bresnahan (1997) stresses the importance of the interactive and interpersonal skills and experience of workers, which is difficult to be measured by traditional skill category.

IT's effect on worker skill level depends on the type of IT application as well, which is the main motivation of the following analysis. The BSBSA distinguishes five types of occupation, as shown in Table 2, which can be interacted with 11 types of information network use variable. The model specification of statistical analysis is based on the methodology in Berndt et. al. (1992), as follows:

$$occupation = \alpha \ln(CAP / VA) + \beta netuse + dummy_{ind} + dummy_{size} + \varepsilon$$

where *occupation* : each of 5 types of occupation variable listed in Table 2

netuse : each of 11 types of network variable

VA : the amount of value added

CAP : the amount of depreciable capital

dummyind : 81 industry dummy variables by the 3-digit BSBSA classification system

dummysize : 5 size dummy variables by the number of employees in Table 1

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categories. (OECD(1997b))

This descriptive regression shows the relationship between each type of occupation and each type of information network use by controlling the share of capital input (CAP/VA), industry and size of firm. Since *netuse* is a qualitative variable, 1 if a firm adopts this type of information network and 0 if not, its coefficient (β) shows whether the adoption of each type of IT application is positively or negatively correlated with the share of each type of job. Table 3 presents coefficients of netuse variables at 10% statistical significance.[11]

Table 3 **Regression results of IT and occupation mix**

	PLAN	R&D	IP	SALES	PROD
Ordering & Transactions	-	0.004*	-0.006***	0.008*	-0.027***
Production	0.004**	0.010***	-0.003**	-0.051***	0.017***
Sales & Inventory Control	-	0.007***	-0.006***	0.011***	-0.036***
Logistics Management	0.003*	0.010***	-0.003**	-	-0.021***
Technology Information	-	0.205***	-	-0.025***	-0.010*
Accounting	0.003*	0.005**	-	-	-0.019***
Human Resource Mgt.	-	-	-0.003**	-	-0.008**
Management Planning	0.004*	-	-	-	-0.033***
Customer Relations	-	-	-	0.016***	-0.043***
Financial Transactions	-	-	0.002*	-	-0.019***
Reservation & Guide	-	0.020***	0.006*	-	-

NOTE: Only statistically significant coefficients at 10% level are presented. Complete regression results will be provided upon request to the author

*** : statistically significant at 1% level

** : statistically significant at 5% level

* : statistically significant at 10% level

The following are some observations and discussions, based on the results:

- In general, information network use works as a complement to white collar type jobs (PLAN, R&D), and as substitute for blue collar type jobs (PROD), which is consistent with past observations.

[11] Regressions are conducted for samples with at least one employee of the occupation as a dependent variable. Tobit regression for all samples is also possible, which results in different implications.

- Mixed results are found in IP and SALES. The negative coefficients of IP with direct business operation networks (ordering&transction, production sales&inventory control and logistics management) imply that the complementary workforce in other categories, such as planning and R&D, is more important than those in information processing. For sales workers, positive coefficients can be found in distribution and customer relations, but negative ones in production and technology management. Presumably this mixed results come from the differences in the firm's strategy for IT investment, e.g. whether it strengthen production capability or the distribution/customer relationship.

- Of the various types of information network use, IT for office support, such as accounting and management planning, has a relatively small impact on occupation structure, as compared to direct business operation networks.

Outsourcing and the relationship with suppliers and customers: IT may also affect inter-firm organizations, for example the strategic outsourcing of its production activities. Theoretically, a firm's decision on outsourcing depends on whether outside resources show technological superiority or higher productivity compared to the firm itself. In addition, transaction costs associated with outsourcing, due to imperfect contracts, need for monitoring, etc, should be taken into account. Brynjolfsson et al. (1994) have argued that the advancement of IT makes outsourcing activities more cost efficient, because IT lessens coordination cost as compared to production cost, and a to make or to buy equilibrium shifts toward to buy. Another argument can be made from the viewpoint of asset specificity in investments. The asset specificity in outsourced firm's investments (in developing a relationship with an outsourcing firm) may lead to problem in coordination between two parts. An outsourced firm could invest only in the case of their being able to write long term contract, but in fact it is impossible to write a perfect contract. (Williamson (1985)). IT might decrease the degree of such specificity by enabling flexible and small batch manufacturing system, which make the coordination problem in outsourcing contract less serious.

In this section, the following descriptive regressions are conducted to show the correlation between five types of inter firm organization variables in Table 2 and 11 types of information network use.[12]

$$Org = \alpha netuse + \beta \ln(SALES) + dummy_{ind} + dummy_{size} + \varepsilon$$

where *Org* : each of 5 types of inter firm organization variable in Table 2

netuse : each of 11 types of network variable

SALES : the amount of total sales

dummyind : 81 industry dummy variables by the 3-digit BSBSA classification system

dummysize : 5 size dummy variables by firm's sales in Table 1

ln(*SALES*) is added, because it is natural to assume that a firm with larger sales is likely to outsource its production. The first dependent variable is OUTS, a qualitative variable, 1 if a firm outsources and 0 if not, and regressions are conducted by PROBIT. For the rest of dependent variables, regressions are done with only firms with outsourcing (OUTS=1), because the purpose is to further assess an outsourcing firm's relationship with its counterparts. Table 4 presents coefficients of netuse variables with at least 10% statistical significance.[13]

Table 4 **Regression results of IT and inter-firm organization**

[12] It should be noted that this regression is not for evaluating the causality of IT and outsourcing, which cannot be addressed by one time cross section data, but to show the static correlation.
[13] As is shown in Table 4, regressions of PR_N and PR_A are done by the Poisson model, and OLS is used for HI_S and HI_C.

	OUTS (Probit)	PR_N (Poisson)	PA_N (Poisson)	HI_S (OLS)	HI_C (OLS)
Ordering & Transactions	0.13***	-0.040***	0.066***	-	0.028***
Production	0.24***	-0.140***	-	0.021***	0.045***
Sales & Inventory Control	0.07***	-0.093***	-0.001**	-	-
Logistics Management	0.07***	-0.057***	-0.177***	0.020***	0.046***
Technology Information	0.18***	0.039***	-0.018***	-	0.029***
Accounting	-	0.032***	0.037***	-	-
Human Resource Mgt.	-	-	0.014***	-	0.027***
Management Planning	-	0.265***	0.242***	-	-0.025*
Customer Relations	-	0.096***	0.172***	-	-0.101***
Financial Transactions	0.15***	0.017***	-	-0.017***	-0.043***
Reservation & Guide	-	-0.530***	-0.017**	-	-

NOTE: Only statistically significant coefficients at 10% level are presented.
Complete regression results will be provided upon request to the author
*** : statistically significant at 1% level
** : statistically significant at 5% level
* : statistically significant at 10% level

First, IT's positive correlation with the probability of outsourcing is found in direct business operation networks such as production and ordering&transaction, but not in network use for back offices. Based on the regression results, the hypothesis of the shift from a to make to a to buy decision by IT is supported for certain types of information network.

Second, regressions on the number of counterparts in outsourcing (PR_N and PA_N) cast light on the relationship between an outsoucing and an outsourced firm, i.e., whether IT encourages a firm to focus on a smaller number of counterparts. Bakos and Brynjolfsson (1993) argue that IT enables sophisticated outsourcing style, which leads American firms to focus on a smaller number of suppliers.[14] It is interesting to see in Table 4 that this hypothesis is supported for direct business

[14] Hart and Moore (1990) develop contract theory to show that the ex post surplus from an incomplete portion of contract is shared, depending on the bargaining power of each party. In this sense, the larger such an incomplete portion is, the smaller the number of parties, because each party's ex ante expectation is larger for a smaller number of stake holders. Bakos and Brynjolfsson (1993) apply this theory to IT and the number of supplier relationships. If outsourcing involving IT is more complicated (with a larger portion of incomplete contracts), the number of suppliers decreases. Bakos and Brynjolfsson (1993) also argue that the specificity of investment also affects the number of suppliers, because the problem of coordination with suppliers is less serious in this case, and they can join in the project even with many other suppliers.

operation networks. On the other hand, positive coefficients can be found with some other types, including management planning and customer relations, although there is no obvious logic in the relationship between these types of network use and the number of suppliers. Finally, regressions on the Herfindahl indices of transaction share with suppliers and customers show similar results, i.e., firms with business operation networks have a closer relationship with particular suppliers and customers.

Productivity: Finally, we investigate IT's impact on productivity. To make most of unique feature of BSBSA data, the following analysis focus on comparing the degree of IT's impact on productivity by the type of IT application.

A Cobb-Douglas production function is used as a model to evaluate the firm level productivity effects of network use. Log form of the model is as follows:

$$\ln(VA) = \alpha \ln(CAP) + \beta \ln(EMP^*) + \gamma netuse + dummy_{ind} + dummy_{size} + \varepsilon_1$$

and quality adjusted labor input measurement *EMP** is derived as follows;[15]

$$\ln(EMP^*) = \beta_1 \ln(EMP) + \beta_2 \ln(1+PLAN) + \beta_3 \ln(1+R\_D) + \beta_4 \ln(1+IP) + \beta_5 \ln(1+SALE) + \varepsilon_2$$

where β_2, β_3 , β_4 and β_5 capture differences in efficiency terms of each job category from that of *PROD*. Therefore, the reduced form of the regression model is as follows:

$$\ln(VA) = \alpha \ln(CAP) + \beta_1 \ln(EMP) + \beta_2 \ln(1+PLAN) + \beta_3 \ln(1+R\_D) + \beta_4 \ln(1+IP) + \beta_5 \ln(1+SALE)$$
$$+ \gamma netuse + dummy_{ind} + dummy_{size} + \varepsilon$$

[15] The specification is a modified version of Disivia aggregation index. The modification is done because not all firms

One major problem with this type of model specification is possible missing variable to explain firm level productivity, such as the manager's ability. Since the manager's skills for business success are likely to be positively correlated with IT network use, the netuse's coefficient may be biased. To mitigate this kind of bias, regressions are conducted for only firms with an information network.[16] Therefore, the regression results in Table 5 can be interpreted as a relative impact of each type of information network compared to the impact of information networks in general.

Table 5. **Regression results of IT and productivity**

	(1)	(2)	(3)	(4)
Ordering & Transactions	0.058***	0.047***	0.071***	-
Production	0.029**	0.026*	0.061***	0.048**
Sales & Inventory Control	0.077***	0.066***	0.104***	0.050*
Logistics Management	0.099***	0.107***	0.100***	0.099***
Technology Information	0.026*	-	-	-
Accounting	0.040***	0.036***	0.060***	-
Human Resource Mgt.	-	-	-	-
Management Planning	-	-	-	-
Customer Relations	-	-0.032**	-	-
Financial Transactions	-	-	-0.032**	-0.049***
Reservation & Guide	-	-	-	0.085*

NOTE: Only statistically significant coefficients at 10% level are presented. Complete regression results will be provided upon request to the author

Each regression is conducted for the following samples;

(1) Firms with intra-firm network or inter-firm network

(2) Firms with intra-firm network

(3) Firms with inter-firm network

(4) Firms with intra-firm network and inter-firm network

*** : statistically significant at 1% level

** : statistically significant at 5% level

* : statistically significant at 10% level

have a positive number of all categories of workers.

[16] Specifically, regressions are done for four kinds of samples: (1) firms with an intra or inter firm network, (2) firms with an intra firm network, (3) firms with an inter firm network, and (4) firms with an intra and inter firm network.

Positive productivity effects of IT networks can be found in production, sales&inventory control system and logistics management in all four type of samples. In contrast, no effects are found in back office type information network, such as human resource management and management planning system. Furthermore, there are some negative and significant coefficients in customer relations and financial transactions. General conclusion from Table 5 is that IT's productivity effects vary by the type of its applications.

These results are not surprising, because the mechanism of IT's impact on productivity is clear in the case of production site applications. That is, a firm is able to achieve benefits of IT investments directly, by improving the efficiency in its production and distribution activities. On the other hand, back office modernization will indirectly affect the firm's performance.

Furthermore, the results provide some insights on IT's productivity paradox. There are some types of IT applications which are likely to link with the productivity level of a firm, and also the others which are not likely to shown up in a firm's performance measurement. A related issue is whether a focus of IT investment is necessary. Management literature (Hammer and Champy (1993)) suggests that a clear objective is needed for successful IT investment. In this sense, manager may be able to have more clear objectives in firm's direct business operation networks than in back office type information network use.

5. Conclusion

This paper provides statistical analysis of how different types of information network affect firm's organizational structure and productivity, based on the micro dataset of Japanese firms. The heterogeneity of information networks is analyzed, and it is confirmed that economic consequences are different, depending on how a firm uses IT. Particularly, it is possible to distinguish between two types of IT applications, direct business operation networks, such as production and logistics control systems, and back office supporting networks, such as human resource management and management planning systems.

As for organizational impacts, a firm with information network is likely to have larger share of white-collar workers and to outsource its production activities. In general, these effects are stronger with direct business operation networks. The result can be interpreted by means of Poter's value chain analysis (Porter (1985)) that by using IT, a firm can shift its resources to supporting functions of the value chain such as business planning and R&D department, by improving efficiency in direct value creation departments, such as production, logistics and sales. Moreover, IT investments may be complement with other innovative efforts such as R&D.[17]

The productivity impact is clear with adoption of direct business operation networks, but not so with back office supporting networks. At this point, it is not clear whether weak impacts of back office supporting network come from measurement problem or from manager's problem in using IT. IT is true that back office modernization is difficult to be measured. In addition, it can be speculated that little impact of back office type IT is related to low productivity in white color workers in Japanese firms. If white-collar productivity can be separated from firm wide productivity, this hypothesis can be tested with the same framework as is in this paper.[18]

Another research agenda is to investigate obstacles to IT network adoption, which leads to important policy implications for structural reform by IT diffusion. The survey of AMT

[17] Milgrom and Roberts (1990) formalize the complement nature of business activities in modern manufacturing technology. Canadian empirical study (Baldwin and Johnson (1995) shows positive correlation between various innovative effort variables.

[18] Nakajima, Maeda and Kiyota (2000) develop the methodology to separate back office productivity from firm wide productivity by using both firm and establishment level data, and show that back office productivity grows slower than that of production site in Japanese firms.

(Advanced Manufacturing Technology) in the U.S. shows that the largest obstacle for introducing AMT is “cost associated with investments”.(U.S. Bureau of the Census (1993)) Another difficulty, can be seen in other developed countries, is “lack of expertise”. (Northcott and Vickery (1993)) Both of reasons comply with the size effect of technology adoption rate. A recent analytical work (Brynjolfsson and Hitt (1996)) suggests these factors are not enough. There are system variables (firm’s organization and human resource strategy), which enable productive use of information technology. These intangible assets at a firm cannot be achieved instantly, and these factors may be much more costly than computers with rapidly falling prices.

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