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How SMEs or Larger Firms and Industries' Productivity Respond to Technology: A Panel Data Study

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Abstract

This paper is an important and necessary extension of the recent study by Lim and Sanidas (2011) where it was rigorously shown that both types of technology positively affect firms and industries in South Korea. How is this technological impact differentiated between SMEs and larger firms? The present paper answers this question and provides policy recommendations accordingly. Following the same methodology as in the just mentioned study, we put emphasis on the role of technological innovations which consist of two components: technical innovations (TIs) and organizational innovations (OIs). We use firm based data and the econometric method of Fixed Effects (FE) to measure the relationship between OIs, TIs and productivity. In these regressions we included some standard control variables such as wage efficiency, educational level, and capital to labor ratio to accommodate for other important influences. Some industries such as electrical machinery, motor vehicles, and non-electrical machinery have become more efficient in terms of OIs and TIs and thus improved productivity considerably. The results indicate that in general the size of firms is rather neutral to the influence of technology and all other factors on productivity. Thus, overall SMEs as well as large firms behave similarly in terms of the established relationships in this paper. However some significant differences which are detected in this study still exist.

JEL Classifications: C23, L23, O33

Keywords: organizational and technical innovations; technology; Just-in-time; panel data, SMEs

1. Introduction

We can further understand the well-established role of technology in economic growth and development by being more specific about the various types of technology that may play this role. Thus, in 1985, the United Nations Centre on Transnational Corporations (UNCTC) has defined technology as follows:

> *'Technology may be embodied in the form of capital goods, such as machinery, equipment and physical structures; or it may be disembodied in such forms as industrial property rights, unpatented know-how, management and organization (authors' emphasis) and design and operating instructions for production systems'* (UNCTC, 1985, p. 119).

Furthermore, Edquist et al (2001) have distinguished four types of technology: product innovations in goods, product innovations in services, technological process innovations[1], and organizational process innovations. According to Sanidas (2004a, 2005), technical innovations (TIs) are equivalent to UNCTC's embodied technology and to Edquist's et al (2001) product innovations in goods, technological process innovations, and some product innovations in services (for example TIs may include a new final or intermediate product, or machines and equipment used in the production process). On the other hand, organizational innovations (OIs) are equivalent to UNCTC's disembodied technology and to Edquist's et al (2001) organizational process innovations; for example we may include[2] a new way to link labor and capital used in the production process such as the *kanban* system in just-in-time (JIT) practices and total quality control (QC).

The aim of this paper is to use both TIs and OIs as a dual character of technology and show quantitatively that both types play an important role in Korean firms and sector economic performance (as measured by productivity) for both SMEs and LEs. This research has not been taken place so far and thus we intend to fill in this gap in the relevant literature. Lim and Sanidas (2011) have recently provided such evidence for South Korean sectors by including both SMEs and LEs together and not separately. However, their work cannot be fully appreciated unless we answer the following questions: do SMEs and LEs behave differently regarding the impact of technology both in terms of TIs and OIs? Or, for example due to the growing process of outsourcing, do SMEs use technology as efficiently as LEs in order to compete with LEs? In answering this two-faced question we can achieve two aims: first if SMEs behave similarly as LEs in terms of technology, and especially in terms of OIs, then we indirectly confirm that OIs (that is JIT/QC etc) are indeed taking place in the economic arena of South Korea (and of many countries in the world as the extensive literature shows). Second, we can confirm that the role of SMEs is inherently linked with that of LEs in terms of productivity growth and hence economic growth.

As Lim and Sanidas (2011) have extensively provided evidence of the importance of OIs (with an appropriate literature review) we simply redirect the reader to their article (see also Callen et al, 2000). However, we will summarize some of the most important issues in the next few paragraphs. Also these authors have reviewed the literature as to the appropriateness of the proxy for OIs, which is the ratio of inventories to sales (see also next couple of paragraphs). On the other hand, the proxy for TIs used in this study is the well-known research and development (R&D) expenditure to sales ratio; the importance of R&D (or patents sometimes) in representing TIs (or technology as it is usually termed) has been extensively demonstrated in numerous other papers; see for example Griliches (1986); Jung and Lee (2009); and so on.

[1] Usually, process innovations are not split into technological and organizational (Ha, 2007).

[2] Some of these organizational innovations, as per Sanidas (2005), are: craft, factory, mass, lean and other types of production systems; linear versus U-shaped machines layout, time and motion studies in scientific management, just-in-time and quality control processes, and so on.

Let us see in more detail the issue of OIs (for a comprehensive account of the importance of OIs in economic growth see Sanidas, 2004a, 2005, and 2006). In particular, the set of OIs grouped under the label of JIT/QC has been in the center of a substantial[3] amount of research papers that provide ample evidence of these OIs' importance in firm performance and growth. Note that JIT/QC is only a generic name for all types of organizational changes that may take place inside and between firms. So, the effect of any such change aiming at reducing inventories is sufficient for calling this system JIT/QC. Therefore, LPS (Lean Production System), JIT/QC, OEM (original equipment manufacturer), flexible manufacturing and outsourcing are all indicative of the system which we call in this paper the JIT/QC system. According to Sanidas (2005, p. 219),

> *"the LPS or JIT/QC is not just one factor, but is a holistic process that encompasses all areas of firm operations".*

JIT/QC enhances the productivity of firms and sectors by reducing waste, satisfying customers, lowering cost, and improving quality. Imai (1997) summarizes the benefits from JIT/QC implementation as follows: improving quality and productivity, reducing inventory, shortening the production line, reducing machine downtime, space, and lead-time. The consequence of lower inventories as sales increase is of particular interest to econometric work, because many researchers have correctly used the ratio of inventories to sales as a proxy to the JIT/QC systems. Thus, Lieberman and Demeester (1999) who evaluate the relationship between inventory reduction and productivity growth concluded that JIT/QC plays a considerably important role in reducing inventories and improving the productivity of a firm. Swamidass (2007) used inventory to sales ratio to see the effects of Toyota production system (TPS) on US manufacturing during 1981-1998. Other important references of scholars having used the inventory to sales ratio are Ramey and Vine (2004), Bairam (1996), Salem and Jacques (1996), Biggart and Gargeya (2002), and Sanidas (2004b, 2005).

The JIT process, a production system first implemented in Japan by Toyota, was introduced in Korea[4] at the end of 1980s by Hyundai automobile company and intensified after the Asian financial crisis of 1999. To overcome both exogenous and endogenous shocks in the 1980s and seize the opportunity of an emerging domestic market, Hyundai had to come up with a more flexible system and thus introduced JIT. Other Korean companies were in the same situation as Hyundai (e.g. Daewoo, the third largest automobile company then in Korea). So at the beginning the automobile industry adopted the new system JIT; the latter was quickly spread to and adapted by other industries such as electronics, ship-building, and heavy industries which are all characterized by assembly lines needing many components to complete a single product. For more details about the Korean experience see Kim et al (1997), Kim and Lim (2005), Lee and Lee (2003), Lim and Sanidas (2011), and Yoo (2001).

In the next section the data and variables used in this paper are presented as well as our empirical results and related analysis. Section 3 concludes.

[3] In 1990, for example, Inman and Mehra reported that over 700 papers on the topic of JIT were published in the 5-year period prior to 1990. Similarly for the period after 1990.
[4] Many other countries have similar patterns to South Korea in imitating Japan and introducing JIT/QC.

2. Data, variables, and econometric results

The main database used here is the one generated by Jung (2008) (and Jung and Lee, 2009).[5] This author has calculated all the components of TFP and other explanatory variables. The sample firms are all the listed and delisted firms in manufacturing industry during 1985-2005 as provided by KIS (Korea Information Service). The sample is large and contains data for more than 18000 firms.

Total factor productivity is in terms of logs, *lnTFP*, which is our dependent variable. According to standard approach we obtain TFP by considering a Cob-Douglas production function:

$$Y = AL^{\alpha_1}M^{\alpha_2}K^{\alpha_3} \tag{1}$$

Y is gross output, A is total factor productivity (TFP), L is labor input, K is capital input and M is materials input; $\alpha_1, \alpha_2, \alpha_3$ are shares of labor, capital, and materials respectively. According to constant returns to scale, we have $\alpha_1 + \alpha_2 + \alpha_3 = 1$. Then, we generate the following equation (2) from equation (1) by taking logs:

$$lnA = lnTFP = lnY - \alpha_1 lnL - \alpha_2 lnM - \alpha_3 lnK \tag{2}$$

Here, α_1, α_2 are determined in accordance with a firm's profit maximization behavior and α_3 is determined by α_1 and α_2:

$$\alpha_1 = \frac{P_L * L}{P * Y}, \alpha_2 = \frac{P_M * M}{P * Y}, \alpha_3 = 1 - \alpha_1 - \alpha_2 \tag{3}$$

P_L is the price of labor input, P_M is the price of materials input and P is the price of output, while L is the labor input, K is the capital input, M is the materials input and Y is the output.

One of our independent variables of major interest is organizational innovations[6] (OIs). Not all firms and not all industries or sectors have been experiencing a decline in this OIs proxy. A low inventory to sales ratio is independent of yearly economic or business conditions and hence it is mainly influenced by JIT/QC practices implementation since the trend is downward for a long period of time. This long term decrease in the inventories to sales ratio has been the focus of analysis in several papers as already indicated in the previous section, and it is due to the implementation of JIT/QC practices (see Lim and Sanidas, 2011 for further details). Consequently the impact of this proxy of inventories to sales ratio on TFP is expected to be negative.

The other variable of major interest in our study is technical innovations (TIs); here, we use R&D expenditure to sales ratio as a proxy for TIs since for patents (another possible proxy) there are many missing data; the impact of R&D on TFP is expected to be positive. Furthermore, K/L can also be another proxy to technical innovations in our research: as K/L increases (and as K is continually replaced by new K) there are many TIs embodied in K. Its impact on TFP is expected to be negative: as K over L increases, TFP decreases (hence there is less of the residual TFP).

The efficiency wage (or salary gap ratio) is a control variable, which implies that each firm has an incentive to offer high salary to their workers in order to increase

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[5] We would like to thank the author Jung for his assistance to provide to us the data he generated for his own studies.

[6] When we say OIs we mean the generic form of JIT/QC as explained above.

their productivity. Therefore, we refer to higher than average salary as efficiency wage and use as its proxy the salary gap ratio defined as follows: ($\frac{W_i - \overline{W}}{\overline{W}}$) which is the difference between the prevailing wage paid by firm i (W_i) and the average wage of the industry ($\overline{W}$), divided by $\overline{W}$. Its impact on TFP is expected to be positive. Finally, we use the control variable education expenditure for promoting sales to sales ratio as a proxy for training on the job, which is another step of 'learning by doing', and is part of the well-known importance of human capital. Its impact on TFP is expected to be positive.

The methods used here are those which are relevant to panel data and to addressing the endogeneity issue. To solve the endogeneity problem caused by the unobserved common factors, we can use the fixed effects (FE) model[7]. To solve the endogeneity problem caused by the two-way causation we can use GMM (system)[8]. In the present study we only present the FE model's results as the paper by Lim and Sanidas (2011) showed that both FE and GMM yield similar results for the same data as we use here[9]. The dependent variable is log of TFP[10]. Note that for the OIs proxy (inventories to sales ratio), there is a lag of one year for the effect of OIs to significantly affect productivity; this was determined empirically by using lags from zero to two years and the one year lag yielded the best results.

Before we examine in more detail the results pertinent to SMEs, let us briefly examine the results obtained for the whole sample (thus including SMEs and larger firms combined together) as shown in Lim and Sanidas's (2011) paper. Table 1 shows the significant (up to 10% level) coefficients with their correct sign for each industry and for total. Older sectors such as *textiles, wood, furniture, paper, petroleum, plastics, and fabricated metals* are not affected by any of the technology variables. On the contrary, there are some key sectors of the Korean economy which strongly and clearly suggest that all five explanatory variables significantly affect TFP of Korean firms. These sectors are *electrical machinery, non-electrical machinery, motor vehicles, primary metals and food*. The *chemicals* sector's TFP is more based on R&D (hence TIs) as expected.

In addition, in Lim and Sanidas's (2011) paper, we can see that since most of the variables are expressed in logs, the coefficients show elasticities. Thus, the elasticity of the inventories to sales ratio (OIs) is -8.1% (statistically significant) in the case of FE model and -9.7% in the case of the GMM model for the "total" category. This is in agreement with previous results like those of Lieberman and Demeester (1999) or Sanidas (2005) and in agreement with our expectations (the coefficient of OIs for each industry further confirms this elasticity). The R&D elasticity is positive and significant as expected. All the control variables have significant coefficients and the expected sign. Finally, the statistical tests showed that these results are significant and one can be confident that they represent realistic estimations.

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[7] The random effects model was also estimated and provided no better results than the FE model. The Hausman test usually supported the FE case.

[8] For a good treatment of these methods see Wooldridge (2002).

[9] Some preliminary GMM calculations confirm this conclusion.

[10] We also used labor productivity (LP) for robustness, which provided similar results to TFP (results not reported here).

Table 1. Summary of results for the whole sample

Industry	OIs	R&D	K/L	Efficiency wage	Training	Number of firms
Apparel	-		-	+		512
Chemicals		+	-	+		2348
Electrical machinery	-	+	-	+	+	3063
Fabricated metals			-	+	+	558
Food	-	+	-	+	+	987
Furniture			-	+		202
Instruments		+	-	+	+	326
Leather	-		(-)	+		166
Motor vehicles	-	+	-	+	+	965
Non-electrical machinery	-	+	-	+	+	1115
Paper			-	+		598
Petroleum			-	+		98
Plastics			-	+		410
Primary metals	-	+	-	+	+	1137
Printing	-			+		92
Stone and clay	-		-	+		577
Textiles				+	+	396
Transportation equipment	-	+	-	+		164
Wood						78
Total	-	+	-	+	+	13792

Note: if there is no positive or negative sign (of the coefficient of the corresponding variable), the coefficient is not significant (up to 10%). The indicated signs are as expected the correct ones.
Source: Lim and Sanidas (2011).

As an extension of these results as just summarized in Table 1, we now examine more precisely the SMEs sector and compare it whenever possible with the large enterprises (LEs) sector. Tables 2, 3, and 4 show some results (other regressions with similar results are not shown here) regarding the effect of size of firms in terms of employment on TFP. The main reason for conducting these regressions is to see whether overall SMEs or LEs are more inclined to be influenced by TIs or OIs and whether the results obtained for total as in Lim and Sanidas (2011) still hold once we differentiate between different firm sizes. A priori one would expect that both SMEs and LEs behave similarly, mainly because of the outsourcing effects which are prevalent in lean production systems, hence in JIT and QC production systems (see Introduction regarding some details of these systems and outsourcing[11]). When employment is used as the criterion for differentiating between SMEs and LEs the cut-off point is a matter of debate; some scholars have suggested 400, others 500, etc. In this paper we will adopt the cut-off point of 250 as suggested by the European Commission (see e-site in references). However, for robustness, in our study more cut-off points will also be used and shown here.

[11] As the production is “lean” more outsourcing is needed to produce a given good. A typical example is the car industry, where vehicles are assembled in the factory by using parts largely produced outside this factory. Consequently, the large firm assembles vehicles and smaller firms (mainly SMEs) provided various components or parts.

In Tables 2 and 3, we can see for the FE model that for all industries together, SMEs (employing less than 250 people; the number of observations is equal to 6361 and 787 firms) have an almost equal coefficient of the OIs variable as that of LEs, but a significantly larger coefficient of the R&D variable than LEs (employing more than 250 people; the number of observations is equal to 7362 and 611 firms), thus indicating that SMEs are more responsive to technological changes in terms of TIs than LEs but rather equally responsive in terms of OIs (due to outsourcing). When we examine each industry separately, SMEs have rather a similar performance as LEs in terms of the OIs but rather better in terms of TIs. However, all these results also depend on the number of firms (hence degrees of freedom) in each industry or type of competition (e.g. oligopoly) or product concentration; thus, the LEs category have only 37 firms in the non-electrical machinery industry whereas the SMEs category have many more (102 firms).

Continuing with our comparison, LEs have a rather larger coefficient of the lagged dependent variable TFP than SMEs (both in terms of total and in terms of each industry). This is an expected result as LEs have already an in-built mechanism which depends on their past performance much more than SMEs (most probably because LEs are usually older than most SMEs). Regarding the efficiency wage coefficient, SMEs are more sensitive (larger coefficient) to wage differentials than LEs both in terms of total and individual industries. For human capital, both categories of SMEs and LEs have similar coefficients in terms of total but differentiated in terms of industries. The coefficient of the KL ratio is also equal in significance for LEs and SMEs, although differences exist on an industry basis. Overall, both SMEs and LEs have some common points but also are different in some respects.

Other cut-off points for SMEs do not change these conclusions significantly. Thus, as we can see in Table 4, if the cut-off point is 400, the coefficients of all variables have values that agree with our conclusions so far; for example there is a stronger effect TIs exerted on SMEs than on LEs, and so on. In addition, if we split the original category of LEs (more than 250 employment) into three more sub categories (first more than 250 and less than 425; second more than 425 and less than 1000; and third more than 1000[12]), we obtain some interesting differences within this LEs category. Thus, as we examine the results from one subcategory to the other in terms of increasing bracket of employment, we observe increasing values of the coefficients for the variables of lagged TFP, the proxy of OIs, and the efficiency wage; whereas for the other coefficients this observation does not hold. All this indicates that it is sometimes difficult to categorize firms in terms of employment only; other criteria are needed as well. In Table 4, we also have included results for two industries and for three different sub-categories of employment bracket for further comparison; the already reached conclusions do not significantly change.

[12] For each one of these 3 categories the number of observations is about 2500.

Table 2. Fixed effects (FE) model for dependent variable lnTFP (employment<250)

Explanatory Variables	Industry																		
	Total	**Food and kindred products**	**Textile mill products**	**Apparel**	**Lumber and Wood**	**Furniture and fixtures**	**Paper and allied**	**Printing publishing and allied**	**Chemicals**	**Petroleum and coal products**	**Leather**	**Stone clay products**	**Primary metals**	**Fabricated metals**	**Non-electrical machinery**	**Electrical machinery**	**Motor vehicles**	**Transportation equipment and ordnance**	**Instruments**	**Rubber and Miscellaneous Plastics**
TFP	0.28	0.38	0.06	1.03	0.12	0.56	0.57	-0.10	0.38	0.51	0.53	0.46	0.58	0.38	0.12	0.20	0.25	-0.36	0.35	0.27
(lag 1 year)	8.37	7.02	0.88	3.52	0.00	3.37	7.20	-0.89	9.17	8.51	3.22	10.71	8.88	4.26	3.06	3.42	1.87	-1.08	8.99	4.33
Inventories to sales	-0.08	0.02	0.52	-0.11	-0.09	0.01	0.06	-0.30	0.13	-0.20	-0.24	-0.02	-0.08	0.02	-0.04	-0.25	0.12	0.15	0.04	-0.06
ratio (lag 1 year)	-3.85	0.29	1.78	-1.07	0.00	0.05	0.90	-2.64	2.69	-2.16	-1.92	-0.64	-2.77	0.50	-1.16	-6.28	1.74	2.01	0.68	-0.47
R&D expenditure	3.82	13.56	-7.38	-5.63	154.78	-13.37	4.09	0.33	2.48	-109.03	6.60	9.14	11.13	-1.50	5.44	3.02	7.76	59.68	2.12	1.87
to sales ratio	4.88	4.45	-0.80	-0.27	0.00	-1.66	0.95	0.39	2.16	-4.49	0.66	1.64	4.02	-0.86	5.09	2.51	1.89	12.78	1.58	0.40
Efficiency wage	0.80	0.78	1.00	0.53	0.80	0.98	0.65	1.05	1.14	0.64	0.06	0.93	0.23	0.79	1.20	0.45	1.38	2.34	1.17	1.54
(salary gap)	12.03	3.04	2.48	2.12	0.00	2.65	2.59	3.01	7.52	1.00	0.15	4.11	3.20	3.77	7.44	2.88	4.95	14.65	3.63	3.00
Education	30.04	84.12	22.47	-543.16	0.00	74.34	-14.29	-65.96	-7.60	78.45	308.47	121.05	53.69	22.18	92.21	101.59	82.74	-624.07	15.98	22.63
to sales ratio	1.69	2.89	0.04	-2.13	0.00	1.91	-1.15	-1.33	-0.31	1.66	1.03	0.89	0.95	0.84	2.23	1.87	2.74	-5.76	0.76	1.29
Capital	-0.12	-0.11	0.16	0.04	-0.10	-0.16	-0.14	-0.31	-0.09	-0.24	0.06	-0.29	-0.07	-0.21	-0.22	-0.08	-0.20	0.24	-0.09	-0.30
to labor ratio (K/L)	-5.82	-2.73	1.62	0.42	0.00	-5.12	-1.99	-5.04	-2.53	-1.95	0.34	-3.57	-2.69	-3.25	-3.31	-1.61	-2.53	1.04	-1.45	-1.71
Constant	2.36	2.06	0.59	-0.50	2.23	2.63	2.50	4.24	2.69	2.90	-0.53	4.21	1.02	3.58	4.05	1.66	4.09	0.96	2.57	4.65
	9.76	4.33	0.50	-0.34	0.00	6.99	2.49	6.49	6.13	1.72	-0.34	4.76	3.06	4.39	5.11	3.24	3.81	0.57	3.55	2.30
Observations	6361	356	122	159	15	82	278	84	883	58	90	177	574	355	739	1693	257	18	245	176
No of Firms	787	29	14	23	1	9	23	15	97	3	8	20	47	35	102	267	35	3	32	24
R-sq within	0.17	0.22	0.19	0.63	0.67	0.63	0.43	0.34	0.37	0.87	0.35	0.61	0.45	0.40	0.21	0.13	0.37	0.83	0.35	0.29
R-sq between	0.47	0.39	0.37	0.84	.	0.88	0.37	0.32	0.61	0.97	0.12	0.74	0.94	0.14	0.17	0.34	0.26	0.44	0.68	0.43

Notes :

(1) TFP stands for total factor productivity; organizational innovations (OIs) are measured by the inventories to sales ratio with 1 year lag ; technical innovations (TIs) are measured by the R&D expenditure to sales and K to L ratios; efficiency wage is measured by the salary gap ratio (see text on "Data and Variables" section for precise formula); learning by education is measured by the education expenditure to sales ratio.

(2) All variables are used in log terms; for the variables 'salary gap', 'R&D to sales ratio' and 'education to sales ratio' we added the number 1 so that log can be defined since sometimes the original number was zero (as per usual practice).

(3) The numbers under the coefficients are t-statistics; given that our samples are not small, a t-statistic of about 1.67 and less than 2.00 indicates statistical significance at 10%; of about 2.00 and less than 2.66 indicates statistical significance at 5%; of more than 2.66 indicates statistical significance at 1%.

(4) For the second column, 'total' refers to all firms together.

(5) In all cases, robust estimations of the variance covariance matrix were estimated. Also, each year is used as a dummy to account for yearly fluctuations, but coefficients are not shown here.

Table 3. Fixed effects (FE) model for dependent variable lnTFP (employment>250)

Explanatory Variables	Industry																			
	Total	**Food and kindred products**	**Textile mill products**	**Apparel**	**Lumber and Wood**	**Furniture and fixtures**	**Paper and allied**	**Printing publishing and allied**	**Chemicals**	**Petroleum and coal products**	**Leather**	**Stone clay products**	**Primary metals**	**Fabricated metals**	**Non-electrical machinery**	**Electrical machinery**	**Motor vehicles**	**Transportation equipment and ordnance**	**Instruments**	**Rubber and Miscellaneous Plastics**
TFP (lag 1 year)	0.59	0.57	0.62	0.55	0.52	0.56	0.48	0.00	0.54	0.77	0.73	0.53	0.55	0.56	0.37	0.58	0.57	0.70	0.69	0.52
	22.18	8.97	9.94	6.63	28.36	4.95	4.68	0.00	8.15	13.44	10.61	8.13	7.40	5.91	6.42	10.02	12.45	25.11	4.39	4.91
Inventories to sales ratio (lag 1 year)	-0.07	0.04	-0.17	0.04	0.13	0.09	-0.10	0.00	0.10	-0.16	0.15	-0.32	-0.13	0.08	0.11	-0.21	-0.02	-0.09	-0.19	-0.07
	-3.63	0.97	-3.61	0.82	2.02	1.36	-1.55	0.00	2.49	-4.06	2.88	-3.63	-5.61	1.08	4.02	-6.28	-0.54	-1.51	-1.19	-1.32
R&D expenditure to sales ratio	1.23	8.87	8.92	6.92	-7.63	-1.74	-2.31	0.00	2.05	17.52	-10.67	17.18	3.92	-2.78	1.81	1.55	0.83	7.00	3.68	1.91
	2.43	1.32	2.04	0.99	-0.11	-0.18	-0.18	0.00	2.52	8.93	-0.52	2.96	0.85	-0.61	1.32	1.73	1.26	1.40	1.59	0.81
Efficiency wage (salary gap)	0.68	0.98	0.26	0.31	0.48	1.02	0.67	0.00	0.85	0.21	0.82	1.52	0.41	0.95	0.65	0.63	0.69	1.18	0.12	0.76
	13.22	5.55	1.77	1.92	2.04	3.18	2.71	0.00	7.47	6.64	4.34	4.29	6.12	4.76	4.84	5.56	5.75	2.85	0.26	2.00
Education to sales ratio	30.37	68.86	55.97	75.02	143.97	15.39	64.66	0.00	18.55	25.08	133.57	43.73	168.17	-16.37	27.77	24.33	92.35	103.65	284.19	82.68
	5.21	3.57	4.79	2.46	2.37	0.15	2.11	0.00	3.10	1.59	0.24	1.63	3.05	-0.55	1.36	1.49	3.27	2.31	2.46	2.38
Capital to labor ratio (K/L)	-0.11	-0.11	-0.03	-0.05	-0.07	-0.23	-0.05	0.00	-0.17	-0.23	-0.12	-0.15	-0.13	-0.22	-0.21	-0.13	-0.18	-0.14	-0.17	-0.03
	-10.39	-3.38	-0.94	-1.54	-8.16	-2.17	-1.55	0.00	-6.42	-8.39	-4.19	-3.36	-9.06	-3.58	-3.61	-3.27	-6.71	-1.92	-1.02	-0.81
Constant	1.79	2.14	0.69	1.37	1.90	3.46	1.08	0.00	2.98	2.77	2.11	1.96	1.74	3.61	3.76	1.69	2.73	1.83	1.62	1.05
	12.54	4.78	1.94	3.28	13.30	2.84	1.99	0.00	7.89	9.39	9.33	3.12	8.87	4.02	5.06	4.57	8.48	2.05	0.77	2.07
Observations	7362	630	273	352	63	118	316		1448	40	76	395	561	195	367	1360	702	146	81	233
No of Firms	611	42	18	27	4	11	21		106	2	5	28	37	24	37	154	55	10	10	18
R-sq within	0.46	0.48	0.50	0.38	0.43	0.58	0.42		0.50	0.91	0.76	0.66	0.62	0.52	0.40	0.37	0.51	0.60	0.51	0.40
R-sq between	0.83	0.52	0.90	0.96	0.72	0.83	0.80		0.87	1.00	0.87	0.36	0.92	0.83	0.74	0.72	0.70	0.78	0.91	0.73

Note: see Table 2 for further explanations

Table 4. Fixed effects (FE) model for dependent variable TFP (other categories)

Explanatory	Various employment cut-off points							
Variables	1] >250 and <425	2] >425 and <1000	3] >1000	4] >425 and <1000 and for icpacode=20	5] >1000 and for icpacode=17	6] >250 and <425 and for icpacode=20	7] <400	8] >400
TFP	0.48	0.50	0.61	0.62	0.54	0.52	0.33	0.60
(lag 1 year)	13.22	13.01	10.92	10.16	3.91	7.43	11.73	15.94
Inventories	-0.04	-0.05	-0.13	-0.16	-0.13	-0.18	-0.07	-0.09
(lag 1 year)	-1.18	-2.31	-3.47	-2.90	-2.67	-3.08	-3.71	-3.77
R&D expenditure	1.84	2.30	0.36	2.50	4.62	1.91	3.63	1.37
to sales ratio	1.80	2.73	0.62	1.86	1.19	1.11	4.79	2.12
Efficiency wage	0.96	0.74	0.64	0.68	0.50	0.92	0.79	0.62
(salary gap)	9.80	10.05	6.75	5.43	3.58	3.92	13.85	10.14
Education	29.57	17.67	51.54	45.23	196.90	44.28	32.95	30.86
to sales ratio	2.97	2.31	4.22	2.03	3.01	1.18	2.86	3.87
Capital	-0.13	-0.07	-0.10	-0.10	-0.12	-0.10	-0.12	-0.10
to labor ratio (K/L)	-6.12	-4.55	-6.32	-2.21	-6.33	-1.68	-7.35	-8.98
Constant	2.33	1.59	1.48	1.48	1.69	1.58	2.31	1.61
	8.27	8.17	7.20	3.67	5.30	2.39	12.00	10.58
Observations	2487	2491	2371	508	226	543	8656	5114
No of Firms	428	323	197	88	16	132	884	413
R-sq within	0.39	0.40	0.45	0.49	0.56	0.40	0.21	0.48
R-sq between	0.63	0.71	0.83	0.75	0.92	0.46	0.61	0.80

Note: see Table 2 for further explanations; icpa codes 17 and 20 are primary metals and electrical machinery industries respectively.

Table 5 summarizes the comparison between SMEs and LEs. In general, there are many similarities in terms of industries which are more technology oriented (either OIs or TIs) between SMEs and LEs; also in terms of the size of coefficients; and in terms of overall efficiency or inefficiency (e,g. for printing or instruments). However, one should be careful about a rigorous comparison between SMEs and LEs for some industries because of limited degrees of freedom. Hence for all the industries together, or for the industries for which we have enough data, the conclusions are relatively safe.

Table 5. Summary of differences between SMEs and Les

Industry	OIs SMEs	R&D SMEs	K/L SMEs	Eff/cy wage SMEs	Sales Train/g SMEs	OIs LEs	R&D LEs	K/L LEs	Eff/cy wage LEs	Sales Train/g LEs
Apparel				0.53					0.31	75
Chemicals		2.5	-0.09	1.1			2.1	-0.17	0.85	18.6
Electrical machinery		5.4	-0.22	1.2	92.2	-0.21	1.6	-0.13	0.63	
Fabricated metals			-0.21	0.79				-0.22	0.95	
Food		13.6	-0.11	0.78	84.1			-0.11	0.98	68.9
Furniture			-0.16	0.98	74.3			-0.23	1.0	
Instruments				1.2						284.2
Leather	-0.24							-0.12	0.82	
Motor vehicles		7.8	-0.20	1.4	82.7			-0.18	0.69	92.4
Non-electrical machinery	-0.25	3.0	-0.08	0.45	101.6			-0.21	0.65	
Paper			-0.14	0.65					0.67	64.7
Petroleum	-0.2		-0.24		78.5	-0.16	17.5	-0.23	0.21	
Plastics			-0.30	1.5					0.76	82.7
Primary metals	-0.08	11.1	-0.07	0.23		-0.13		-0.13	0.41	168.2
Printing	-0.3		-0.31	1.1						
Stone and clay		9.1	-0.29	0.93		-0.32	17.2	-0.15	1.5	43.7
Textiles				1.0	22.5	-0.17	8.9		0.26	56
Transport/ion equipment		59.7		2.3				-0.14	1.2	103.7
Wood								-0.07	0.48	144
Total	-0.08	3.8	-0.12	0.8	30	-0.07	1.2	-0.11	0.68	30.4

Source: From Tables 2, and 3. Note: only the significant (up to 10%) coefficients are recorded in this Table. For more details see Tables 2 and 3.

6. Conclusion

In this study we show for SMEs separately and LEs separately, for the first time in the literature in a systematic way, that technology has a considerable impact on fluctuations of total factor productivity (TFP) for Korean manufacturing industries. Thus, we provide evidence that firm reorganization through organizational innovations (OIs) and technology (or technical innovations-TIs) significantly improve the productivity of manufacturing firms and sectors in Korea. Here, we especially focus on JIT/QC as a major reorganizational effort and show how this system increases the productivity of Korean manufacturing firms and sectors. Both OIs and TIs have a positive impact on productivity; this simultaneous influence has not been shown before in the literature. We use the well-established inventory to sales ratio as a proxy for JIT/QC, whereas we use the proxy of R&D to sales ratio to represent TIs. In addition the factors capital to labor ratio (K/L), efficiency wage, and sales education are used as control variables and have a considerable impact on total factor productivity (TFP).

Both types of technology, OIs and TIs have a significant impact on various categories of firms according to employment bracket, such as SMEs and LEs. When we analyze the data as per industry, we can see that at least the major moving forces of the Korean economy (e.g. non electrical machinery, electrical machinery, and motor vehicles) are positively affected by both types of technology. However, some sectors (e.g. chemicals) are positively affected by only technical (hardware) innovations (plus the control variables), or only by the OIs (e.g. primary metals for LEs).

The similarities and differences between SMEs and LEs are important to know for both industrialists and the government (see again Table 5 for details). Thus, industrialists should improve on OIs and/or TIs depending on which industry they belong to. The government should encourage through dissemination of appropriate knowledge the industries which are left behind in terms of TIs or OIs, especially in the SMEs sector, as there is an ongoing research recently which suggests that SMEs are not sufficiently developed in this country. However, our paper is more related to the degree of technological efficiency of existing firms and industries than to the possibilities of more growth in the number of SMEs, although these two issues are closely interdependent. Finally note that this study based on Korean micro data can easily be applied to any country which has similar databases.

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