Evaluation and estimation of the impact of organizational technology on productivity of Korean firms and sectors

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Abstract

It is a well known fact that technology innovation is a key element of economic growth. However, researchers usually dismiss the organizational part of technology innovation and emphasize only the technical part of technology innovation. Technology innovation includes not only technical innovation but also organizational innovation as well.

The just-in-time and quality control (JIT/QC) process is one of the most influential organizational innovations which has been widely used in various industries and many countries. Therefore, it is worthwhile to examine economic growth in terms of this organizational innovation. Sanidas (2004, 2005, 2006) already studied the relationship between organizational innovation and economic growth using both Japan and USA cases.

However, Korea has not been studied yet and is worthy to study for the following two reasons. First, Korea is still a developing country unlike USA and Japan. It can give us different results coming from different industrial or cultural backgrounds. Second, Korea has achieved a very high economic growth in a very short period of time. All this should present a very good case for reaching some explicit and direct conclusions for the usefulness and importance of JIT/QC in a fast developing country such as Korea.

This study uses the same methodology as per Sanidas (2004, 2005). Accordingly, the inventory to sales ratio will be used as a well justified proxy for JIT/QC implementation on sectors and we will regress this proxy on Korean sectoral TFP (Total Factor Productivity). Nevertheless, we use the KIS data base which is firm level data and not sectoral level data directly since it contains financial statements, having many critical variables for our study; this data base contains all Korean firms listed on KOSDAK (Korean stock market). So, we use firm level analysis and do the sectoral level analysis by grouping these firms according to their industrial codes.

We expect that the JIT/QC organizational innovation has a significant impact on changes in productivity of Korean firms and sectors. Furthermore, using firm level panel data, we can be more confident with the hypothesis than previous research.

Introduction

1.1 Motivation of this study

There is plenty of evidence that technological innovation is one of the most important factors of economic growth. Technological innovation basically consists of two major concepts; 1) technical innovations and 2) organizational innovations. Technical innovations are based on new technical findings but there are more conditions required for technical innovation such as enhancing the working procedure and the overall condition of a group. On the other hand, however, organizational innovation is the intentional effort firms to change an organization for enhancing the overall efficiency of the group by finding and solving problems of the organization. There are many interesting issues between organizational innovations and technical innovations. However, we are going to concentrate more on the relationship between organizational innovations and productivity of a firm in this paper by considering a variety of other influencing factors such as technical innovations.

Unlike technical innovation, organizational innovation has not been studied by many researchers because of its measurement problems. In other words, many researchers ignore the importance of organizational innovations in economic growth, not because it is less important than technical innovations, but it is difficult to find out things to measure the organizational innovations. Nonetheless Sanidas (2005) has brought the issues in regard of organizational innovations into the major economic analysis because of its importance in economic growth. He believes that the organizational innovation is as important reason for the growth in productivity as technical innovations.

His most important finding is that JIT/QC system, one of the most important organizational innovations, greatly improves the productivity of firms and sectors: He proves his hypothesis by means of inventory to sales ratio, a proxy for JIT/QC implementation. His research has concentrated on sectoral analysis and on a limited number of explanatory variables. In our paper we will use data on a firm basis and include more explanatory or controlling variables. Therefore, we use firm-level panel data in order to see how the Korean manufacturing firms, the actual body of JIT/QC implementation, responds to the organizational innovations. Furthermore, we solve the endogeneity problem more efficiently by using Fixed Effect (FE) and System GMM models.

2. Productivity and its measurement

2.1 Productivity and its measurement

Productivity is how many outputs one can produce with the same amount of inputs. Therefore, a highly productive firm can produce more outputs with the same amount of inputs. This indicates that productivity growth is a desirable phenomenon for the society since only society can spend more goods than before but also firms can have more efficient production system which makes their continuous growth possible. There are mainly two broad concepts for the productivity: 1) Labor productivity (LP) and 2) Total factor productivity (TFP). LP is calculated as output per worker, while TFP is output residual which is not explained by tangible inputs. Both measurements are widely accepted but TFP is better measurement for our research with the following two reasons.

Since TFP is an output residual, it reflects the impact of unobservable factors such as organizational innovations or technical innovations better than LP does. Sanidas (2005) briefly explained the relationship between TFP and LP in order to show the superiority of TFP over LP with the following formula.

$$TFP= (Y/L) - b\ (K/L) = (Y/K) + (1-b)(K/L) \qquad (2.1)$$

While,

$$LP= (Y/L) = (K/L) + (Y/K) \qquad (2.2)$$

TFP, LP and all terms in brackets are expressed as growth rates (first differences in natural logs). The constant b is capital's share in total revenue, Y is production and L is labor. Equation (1) can be interpreted as follows: Capital productivity (Y/K) expresses (is a proxy of) disembodied technology, or OIs in the recent analysis, whereas (K/L) expresses embodied technology, or TIs in the recent analysis (Reati, 2001). Consequently, according to equation (2), TFP is either the difference between labor productivity (Y/L) and a fraction of embodied technology (K/L=TI), or the addition of disembodied technology (Y/K=OI) and a fraction of embodied technology (K/L=TI).

To sum, we first choose TFP as our indicator for the productivity of Korean manufacturing firms and sectors. This is because TFP might be able to catch the impact of organizational innovations better than LP and it is more suitable to observe manufacturing industry which is the target space of the research. However, we can also check the result with LP or other productivity calculation method in order to enhance the robustness of our result.

2.2. Modeling TFP and its estimation

There are numerous ways to calculate TFP. However, it can be classified by two broad concepts according to Richard and Kenneth (2004): 1) growth accounting method and 2) index number method. However, our method is more similar to the index number method in order to see a long-run trend of the productivity. Suppose there is a Cob-Douglas production function:

$$\mathbf{Y = AL^{\alpha_1}K^{\alpha_2}M^{\alpha_3}} \tag{2.3}$$

Y is gross output, A is total factor productivity (TFP), L is labor input, K is capital input and M is material input; $\alpha_1, \alpha_2, \alpha_3$ are shares of labor, capital, and material respectively. Since we suppose constant returns[1] to scale (CRS), $\alpha_1 + \alpha_2 + \alpha_3 = 1$.

We can easily generate the equation (2.4) and (2.5) from the equation (2.3):

$$\mathrm{lnY = lnA + \alpha_1 lnL + \alpha_2 lnK + \alpha_3 lnM} \tag{2.4}$$

$$\mathbf{lnA = lnTFP = lnY - \alpha_1 lnL - \alpha_2 lnK - \alpha_3 lnM} \tag{2.5}$$

Furthermore, α_1, α_2 and α_3 are determined by the following equations below in accordance with firm's profit maximization behavior:

$$\alpha_1 = \frac{P_L * L}{P * Y}$$

$$\alpha_2 = \frac{P_K * K}{P * Y}$$

[1] For the justification of the research, you can see Sanidas book p223

$$\alpha_3 = \frac{P_M * M}{P * Y}$$

P_L is a price of labor input, P_K is a price of capital input, P_M is a price of material input and P is a price of output, while L is a labor input, K is a capital input, M is a material input and Y is output.

Organizational issues and its measurement

3.1 Organizational issues and its measurement

There have been several attempts to prove the relationship between organizational innovations and productivity. Baily and Gersbach (1995) wants to explain the difference of labor productivity by organizational innovations. Furthermore, Brynjolfsson and Hitt (2000) points out that organizational innovation is a major driver of IT accomplishment and there might have been serious productivity loss if there was no organizational innovations followed by technical innovations. Recently the JIT/QC (just-in-time/quality control) system is one of the most important organizational innovations firms and sectors. Tomer (2001) pointed out that "JIT/QC is the high performance work system which requires fundamentally and radically different organizations and employer-employee relationships." JIT/QC which is also linked as LPS (lean production system) enhances the productivity by reducing all the waste, satisfying customers, lowering cost, and improving quality. These became all possible since JIT/QC system produces goods right after customer's order. For this reason, the overall firms cannot only remove inventories but also reduce all the waste and the overall cost of keeping and managing inventories. Moreover, firms produce goods suiting for the taste of their customers so it improves the quality of products and achieve the customer satisfaction.

One of the most important waste is firm's inventory which is reflection of efficiency of a firm. Therefore, we conclude that the key feature of JIT/QC system is low inventory ratio[2] (for more details

[2] The inventory to sales ratio generally reflects an efficiency of a firm. The lower the ratio, the more efficient firms become, and therefore productivity increases. Reduction in this ratio over time is due to an important

you can Sanidas, 2005, which includes as a extensive literature review on this). This lies in the fact that all the advantages of JIT/QC system are reflected in a low inventory ratio. Furthermore, Lieberman et al. (1999) who evaluates the relationship between inventory and the productivity level of a firm, concludes that JIT/QC system plays a considerably important role in reducing its inventory level and improves the productivity level of a firm.[3] Besides Lieberman et al., there are still many researchers such as Callen et al. (2000), Mitenburg (1993), and Jakes and Power (1993) who have considerable interests in JIT/QC system and its impact on firm performances. To sum, we use inventory to sales ratio as a proxy for JIT/QC implementation, one of the important organizational innovations, and examine its effect on firm performances to account for the hypothesis, "organizational innovation greatly influence the productivity of a firm."

3.2 Implementation of the JIT/QC system in Korea

JIT, one of the "Japanese production systems", was first introduced in Korea at the end of 1980s by Hyundai automobile company. Lee (1995) analyzed why Hyundai, the biggest automobile company in Korea, introduced the system and summarized reasons in three perspectives. First, Hyundai faced demand shock at the end of 1980s. Hyundai had no choice to prevent such a drastic demand change in North America market since Hyundai was based on mass production system. Moreover, first union of Hyundai was established in 1987 and it made Hyundai more rigid and fixed. Even some negative signs for Hyundai, domestic market came to be bigger and bigger since the motorization period came to Korea. To overcome both exogenous and endogenous shock in 1980s and catch an opportunity on an emerging domestic market, Hyundai had to come up with more flexible system and decided to introduce JIT. However, Hyundai was not the only company having such problems in Korea. As we last mentioned, it was a worldwide phenomenon and most of Korean companies had the same

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organizational innovation, the JIT/QC system; however any other system that resembles the JIT/QC system can also be a cause of reduction in this inventory to sales ratio.

[3] He wonders which factors determine the inventory level of a firm and finds that customer communication and participation of employees in its problem solving process is the most important element to reduce the inventory level of a firm. Therefore, he conclude that JIT/QC system significantly contributes the low inventory ratio.

problem with Hyundai. Daewoo, the third largest automobile company in Korea, had more serious problems based on Daewoo itself. Daewoo was a joint company with GM and it made Daewoo much harder to dare with problems instantly. Finally, Daewoo decided to become independent from GM and implemented JIT in 1992. At the starting point with automobile industry, JIT quickly spread and adapted to other industries such as electronics, ship-buildings, and heavy industries which are characterized by assembly industry needing many components to complete a single product. Kim et al (1997) did the survey on 64 different firms of sizes and sectors in Korea and concluded "Korean manufacturers widely use JIT but the degree of JIT implementation is different on each company." It means almost all major companies in Korea, including Samsung, LG, Hyundai, GS etc., competitively adopted JIT in 1990s even though there were some differences in times and degrees.[4] In order to increase the competitiveness of a company, many industries in Korea, not only manufacturing industries, have been trying to adopt JIT. Yoo (2001) studied the performance of JIT implementation on Korea service industry and revealed that many service firms in Korea did not yet implement JIT but it is very important task for service industry to adopt JIT since service industries are the dominant sector in Korea and its importance would be bigger and bigger.

To sum up, Korea had experienced rapid growth after the Korean War but later reached some growth limitation and worldwide difficulties at the end of 1980s. To overcome these difficulties in the late 1980s, Korean companies decided to adopt JIT. However, they partially failed to improve firm performances in the first place, because they just imported JIT and they misunderstood it: JIT is not just a system, which is explicit, but it also philosophy, which is tacit. Therefore, organizational innovation should be needed for implementing JIT, not the process innovation or systemic innovation. Fortunately, there was a chance to revise the result in 1997. Through the financial crisis in 1997, many Korean companies found the true value of JIT and realized its importance in management system. Therefore, they started to implement JIT as a new strategy for global leading companies after 1997

[4] Newspapers in 1990s were also checked and provide further evidences for this.

and emphasized its importance to their employees, too.[5] As a result, JIT was transformed to fit their industrial characteristics and now it has been widely used no matter what the sector is.

There are some special reasons for why Korean companies should adopt JIT: Korea has better NIS (National Innovation System) for JIT that Korea is the country which can maximize the profit from JIT. (Rephrasing) First, Korea is strong in IT (Information Technology) industry. In the past, JIT was based on KANBAN, card system, but now it uses computer system for collecting or sending data. Korea can manipulate and use better systems for JIT like RFID and we can expect it will give considerable effects on firm's profit from this. Second, Korea industries are consisted of big and diversified companies like Samsung, LG or Hyundai called Chaebols: it means needs for JIT is more prevalent in Korea. Already, top firm dominance in Korea is over 60% and it proves the need for JIT. Chaebols have so many subsidiary firms, locating in distant places, that they need faster and more accurate communication method for collecting and sending data for JIT. Moreover, JIT not only helps to increase firm performance but also have the positive side-effects on relating industries. Therefore, JIT will be more widely used in Korea for better performances and outcomes.

4 Empirical analysis

4.1 Data and variables

(1) Data

We mostly use the data established by Jung in 2009.[6] He already calculated all the important components of TFP such as labor, capital and other explanatory variables. Based on his calculation, we made lnTFP and some other independent variables. The sample firms are all the listed firms and

[5] This shows that Korea companies now understand what the true meaning of JIT is and how they try to do for it.

[6] We so much appreciated to Moo Sup, Jung since he did great works to establish the dataset we use. Jung's data is based on firm level data, KIS (Korea Information Service) and it has financial statements of all the listed and delisted firms and he calculated the firm level TFP and other explanatory variables depending on this. For more information about the data, you can find in his 2009 doctoral thesis, 'Sectoral Systems of Innovation'.

delisted firms in manufacturing industry during the sample periods. This firm sample includes also the firm observations found in the period before the firm is listed. We exclude the firms under 8 years and some important missing or extreme values.

Table 4-1 Firms by sector and year in the sample

ICPA code	Industry name	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	20095	sum
6	Food and kindred products	41	42	38	41	41	39	37	37	39	39	40	42	47	50	44	45	48	44	44	49	47	894
7	Textile mill products	11	17	19	17	18	20	19	21	21	22	21	21	22	20	22	23	22	25	23	25	24	433
8	Apparel	12	13	16	16	18	16	16	17	17	14	19	15	20	27	24	23	22	23	25	22	24	399
9	Lumber and wood	3	3	2	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	76
10	Furniture and fixtures	5	6	6	8	9	6	7	7	8	6	7	6	9	13	11	10	11	10	9	8	8	170
11	Paper and allied	15	22	23	25	23	27	27	30	30	31	28	28	32	32	28	28	29	27	27	31	31	574
12	Printing publishing and allied	1	1	1	2	2	2	2	2	2	2	3	4	4	5	6	4	5	4	4	6	6	68
13	Chemicals	64	64	62	62	55	61	59	67	69	67	71	77	86	99	94	86	87	80	74	83	86	1,553
14	Petroleum and coal products	3	3	4	4	4	4	3	4	4	4	4	4	3	4	3	4	4	3	4	5	5	80
15	Leather	5	5	6	7	8	8	8	8	8	8	8	9	9	9	8	9	9	8	9	8	8	165
16	Stone clay glass	23	25	25	22	21	23	23	23	22	22	23	25	26	27	26	26	29	26	23	24	24	508
17	Primary metal	37	38	42	47	49	52	53	54	55	59	59	63	65	67	68	68	69	70	70	71	71	1,227
18	Fabricated metal	9	13	15	18	21	24	21	26	23	28	24	28	28	28	23	25	26	29	30	29	29	497
19	Machinery non-elect	15	18	19	23	24	23	26	29	30	26	35	47	56	54	59	52	54	60	66	69	72	857
20	Electrical machinery	43	58	64	69	69	81	78	92	93	99	101	132	155	177	181	168	168	180	184	189	184	2,565
21	Motor Vehicles	24	31	37	37	43	41	41	43	45	41	43	42	52	53	50	51	48	52	49	52	52	927
22	Transportation equipment and ordnance	7	8	8	8	8	7	5	6	6	7	6	8	8	8	6	6	6	7	5	7	6	143
23	Instruments	5	5	5	4	3	5	7	9	10	9	13	15	11	14	15	13	18	15	16	17	16	225
24	Rubber and misc plastics	10	10	11	12	12	11	14	17	15	15	16	21	22	26	25	29	25	24	23	22	22	382
	Total	333	382	403	424	430	453	450	496	501	503	525	591	659	717	697	674	684	691	690	721	719	11,743

Notes: ICPA is the abstract of International Comparison of Productivity among Asian countries and it is a kind of industry classification method.

(2) Dependent variable: $\mathbf{lnTFP_{f,t}}$

The dependent variable, representing the productivity, is lnTFP which is calculated in section 2, equation (2.5).

$$\mathbf{lnTFP = lnY - \alpha_1 lnL - \alpha_2 lnK - \alpha_3 lnM} \quad \textbf{(4.1)}$$

$$\alpha_1 = \frac{P_L * L}{P * Y},\ \alpha_2 = \frac{P_k * K}{P * Y},\ \alpha_3 = \frac{P_M * M}{P * Y}$$

$$(\alpha_1 + \alpha_2 + \alpha_3 = 1)$$

According to this formula, we generate lnTFP by using real sales for Y, number of employees for L, amount of real capital stock for K, and amount of real material for M Also, we use nominal salary of employees for $P_L * L$, nominal material cost for $P_M * M$, and nominal sales for P*Y . Above all, most important thing in here is that we calculate α_2 as $1-\alpha_1-\alpha_3$ instead of $\alpha_2 = \frac{P_K * K}{P * Y}$ since we assume $\alpha_1 + \alpha_2 + \alpha_3 = 1$ which means Constant Returns to Scale (CRS).

The summary of relevant statistics is shown in table 4-2. The average lnTFP has been increased until 1996 but decreased in1997-1998.[7]

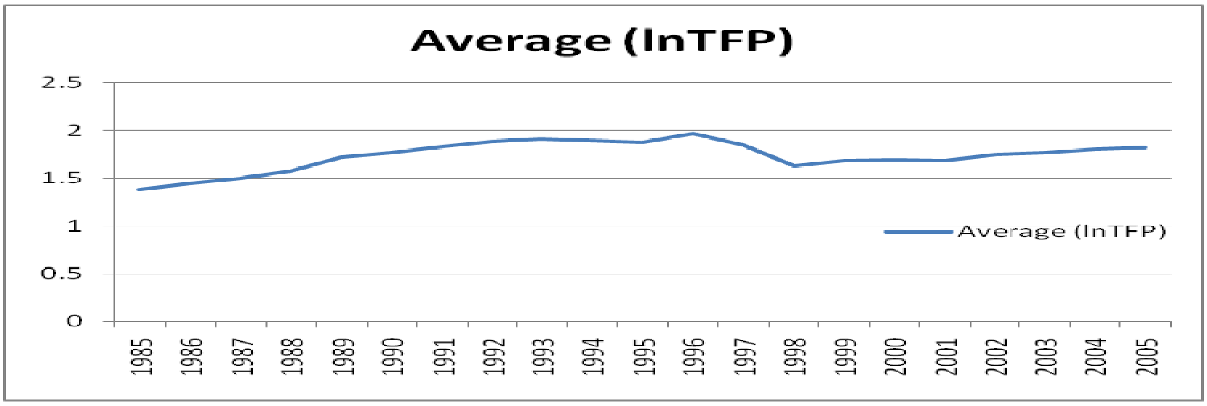
Table 4-2 Basic statistics of lnTFP of Korean manufacturing firms

Year	N	Min	Ave	Max	S.D
1985	333	-0.2208083	1.37987	3.655658	0.6652139
1986	382	0.1240976	1.446067	4.525209	0.6634652
1987	403	0.1830527	1.501747	7.681687	0.7152628
1988	424	0.0919996	1.573021	7.500089	0.7270731
1989	430	0.1521869	1.720657	4.714948	0.7657983
1990	453	0.1801595	1.768846	6.627207	0.8612827
1991	450	0.2761996	1.832516	6.320239	0.8221902
1992	496	0.2602434	1.887486	5.577044	0.8198778
1993	501	0.2243188	1.91578	6.31553	0.8210027
1994	503	0.2670184	1.892634	6.743624	0.7973706
1995	525	0.2986575	1.878173	5.583751	0.8137102
1996	591	0.3065836	1.968786	6.746835	0.8635861
1997	659	0.1547144	1.850326	7.197788	0.8646484
1998	716	-0.1819205	1.629648	5.158665	0.7510954
1999	697	-0.0126298	1.684207	5.429958	0.7366585
2000	674	0.1034023	1.692368	5.911024	0.8035699
2001	684	-0.1289452	1.68212	5.806043	0.7563073
2002	691	-1.236561	1.74863	6.349205	0.8228802
2003	690	-0.5199544	1.762732	6.728796	0.8414477
2004	721	0.044456	1.801422	6.875051	0.8961543
2005	719	-0.852604	1.824905	7.840692	1.018244
Total	11742	-1.236561	1.748789	7.840692	0.8259959

*Notes: 'N' denotes the number of firms of the year.
'Min' denotes the minimum level of lnTFP of the year.
'Ave' denotes the average level of lnTFP of the year.
'Max' denotes the maximum level of lnTFP of the year.
'S.D' denotes the standard deviation of lnTFP of the year.

[7] The financial crisis of East Asia occurred in 1997 and productivity might be affected by the crisis.

Graph1. Average lnTFP of Korean manufacturing firms from 1985 to 2005



(3) Independent variables

Organizational innovation

The importance of organizational innovations and its impact on firm performances are already discussed in section3. To reflect its impact on the productivity of a firm, we use fist lagged **inventory to sales ratio** as a proxy for JIT/QC implementation, one of the most important organizational innovations of the recent firms.[8] Our hypothesis is that this proxy might move toward the opposite way with its dependent variable. In other words, lnTFP would be high when there is low inventory to sales ratio is low.

Table 4-3 Basic statistics of organizational innovation (inventory to sales ratio) of Korean manufacturing firms

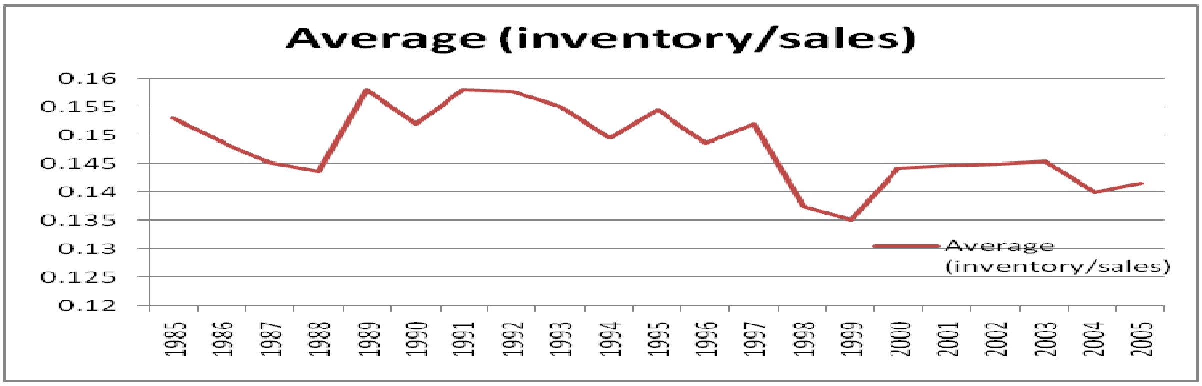
Year	N	Min	Mean	Max	S.D.
1985	333	0.0160597	0.1530377	0.4587215	0.0825283
1986	382	0.0017373	0.1488465	0.4988559	0.0853205
1987	403	0.0101791	0.1452755	0.4765949	0.0823643
1988	424	0.0051579	0.1436668	0.4805244	0.0828182
1989	430	0.0064191	0.1580199	0.4877077	0.0943394
1990	453	0.0051404	0.1520546	0.4654154	0.0909525
1991	450	0.0050866	0.1579913	0.4993039	0.0979253
1992	496	0.0011682	0.1577134	0.4991425	0.0997336

[8] We use first lagged inventory to sales ratio as a proxy for organizational innovation since normally inventory is measured at the end of year and its impact is reflected on the next year.

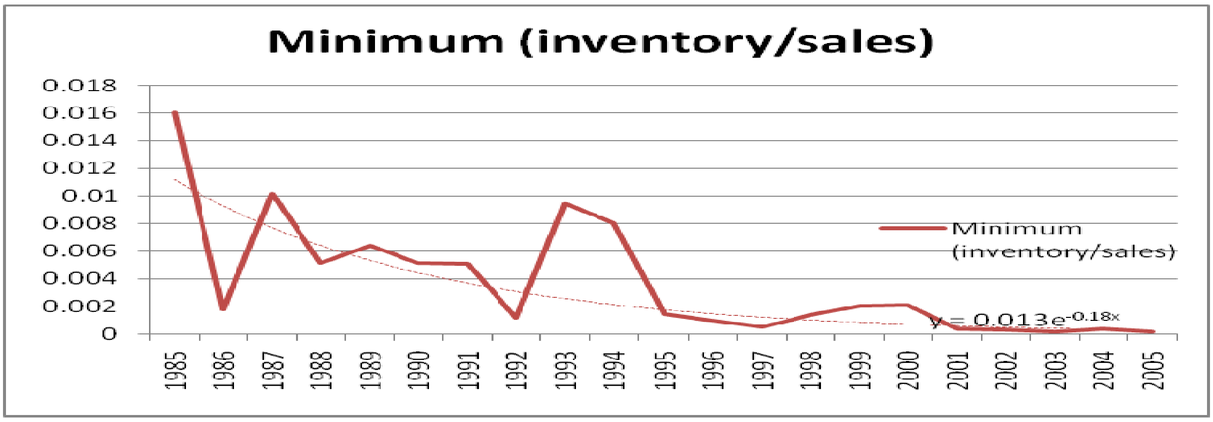
1993	501	0.0094726	0.1550362	0.498036	0.1005645
1994	503	0.0080384	0.149444	0.4945502	0.0938321
1995	525	0.0014349	0.1544389	0.4979129	0.0944955
1996	591	0.0009594	0.1486228	0.4840247	0.0976862
1997	659	0.0004924	0.1520245	0.4828551	0.0955592
1998	717	0.0013573	0.1374854	0.4998363	0.0969608
1999	697	0.0020081	0.1350695	0.4798976	0.0892584
2000	674	0.0020842	0.1441873	0.48816	0.0935725
2001	684	0.0003967	0.1446189	0.4831915	0.0957718
2002	691	0.0002979	0.1449994	0.499683	0.0979012
2003	690	0.0002071	0.1453651	0.4923962	0.0950484
2004	721	0.0003857	0.1399202	0.4992245	0.092623
2005	719	0.0001744	0.1414903	0.4930248	0.0978475
Total	11743	0.0001744	0.1470927	0.4998363	0.0941481

Notes: 'N' denotes the number of firms of the year.
'Min' denotes the minimum level of lnTFP of the year.
'Ave' denotes the average level of lnTFP of the year.
'Max' denotes the maximum level of lnTFP of the year.
'S.D' denotes the standard deviation of lnTFP of the year.

Graph4-2. Average inventory to sales ratio of Korean manufacturing firms from 1985 to 2005



Graph4-3. Minimum inventory to sales ratio of Korean manufacturing firms from 1985 to 2005



Graphs 4-2, and 4-3 explicitly show us that low inventory level is not only caused by the economic condition of the year but also more considerably influenced by JIT/QC implementation. This is because the average inventory to sales ratio has continuously decreased since the early 1990s which was the starting point of JIT/QC implementation, even though there were small ups and downs during the period. The fluctuation has been largely influenced by the economic condition of the year. Furthermore, minimum level of inventory to sales ratio shows us more explicitly that inventory to sales ratio dropped due to the firm's intentional effort to reduce its inventory level. Therefore, inventory to sales ratio functions appropriately as a proxy for JIT/QC implementation and organizational innovation for our research.

However, here is one more thing to consider. When we use inventory to sales as a proxy for the organizational innovation, we should use the first lagged one for the research. This is because organizational innovation needs time to be implemented and also we need to inventory level at the end of the year. Therefore, we specifically use the first lagged variable of inventory to sales ratio as a proxy for the organizational innovations.

Innovation capability

Innovation capability is considered as one of the most important factors for the productivity. Normally, R&D expenditure and the number of patents are most widely used to measure the innovation capability of a firm (Solow (1957), Griliches (1964, 1973, 1979, 1980, 1984, 1986)), Scherer (1965)). However, R&D expenditure and patents are strongly correlated with each other so that only need to choose one for the research. We choose R&D expenditure to sales ratio as a proxy for the innovation capability of a firm. This is because 1) patents are not normally collected by all the sample firms during the sample period and 2) patents have so many variations cross the sample firms throughout the years. On the other hand, R&D expenditure to sales ratio is easy to be found and calculated in its financial statements and has no such a huge variation across the firms throughout the years.

Efficiency wage

'Efficiency wage hypothesis' believes that each firm has an incentive to give high salary to their workers in order to increase their productivity. Normally people prefer to work for firms paying their employees high salary. So, the firm willing to pay high salary can choose efficient workers and induce them put intense effort on work. Therefore, employees would not attempt to leave such a company. As a result, such a firm can lower the transaction cost. High salary prevents the labor union as shown in the case of Samsung [9]and gives sociological reward to their workers. Many researchers such as Stiglitz (1974,1976, 1984) , Solow (1979) and Dickens (1986) supported the hypothesis and there have been so many empirical works in various ways. Therefore, we refer higher salary to efficiency wage and use firm's relative salary level, in a comparison with to its industry level, (average salary of a firm- average salary of the industry) / average salary of the industry, as a proxy for efficiency wage of each firm.

Learning by education

'Learning by education' is the next step of 'Learning by doing'. People can improve their skills when they learn. Therefore, it is no surprise that 'Learning by education' is the most common way to enhance one's ability. Based on the hypothesis, we use education expenditure for sales to sales ratio as a proxy for learning by education. From the model, we can see whether firm's investment in its human resource brings a good result to the firm or not.

K/L

To control technical innovation, we use K/L, real capital stock to the number of employees, as a proxy for technical innovation in case of using labor productivity (LP) as a proxy for the productivity.

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[9] Samsung does not have a labor union and many people point out that one of the biggest reason for this is they have the highest salary than any other groups in Korea.

However, K/L should be negatively correlated with its productivity level in case of TFP since K and L both are the input factors lowering the TFP and usually K grows faster than L.[10]

The summary of descriptive statistics is shown in table 4-4 and correlation among the variables is shown in table 4-5. Also, we can check the partial correlation of the variables in table 4-6. Just note that: 1) There is no apparent problems of multicollinearity. 2) Partial correlation of first lagged inventory to sales ratio is negative which is indicative of the result we expect.

Table 4-4 Descriptive table of independent variables

Variables	Level	N	Min	Mean	Max	S.D.
Organizational innovation (inventory sales ratio)	Firm	11743	0.0002	0.1471	0.4998	0.0941
Innovation capability (R&D expenditure sales ratio)	Firm	11743	0.0000	0.0107	0.2924	0.0230
Efficiency wage (salary gap ratio)	Firm	11696	-0.6300	-0.0178	0.7900	0.2432
Learning by education (education expenditure for sales)	Firm	10822	0.0000	0.0003	0.0009	0.0003
K/L (captital stock/num. of employees)	Firm	11743	443	97438	1974873	143787

Notes (1): 'N' denotes the number of firms of the year.
'Min' denotes the minimum level of lnTFP of the year.
'Ave' denotes the average level of lnTFP of the year.
'Max' denotes the maximum level of lnTFP of the year.
'S.D' denotes the standard deviation of lnTFP of the year.

Notes (2): since variables are not measured by an integrated unit, it is meaningless work to compare its coefficient value across the variables.

[10] lnTFP is calculated as $\ln Y - \alpha_1 \ln L - \alpha_2 \ln K - \alpha_3 \ln M$. Therefore, lnTFP increases only if L increased more than K or L decreased less than K. However, normally K increases and L decreases when technology develops, so usually K/L gives negative sign to the lnTFP.

Table 4-5 Correlation among the variables

		1	2	3	4	5	6	7
Productivity	1	1.00						
L.Productiviry	2	0.87	1.00					
Organizational innovation	3	0.07	0.12	1.00				
Innovation capability	4	0.15	0.14	0.11	1.00			
Efficiency wage	5	-0.06	-0.11	-0.11	-0.03	1.00		
Learning by education	6	0.10	0.08	-0.04	0.12	0.08	1.00	
K/L	7	-0.30	-0.27	-0.06	-0.08	0.23	0.04	1.00

Notes (1): correlations between explanatory variables are not that significant.

Notes (2): Productivity is measured by lnTFP and L.lnTFP means first lagged variable of lnTFP.
Organizational innovation is measured by the first lagged variable of inventory/sales.
Innovation capability is measured by R&D expenditure/sales.
Efficiency wage is measured by average salary of a firm/average salary of the sector-1.
Learning by education is measured by education expenditure /sales.

Table 4-6 Partial correlations with dependent variable

Variable	Partial correlation	Significance
L.lnTFP	0.86	0.00
Organizational innovation	-0.08	0.00
Innovation capability	0.06	0.00
Efficiency wage	0.05	0.00
Learning by education	0.10	0.00
K/L	-0.17	0.00

Notes: dependent variable is lnTFP
L.lnTFP means first lagged variable of lnTFP.
Organizational innovation is measured by the first lagged variable of inventory/sales.
Innovation capability is measured by R&D expenditure/sales.
Efficiency wage is measured by average salary of a firm/average salary of the sector-1.
Learning by education is measured by education expenditure /sales.

4.2 Regression models

As foreshadowed previously we will now make the following hypothesis so that we can test it empirically.

Hypothesis: Organizational innovation is positively correlated with the productivity level of a firm.

There are mainly three things to be considered for the regression. First, we should check and control the economic condition of the year.[11] This is because the key variable, inventory to sales ratio, the proxy for organizational innovation, is strongly influenced by the economic condition of the year. However, by the number of the simple regression, we found the fact that the economic condition of the year does not significantly influence the productivity of a firm.[12] Therefore, we do not need to concentrate on this issue as long as we use inventory to sales ratio as a proxy for the organizational innovation.

Second, we should consider the individual differences of firms which can cause trouble with the error term. Even though we focus only on the firms in manufacturing sectors, there are still many different characteristics depending on firms and sectors. Therefore, we should either include the individual dummies or do other things to solve the problems. We use the Fixed Effect (FE) model in this case and extract the individual term by demeaning the value from the original model. However, there are still endogeneity problem caused by its first lagged dependent variable and inventory to sales ratio.

Therefore, we finally use the system GMM to solve the the endogeneity problems of the model. There are mainly two major reasons for the endogeneity problems, unobserved common factors and two-way causation. To solve the endogeneity problem caused by the unobserved common factors, we use the Fixed Effect (FE) model. However, the endogeneity problem occured by the two-way causation still remains even though we use the FE model. Therefore, we should find another way to solve both endogeneity problems. However, GMM is the only way to solve the endogeneity problem of the dynamic panels. Therefore, we use System GMM which is more efficient model than GMM to prove the hypothesis.

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[11] For example, economic boom or crisis is the best illustration for economic conditions.

[12] We did the simple regression to know whether productivity is influenced by low level of inventory due to the economic condition of the year. However, low inventory level due to the economic boom in 1985-1989 did not significantly influence the productivity level in 1985-1989. On the other hand, low inventory level due to the JIT/QC implementation significantly enhances the productivity level.

4.2.1 Simple regression model

JIT/QC started to be implemented in Korea at the end of 1980s. Therefore, we can briefly recognize the impact of organizational innovations on firm's performance by comparing before and after the implementation of JIT/QC. The period before JIT/QC implementation is 1985 to 1987 and the period after JIT/QC implementation is 1988 to 2005.

Dependent variable is lnTFP and independent variables are first lagged lnTFP and first lagged inventory to sales ratio: we use the first lagged lnTFP to control the autocorrelation problems and first lagged inventory to sales ratio is used for measuring the impact of organizational innovation.

$$\mathbf{lnTFP_{f,t} = \alpha_0 + \alpha_1\, lnTFP_{f,t-1} + \alpha_2 OIs_{f,t} + \varepsilon_t} \qquad \textbf{(4.2)}$$

From the regression, we can find out the fact that there is no strong relationship between inventory to sales ratio and the productivity level of a firm.[13] In other words, the economic condition of the year does not seriously affect the productivity level of a firm by lowering the inventory level. This is because inventory to sales ratio in 1985-1987 was fully influenced by the economic condition of the year,[14] but it failed to enhance the productivity of a firm significantly.

On the other hand, however, inventory to sales ratio in 1988-2005 has a strong negative relationship with its productivity level: this is what we have expected as the productivity of a firm increases when the inventory level is low. Since inventory to sales ratio in 1988-2005 is influenced not only by the economic condition of the year but also by JIT/QC implementation which started to be implemented

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[13] T-statistics of organizational innovation indicates that organizational innovation in 1985-1987 is not significant, which is correct expected result of us.

[14] Inventory to sales ratio is fully influenced by economic condition in 1985-1987 since JIT/QC was not yet introduced in Korea. However, 1985-1987 is economic boom in Korea since 1988 is the year which held the Seoul Olympic in Korea, so we can check from the graph 4-2 the inventory to sales ratio dropped in 1985-1987.

in Korea at the end of 1980s, we can generalize the fact that low inventory to sales ratio due to the JIT/QC implementation increases the productivity of firm significantly. In other words, organizational innovation enhances the productivity of a firm significantly.

Table 4-7 Simple regression before and after JIT/QC implementation

Variable	Level	Before	After
Past level of Productivity	Firm	0.87**	0.88**
(L.lnTFP)		(32.68)	(105.82)
Organizational innovation	**Firm**	**-0.25**	**-0.30****
(L.inventory/sales)		(-1.41)	(-6.24)
Constant	Firm	0.26**	0.25**
		(7.58)	(18.26)
Obseravaions		661	9956
Adjusted R-square		0.8	0.76

legend: + p<.1; * p<.05; ** p<.01

Notes (1): Before JIT/QC implementation is 1985-1987.
After JIT/QC implementation is 1988-2005.

Notes (2): L.lnTFP means first lagged variable of lnTFP.
Organizational innovation is measured by first lagged variable of inventory to sales ratio.

Table 4-8 Simple regression for finding the year in which JIT/QC started to be implemented

Variable	Level	1985-1986	1985-1987	1985-1988	1985-2005
Past level of Productivity	Firm	0.84**	0.87**	0.90**	0.88**
(L.lnTFP)		(17.78)	(32.68)	(46.33)	(105.82)
Organizational innovation	**Firm**	**0.07**	**-0.25**	**-0.26+**	**-0.30****
(L.inventory/sales)		(0.23)	(-1.41)	(-1.90)	(-6.24)
Constant	Firm	0.24**	0.26**	0.24**	0.25**
		(4.47)	(7.58)	(8.25)	(18.26)
Obseravaions		311	661	1032	9956
Adjusted R-square		0.77	0.8	0.81	0.76

legend: + p<.1; * p<.05; ** p<.01

Notes (1): L.lnTFP means first lagged variable of lnTFP.
Organizational innovation is measured by first lagged variable of inventory to sales ratio.

Notes (2): We also did the same regression for 1985-1989 and got more strong results than 1985-1988.
However, 1985-1988 result already give us the strong result, so we did not add in here.

4.2.2 Panel Data Analysis

(1) Pooled OLS Model (N: 9125 firms, T: 20 years)

Now we want to prove the hypothesis with other explanatory variables which are already proved to be valid in other studies to explain the productivity. Therefore, we use $\ln TFP_{f,t}$ as a dependent variable for the productivity of a firm and independent variables are 1) inventory to sales of a firm, 2) R&D expenditure / sales of a firm, 3) average wage of a firm / average wage of the sector – 1, 4) education expenditure for sales /sales of a firm and 5) capital stock/ number of employees of a firm. However, we also put the first lagged dependent variable to adjust the autocorrelation problem of the model and industry and time dummy variables to control the industry and time effect.

$$\mathbf{lnTFP_{f,t} = \alpha_0 + \gamma\, lnTFP_{f,t-1} + \sum_{i=5}^{5} \beta_i X_{i,f,t} + \theta_{ind} + \tau_{year} + \varepsilon_{f,t}} \qquad (4.3)$$

- Independent variables: $\sum_{i=1}^{5} \beta_i X_{i,f,t}$

  ① Organizational innovation: first lagged (inventories/sales) of a firm
  ② Innovation capability: R&D expenditures/ sales of a firm
  ③ Efficiency wage: Average wage of the firm/Average wage of the sector – 1
  ④ Learning by education: Education expenditure for sales /sales of a firm
  ⑤ K/L: capital stock/ num. of employees

(2) Fixed Effect (FE) Model (N: 9125 firms, T: 20 years)

Each firm has all different characteristics and they determine the way to produce, and affect the productivity level of a firm. Therefore, we should take account the individual effects of each firm into the model. Fortunately, we use panel data for our research and there are many effective ways to control the individual effect in panel data analysis. We control the individual effects by putting individual intercept into the model and transforming the equation either using Fixed Effect (FE) or Fist Difference (FD) model. Since any individual effects of a firm are not considered in Equation (4.3), we make the new model, equation (4.4), which adds individual intercepts (α_f) in the presence of the common intercept (α_0).

$$\mathbf{lnTFP_{f,t} = \alpha_0 + \gamma\, lnTFP_{f,t-1} + \sum_{i=1}^{5} \beta_i X_{i,f,t} + +\theta_{ind} + \tau_{year} + \varepsilon_{f,t}} \qquad (4.4)$$

$$\mathbf{where,} \quad \boldsymbol{\varepsilon_{f,t} = \alpha_f + \epsilon_{f,t}}$$

However, equation (4.4) is not an appropriate model for OLS estimation since individual effect term (α_f) is correlated with other explanatory variables. Furthermore, random effect estimation also can bring some inefficient results to us since individual firm's characteristics are also correlated with its dependent variable, productivity level. Therefore, we should find another method to estimate parameters. Fixed effect (FE) model is the most common and simple way to solve this kind of problem by removing the individual effect term from the model. Therefore, we use FE model for the research, but unfortunately we lose our time-invariant variables such as industry dummies (θ_{ind}) during the process.

(3) Regression Results with Pooled OLS, FE and RE

The regression results are very satisfactory in overall. However, there are still several interesting things to discuss. First, the past productivity level is influence the most powerfully the present level of the productivity. This is because the productivity, usually considered as an equivalent to the technology, is not the one which is easily disappeared or discarded. Technology is not easily discarded since it usually embodies people in a firm and is continuously kept by the people. Therefore, the productivity of today is continuously influenced by the past level of it unless there is a big paradigm shift making all the past experiences become useless.

Second, efficiency wage, innovation capability, learning by education and organizational innovations are all the important factors for the productivity. However, there are some other important points to be mentioned. All the variables including organizational innovation and innovation capability become stronger and more significant only after controlling the individual effect by using FE or RE model. In other words, organizational innovation and other variables are heavily influenced by the individual characteristics of a firm, which are unobservable, but should be controlled. This result implies that each firm differs in characteristics which suit only for the company. Therefore, so many things should be considered when they want to change their policy to improve the productivity.

To sum up, no matter what the model we use, we consistently have the good result with other important explanatory variables for the productivity. Therefore, we almost get to the point that "organizational innovation is positively correlated with the productivity level of a firm" but there is still one more thing that is not yet solved but should be solved.

Table 4-9. Regression results with lnTFP and explanatory variables

Variable	Level	OLS	FE	RE
Past productivity level	Firm	0.85**	0.58**	0.76**
		(87.02)	(33.98)	(59.81)
Organizational innovation	**Firm**	**-0.31****	**-0.56****	**-0.47****
		(-5.71)	(-7.07)	(-7.08)
Innovation capability	Firm	1.06*	3.01**	1.68**
		(2.55)	(5.41)	(3.56)
Efficiency wage	Firm	0.18**	0.59**	0.33**
		(10.14)	(18.36)	(13.97)
Learning by education	Firm	44.93*	76.21**	56.62**
		(2.50)	(3.64)	(2.83)
K/L	Firm	-0.00**	-0.00**	-0.00**
		(-10.84)	(-9.39)	(-10.97)
constant	Firm	0.32**	0.75**	0.46**
		(13.75)	(25.40)	(15.03)
Observation		9125	9125	9125
Adjusted R-square		0.77	0.44	
Wooldridge test statistics		235.06 (0.00)		
Hausman test statistics			386.66 (0.00)	

legend: + p<.1; * p<.05; ** p<.01

Notes (1): Productivity is measured by lnTFP and L.lnTFP means first lagged variable of lnTFP. Organizational innovation is measured by the first lagged variable of inventory/sales.

Innovation capability is measured by R&D expenditure/sales.
Efficiency wage is measured by average salary of a firm/average salary of the sector-1.
Learning by education is measured by education expenditure /sales.

Notes (2): OLS means Ordinary Least Square model while FE means Fixed Effect model and RE means Random Effect model. Industry and year dummy variables are included in the model.[15] All estimates in table are from white-heteroskedasticity-consistent covariance matrix estimator. Wooldridge test justify the regression result with the first lagged dependent variable[16] and Hausman test justify the regression result with RE.

4.2.3 Dynamic Panel Data Analysis

(1) System - Generalize Method of Moment (GMM) model

To eliminate the endogeneity problem caused by the unobserved common factors, we use FE model. However, we still have the endogeneity problem due to the two-way causation and it is very difficult to find the instrumental variables (IV) outside of the model. To solve this problem, GMM needs to be developed. GMM tries to find instruments for endogenous variables in its model. Therefore, it is widely used for its convenience. GMM is based on the First Difference (FD) Model. We can directly generate the equation (4.6) from the equation (4.4).

$$\Delta \mathbf{lnTFP_{f,t}} = \boldsymbol{\gamma}\Delta\ \mathbf{TFP_{f,t-1}} + \sum_{i=1}^{5} \boldsymbol{\beta_i} \Delta \mathbf{X_{i,f,t}} + \Delta \boldsymbol{\tau_{year}} + \Delta \boldsymbol{\epsilon_{f,t}} \qquad \textbf{(4.5)}$$

Even though we transform the equation (4.4) to (4.5), we can see that the first lagged time differencing variable ($\Delta\ \mathrm{TFP_{f,t-1}}$) still generate the endogeneity problem with its error term ($\Delta\epsilon_{f,t}$), which is called two-way causation. Therefore, we should find another method to solve the endogeneity problem of FD model and use Generalized Moment Method (GMM) instead of FD. Arellano and Bond (1991) developed GMM method from the Anderson and Hsiao which uses only the second lagged variable ($\mathrm{lnTFP_{f,t-2}}$) as its IV while GMM uses every possible moment conditions ($\mathrm{lnTFP_{f,1}}, \dots, \mathrm{lnTFP_{f,t-2}}$) to find its' consistent estimates.

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[15] We also include the result with dummy variables in Appendix 4-1.

[16] Wooldridge test(2002) is the test for autocorrelation in panel data. H_0 is no first order autocorrelation. A significant test statistic indicates the presence of serial correlation.

$$\Delta \ln \mathrm{TFP}_{f,t} = \alpha_0 + \gamma\Delta\,\mathrm{TFP}_{f,t-1} + \sum_{i=1}^{5} \beta_i \Delta X_{i,f,t} + \Delta\epsilon_{f,t} \quad \text{for } \forall\, t. \tag{4.6}$$

However, GMM method can also generate the biased result by excluding some important time-invariant variables. Therefore, we decide to use System GMM which uses both time differencing equation and level equation at the same time. Therefore, System GMM basically uses both equation (4.4) and (4.6). However, System GMM uses differenced variables as its instruments for level equation. To eliminate the endogeneity problem of the model, we use various variables in the model and use its lagged differencing and lagged variables as its IV.

(2) Regression results for an electric machinery industry

We do the case study first before we apply the System GMM into all the sample firms in manufacturing industry. This is because we need confidence in the research even if there are no endogeneity problems between the dependent and independent variables. We decide to choose the electric machinary industry for our case study to measure the impact of organizational innovations on the performance of firms since 1) electric machinery industry is one of the most representative industries for the JIT/QC implementation and 2) it has so many sample firms that it has a fewer variation than others.

On the other hand, we do not choose motor vehicle industry for our case study, even though motor vehicle industry is the most famous industry for the JIT/QC implementation. The major reason is that motor vehicle industry is dominated by the small number of Chaebols which means that the result would be largely affected by only the large number of small firms in the sector. Unfortunately, however, we cannot assure the productivity enhancement on small firms in car industry. This is because many articles already pointed out that small firms in motor industry have harder time than before since they are heavily depending on the small number of large firms and they have no choice whether to increase or decrease their inventory ratio. Therefore, the inventories that used to be in Chaebols go directly to small firms under Chaebols. So, we worry that many small firms under Chaebols might give us the wrong result.

To prove the hypothesis, we basically use the same model with simple regression model in (4.2.1) and include some important explanatory variables which are already explained in panel data analysis in (4.2.3).[17] We only consider the first lagged dependent variable (lnTFP(t-1)) and organizayional innovation (inventory to sales ratio (t-1)) as endogenuous and treat year dummy variables and innovation capability (R&D expenditure to sales ratio (t)) as exogenuous. Therefore, only (lnTFP(t-1)) and (inventory to sales ratio (t-1)) are estimated by GMM method and other explanatory variables such as learning by education or K/L is estimated by instrumental variables coming from the outside of the model. Export to sales ratio is used instead of education expenditure to sales ratio and the number of patents is used instead of K/L.

The regression result shows us that organizational innovation is still very important factor for the productivity enhancement. In this model, the technical part such as innovation capability and K/L is not that important factor for the productivity enhancement. It is an unexpected result because technical part is normally considered as more important factors for the productivity of a firm in electric machinery industry. However, the result clearly shows us that organizational part is more important factor for the firms in electric machinery industry. Therefore, they should make more effort on organizational innovation.

[17] We include and exclude variables except some important key variables such as organizational innovation and innovation capability which we should see the result. This is because most of variables in the model has endogeneity problem with its dependent variable so it is impossible to extract the endogeneity problem keeping with all the variables in the model.

Table 4-10. Regression results of electrical machinery industry

Variable	Level	system GMM
Past productivity level	Firm	0.27+
		(1.70)
Organizational innovation	**Firm**	**-2.57****
		(-3.39)
Innovation capability	Firm	0.54
		(1.35)
Efficiency wage	Firm	2.29**
		(3.46)
K/L	Firm	-0.00*
		(-2.26)
constant	Firm	0.98**
		(2.71)
Observation		8454
Sargan test statistics		40.94 (0.161)
Hansen test statistics		26.33 (0.788)

legend: + p<.1; * p<.05; ** p<.01

Notes (1): Productivity is measured by lnTFP and L.lnTFP means first lagged variable of lnTFP.
Organizational innovation is measured by the first lagged variable of inventory/sales.
Innovation capability is measured by R&D expenditure/sales.
Efficiency wage is measured by average salary of a firm/average salary of the sector-1.

Notes (2): Sargan test indicates that there is no endogeneity problem in the model, while Hansen test indicates that subsets of instruments which we use for the model are valid. Sargan test is not robust but not weakened by many instruments, but Hansen test is robust but can be weakened by many instruments. Since we have a good result from the both test, we do not need to worry about the instruments no matter what we used for the model.

Notes (3): We did not attach all the other variables since they are used as instrument variables for the model. These are year dummy variables, industry dummy variables, export to sales ratio and number of patents.

(3) Regression results for all firms in manufacturing industry

Based on the result from the electric machinery industry, we apply the same approach to all the firms in manufacturing industry. This time we include more dummy variables which are not explained by the model but make other variables exogenuous. We generate the interaction term between industry dummies and efficiency wage, and industry dummies and K/L. Then we treat the first lagged dependent variable, organizational innovation as endogenuous and R&D expenditure to sales ratio and the interaction term between industry dummies and K/L as exogenuous. We also introduce the export to sales ratio and education expenditure to sales ratio as instruments for the model.

The regression result shows us that both organizational part and technical part are two major important factors for enhancing the productivity level of a firm. However, efficiency wage is not applied the case of overall manufacturing industries when we get rid of the endogeneity problems. In other words, efficiency wage effect which indicates higher salary than other firms in the same industry might not be the cause of enhancing the productivity level but the result of high productivity of a firm.

To sum up, even though not many variables are important factors for enhancing the productivity level of a firm, organizational innovation is a very important factor for the productivity enhancement in overall manufacturing industry in Korea along with the technical innovations.

Table 4-11. Regression results of all sample firms in manufacturing industry

Variable	Level	system GMM
Past productivity level	Firm	0.65**
		(5.42)
Organizational innovation	**Firm**	**-1.64****
		(-2.63)
Innovation capability	Firm	2.48**
		(3.89)
Learning by education	Firm	46.83
		(0.78)
K/L	Firm	-0.00**
		(-3.25)
constant	Firm	0.98**
		(2.71)
Observation		8454
Sargan test statistics		56.95 (0.263)
Hansen test statistics		48.21 (0.585)

legend: + p<.1; * p<.05; ** p<.01

Notes (1): Productivity is measured by lnTFP and L.lnTFP means first lagged variable of lnTFP.

Organizational innovation is measured by the first lagged variable of inventory/sales.
Innovation capability is measured by R&D expenditure/sales.
Learning by education is measured by education expenditure /sales.

Notes (2): Sargan test indicates that there is no endogeneity problem in the model, while Hansen test indicates that subsets of instruments which we use for the model are valid. Sargan test is not robust but not weakened by many instruments, but Hansen test is robust but can be weakened by many instruments. Since we have a good result from the both test, we do not need to worry about the instruments no matter what we used for the model.

Notes (3): We did not attach all the other variables since they are used as instrument variables for the model. These are year dummy variables, industry dummy variables, export to sales ratio, number of patents, interaction term between industry dummy variables and efficiency wage, and interaction term between industry dummy variables and K/L.

5. Conclusions

5.1. Concluding remarks

To show that organizational innovation strongly enhances the productivity level of Korean manufacturing firms and sectors, we use the firm-level data analysis. We use three different levels of empirical methods. First, Pooled regressions, secondly, panel data with fixed effect and random effect variants and system GMM. Each one of these methods has its own merits and in particular system GMM takes account the endogeneity problem. We find consistently good result as expected according to our theoretical considerations as explained above in previous sections.

As the most important result we found that organizational innovation is consistently important factor for the productivity level along with the technical innovation. In section 4, we used several different econometric approaches and use other explanatory variables to find the true relationship between organizational innovation and the productivity level of a firm. Thus, we consistently have a robust result with other explanatory variables no matter what the model we use. Therefore, the impact of organizational innovation on firm performances definitely has strong relationship with its productivity level.

On the other hand, organizational innovation takes time to be reflected on its productivity level, while technical innovation is directly reflected on it. For this reason, we use the first lagged inventory to sales ratio as our proxy for organizational innovation. However, it is an interesting fact that we cannot prove the hypothesis with the present value of inventory to sales ratio. It indicates that organizational innovation is the major reason for enhancing the productivity. This is because organizational innovation takes time to be reflected and low inventory level does not directly enhance the productivity level of a firm.

Also, each firm has its unobserved common factors but they do not significantly change the results. In addition, the explanatory variables we use for the pooled OLS are already calculated as a form of controlling the size effect of the firms.[18] However, still it is hard to deny the fact that explanatory variables are very powerful factors as to explain the dependent variable, since the correlation between explanatory variables and productivity becomes stronger and more significant when we take account the unobserved common factors into the model. Therefore, firms would effectively enhance their productivity level when they take account their abilities and situations which are different with others.

On the other hand, different industry needs different types of approach to enhance the productivity level. This is based on our research that technical innovation is important factor for the overall manufacturing industry but not in electric machinery industry, which is represented as high-tech industry. Generally, it is easy to think that high-tech industry needs more technical innovations to improve the productivity level: it means technical innovation is more important factor for the productivity enhancement in high-tech industry. However, the result shows us that organizational innovation is much more important in high-tech industry. This is plausible result since every firm in high-tech industry try to have more technical technologies to improve their productivities, while very

[18] We use the real sales and number of employees to control the size effect of a firm and divide explanatory variables by either real sales or number of employees.

few of them might understand the importance of organizational innovation and try to have it.

In conclusion, we find many interesting points from the research. First we realize the importance of organizational innovations together with technical innovations: even though electric machinery industry did not give us very significant result on technical innovations, we can also check that technical innovation is a very important factor for the productivity for all firms and manufacturing industries. Furthermore, we recognize the important difference between organizational innovation and technical innovation: organizational innovation needs time to be reflected on its productivity level while technical innovation does not. Moreover, we find the reason we should consider the individual characteristics of firms and finally come to know that why different industries need different factors for enhancing the productivity level.

5.2 Discussion and Policy implication

The critical point of this analysis is that we should be careful about policy recommendations. For example, very probably organizational innovation is more required than technical innovation in high-tech industry[19]. However, this is not normally what we think of the high-tech industry. Brynjolfsson and Hitt (2000) insist that 'organizational complements such as new business process, new skills and new organizational and industry structures as a major driver of the contribution of information technology (IT).' Therefore, we should thoroughly think and decide the factors before we make the strategy for better business performance.

Also, organizational innovation should be treated differently since it is very different with technical innovation. Usually technical innovation improves the productivity level of a firm once it is implemented to a firm. On the other hand, organizational innovation might not be properly implemented or even lower the productivity level of a firm if the technology is not appropriate for a

[19] Examination of more industries will confirm this conclusion for electric machinery industry.

firm. Therefore, firms should find and search the characteristics of their organizations first and then decide whether they take the organizational technology or not. Furthermore, they should approach more carefully for this and try to be implemented by all people in a firm, not by just a few of them, and do not make a hasty conclusion with its impact on productivity level.

In addition, to keep the people employed in a firm is the most important thing in order to prevent the productivity loss of a firm. This is because the past productivity level is the most important factor of the present level of it. Technology cannot exist by itself. It means technology combines with its human capital and decends to the next period with its people. This effect even exceeds the overall productivity gain by education or other activities to improve the productivity.

In conclusion, organizational innovation is very different type of technology innovation comparing with the technical one but it also considerably contributes to the productivity growth of a firm. In other words, it significantly contributes to economic growth. However, the study for organizational innovation has been rarely done by very few economists because of it measuring problems but it should be studied because it is major factor of economic growth. Therefore, we should understand its importance in economic growth and try to develop and find things for the organizational innovation. From the research, we provide evidence that organizational innovation has been significantly improved the productivity of Korean manufacturing firms and sectors. Moreover, we realize that organizational innovation should be accompanied by the correct diagnostic of the firms and active support from the top and active response from the bottom. However, once organizational innovation achieved and implemented to the firms it would greatly enhance the productivity of firms continuously and consistently.

Appendix 4-1 Regression result with dummy variables

Variable	OLS	FE	RE

L.lnTFP	0.85**	0.58**	0.76**
(first lagged dependent variable)	-87.02	-33.98	-59.81
Organizational innovation	-0.31**	-0.56**	-0.47**
(inventory to sales ratio, firm level)	(-5.71)	(-7.07)	(-7.08)
Innovation capability	1.06*	3.01**	1.68**
(R&D expenditure to sales ratio)	-2.55	-5.41	-3.56
Efficiency wage	0.18**	0.59**	0.33**
(salarygap ratio)	-10.14	-18.36	-13.97
Learning by education	44.93*	76.21**	56.62**
(education expenditure for sales to sales ratio)	-2.5	-3.64	-2.83
K/L	-0.00**	-0.00**	-0.00**
(capital stock/num. employees)	(-10.84)	(-9.39)	(-10.97)
Industry 7	0.01	0	0.04
(food and kindred)	-0.49	(.)	-0.95
8	0	0	0.03
(textile and mill product)	-0.02	(.)	-0.62
9	0.02	0	0.05
(apparel)	-0.9	(.)	-1.04
10	-0.04	0	0.02
(lumber and wood)	(-1.17)	(.)	-0.37
11	0.02	0	0.03
(furniture and fixtures)	-0.91	(.)	-0.76
12	-0.05	0	-0.04
(paper and allied)	(-0.67)	(.)	(-0.29)
13	0.04*	0	0.08**
(chemicals)	-2.27	(.)	-2.8
14	0.01	0	0.01
(patroleum and coal products)	-0.34	(.)	-0.14
15	-0.07**	0	-0.07+
(leather)	(-2.79)	(.)	(-1.81)
16	0.06**	0	0.11**
(stone clay glass)	-2.62	(.)	-3
17	-0.07**	0	-0.09**
(primary metal)	(-3.96)	(.)	(-3.36)
18	0.02	0	0.07+

(fabricated metal)	-0.93	(.)	-1.91
19	-0.01	0	0.03
(machinary non-elect)	(-0.21)	(.)	-0.89
20	0	0	0
(electrical machinary)	(-0.22)	(.)	-0.1
21	-0.01	0	0.03
(motor vehicles)	(-0.47)	(.)	-0.8
22	0.02	0	0.04
(transportation equipment)	-0.35	(.)	-0.56
23	0.01	0	0.05
(instruments)	-0.19	(.)	-0.95
24	0	0	0.04
(rubber and misc plastics)	(-0.12)	(.)	-0.9
Year 1986	-0.04+	-0.03	-0.04+
	(-1.75)	(-1.33)	(-1.73)
1987	0	0	
	(.)	(.)	
1988	0.05*	0.06**	0.05*
	-2.14	-2.64	-2.45
1989	0.12**	0.15**	0.13**
	-5.08	-6.21	-5.69
1990	0.06**	0.12**	0.08**
	-2.64	-5.12	-3.75
1991	0.09**	0.17**	0.12**
	-4.13	-7.39	-5.63
1992	0.04*	0.15**	0.09**
	-1.99	-6.9	-4.14
1993	0.04*	0.15**	0.09**
	-2.13	-6.89	-4.29
1994	0.03	0.14**	0.07**
	-1.42	-6.5	-3.67
1995	0.01	0.12**	0.06**
	-0.43	-5.47	-2.63
1996	0.05**	0.16**	0.10**
	-2.67	-7.62	-5.09
1997	-0.06*	0.05*	-0.01
	(-2.56)	-1.97	(-0.50)
1998	-0.24**	-0.15**	-0.19**
	(-10.73)	(-6.56)	(-8.87)
1999	0.07**	0.08**	0.09**

	-3.11	-3.54	-3.96
2000	0.03	0.06*	0.05*
	-1.18	-2.39	-2.21
2001	0.02	0.05*	0.05*
	-0.87	-2.12	-2.04
2002	0.07**	0.12**	0.10**
	-3.2	-4.93	-4.5
2003	0.04+	0.12**	0.08**
	-1.84	-4.78	-3.61
2004	0.03	0.10**	0.07**
	-1.24	-3.64	-2.7
2005	0.06*	0.13**	0.10**
	-2.1	-4.76	-3.66
constant	0.32**	0.75**	0.46**
	-13.75	-25.4	-15.03
Observation	9125	9125	9125
Adjusted R-square	0.77	0.44	
Wooldridge test statistics	235.06 (0.00)		
Hausman test statistics		386.66 (0.00)	

legend: + p<.1; * p<.05; ** p<.01

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