Innovation Heterogeneity and Firm Growth in the Korean Service Industry

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Abtract

This paper is to examine the impact of innovation on firm performance in the Korean service sectors, focusing on the impacts by innovation type (product and process innovation) and moreover, tries to look for the reason of heterogeneity in terms of innovation type among service industries. Using the data of「Korean Innovation Survey 2003: Service Sector」, which were carried out by Science and Technology Policy Institute (STEPI) and Korea Information Strategy Development (KISDI) in 2003, the empirical tests have major findings as follows. First, contrary to the recent firm level studies failing to confirm the significant impact of innovation, innovative firms show significantly better performance than non-innovating firms with respect to the growth in sales, employment and labor productivity for most of service industries except motion picture and broadcasting. Second, unlike the recent manufacturing studies, production innovation turns out to have more significant impact on performance than process innovation by and large when all service sectors are considered into the model estimation. Third, the observed innovation heterogeneity by service sector is consistent with performance impact by innovation type with an exception of finance service sector.

Key Words: product innovation, process innovation, service industry, productivity

JEL Classifications: L6

1. Introduction

Technological innovation is regarded as core value in knowledge-based economy. A variety of questions have been raised in relation to technological innovation and many of them have been answered by researchers of innovation studies. Of the questions, the most important topic might be the impact of innovation on firms' performance since firms do not need to carry out innovation unless it leads to better performance. Studies on the relation between innovation and performance have been undertaken actively for the manufacturing industry (Crepon et al., 1998; Loof and Heshmati, 2006; Heshmati et al., 2006; Heshmati, 2006). However, they have limitation in that they do not take into account innovation process in analyzing performance. For instance, product innovation and process innovation might produce differences in firms' performance. This paper, therefore, starts at the point that different innovation type might have different impact on performance.

Traditionally, innovation studies have investigated the manufacturing industry. The research on the relation between innovation type and performance is not the exception[1]. Recently, however, as the importance of the service industry is rapidly growing[2] in many countries, innovation studies for the service industry tend to increase. Furthermore, conducting research on service innovation has become easier thanks to the release of reliable survey results such as CIS (Community Innovation Surveys) or Korean Innovation Survey. Even though many studies on the service innovation explore the characteristics of service innovation[3] (Howells, 2000; Evangelista, 2006; Drejer, 2004; Tether, 2005; de Jong et al., 2003), heterogeneity among sectors (Tether, 2003; Hipp and Grupp, 2005), and determinants of innovation (Tether,

[1] Some studies compare the impact of product innovation and process innovation on performance (Yamin et al., 1997; Hwang, 1999; Parisi et al., 2006; Lee et al., 2007). Most of them find that process innovation has larger impact.

[2] In 2003, the service industry accounted for 63.6 percent and 57.2 percent of employment and GDP, respectively, in Korea.

[3] Many studies on the service innovation focus on the differences between innovation in the manufacturing industry and innovation in the service industry. High degree of heterogeneity, close interaction between production and consumption, and key role of human resources are more dominant in the service industry.

2003; OECD, 2005; Kam and Singh, 1997), there are some studies which investigate the relation between innovation and performance.

Cainelli et al. (2004) and van der Wiel (2001) find that the productivity (growth) of innovative firms is higher than that of non-innovative firms for the Italian service industry and the Dutch business service industry, respectively, through descriptive analysis for firm-level data. van Ark et al. (2003), however, show that the impact of innovation on productivity is not clear, analyzing the Dutch service industry. Mansury and Love (2007) is the latest study on the innovation and performance for the service industry. They examine the impact of innovation on the performance of 206 US business service firms through econometric analysis and find that service innovation has positive effect on sales growth but no effect on productivity.

As to research on the linkage between innovation type and performance in the service industry, there are only a few studies and they report different results. Hipp et al. (2000) examine the survey results for 2,900 German service firms in 1995. According to the survey, 59 percent of the firms declared that their sales had increased in the innovation period and 62 percent replied that the expected sales would increase after the innovation. One third of the innovating firms claimed that improvements to their own productivity had been a “very important” effect of their innovation. As to innovation type, the proportion of firms claiming important process-innovation-type effects for the innovation was high, above 70 percent. The results also suggest that innovation in services is more effective when several types of innovation are introduced rather than only one type of innovation is adopted. Prajogo (2006) analyzes the survey results for 194 Australian firms (both manufacturing and service industry) and finds that product innovation has significant correlation with sales and profitability, whereas process innovation in the service industry does not have relevance to business performance such as sales, market share and profitability.

The impact of innovation on employment does not seem clear. Klomp and Leeuwen (2000) find a significant positive effect of innovation on turnover growth but the relation does not apply to employment growth for the Dutch manufacturing industry. Evangelista and Savona (2002) examine the employment

impact of innovation in services using the 1993-95 Italian innovation survey. The empirical evidence shows that the impact of innovation on employment is different by sector and by the level of qualification of labor force. The employment impact of innovation is positive for sectors that have a strong scientific and technological base. For capital-intensive sectors and all financial-related sectors, however, the relation is negative. For the service industry overall, innovation has negative impact on employment.

The above studies, however, have limitations as they employ too simple method such as descriptive analysis or correlation test. For Prajogo(2006), the sample size might matter. The sample for the service industry is only 92 firms. Klomp and Leeuwen (2000) and Evangelista and Savona (2002) do not separate the innovation impact by innovation type even though different innovation type can produce different effect. Hence, this paper attempts to examine the impact of innovation on performance by innovation type through econometric analysis. In particular, we attempt to answer the following four research questions.

First question is whether innovative firms in the service industry show better performance (sales, productivity, and employment) or not. Increasing number of research has examined the nature, types, and causes of innovation in services in the last decade but there is much less research on the impact of service innovation on business performance. Second question is whether different innovation type has different effect on performance. For example, do both product and process innovation tend to increase firms' productivity? Each innovation type plays a different role and it can lead to different effect on firms' performance. However, previous studies on innovation in services do not raise this question. Third question is whether there exist differences between the manufacturing industry and service industry in relation to innovation and performance. The research on the manufacturing industry usually finds that process innovation has better performance. Does it apply to the service industry as well? Considering peculiarities of innovation in services, we hypothesize that in the service industry product innovation shows better performance, while in the manufacturing industry process innovation has better performance. The last question is whether there is strong innovation heterogeneity within the service industry in the relation

between innovation and performance. Most of the previous literature on service innovation finds strong heterogeneity among service sectors with respect to innovation pattern. Previous research on service innovation and performance, however, fail to consider the sectoral differences. Based on the finding, we hypothesize that the effect of each innovation type on performance varies sector by sector.

The rest of this paper is organized as follows. Chapter Two views innovation type and performance from a theoretical perspective. The results of descriptive and empirical analysis are presented in chapter Three and Four. Chapter Five concludes this paper.

2. Innovation Type and Performance: Theoretical Aspect

Of various ways to categorize innovation, dividing innovation into product innovation and process innovation is the most prominent. It is based on the OECD Oslo Manual for CIS (community innovation survey). CIS has been conducted in many regions, in particular in Europe since mid 1990s. In Korea, nationwide survey for the manufacturing industry and the service industry was carried out in 2002 and 2003, respectively, by STEPI (Science & Technology Policy Institute). As to categorization of innovation type and the definition of each type, this paper follows those of the above survey.

The definition of each innovation is as follows. Product innovation indicates to develop, produce and release technologically new product to a market. Process innovation is to adopt technologically new or improved production process, equipment, and product delivery method in order to reduce production cost or to improve productivity and quality of product. For instance, providing new insurance service can be one example of product innovation and introducing new software or networking system can be process innovation in the insurance industry (KISDI and STEPI, 2003). In general, product innovation tends to be relatively radical and process innovation tends to be incremental.

Then, do the two types generate differences in the effects on performance? For the manufacturing industry, there are some studies on this question. Lee et al. (2007) find that process innovation has stronger impact on

performance for the Korean manufacturing industry. According to the research, radical innovation, or product innovation generally involves great amount of knowledge, development cost, and risk but when the innovation is successful, it is expected to bring improvement in technology, productivity and business performance to a large extent. For incremental innovation, the impact is rather smaller than radical innovation but it requires relatively less amount of knowledge, development cost, and risk and the probability of success is high. In addition, incremental innovation might not cause conflicts with existing technology and an inner organization. Hence, incremental innovation, which is usually process innovation, is more likely to result in productivity improvement (ibid).

Second, product-related innovation generally aims to expand markets or develop new market and ultimately seeks larger price-cost margin. The purpose of process innovation, however, is to improve productivity in a direct way by reducing production cost and defective rate (Llorca, 2002). Accordingly, it is expected that process innovation is more likely to lead to productivity improvement than product innovation in the short run (Lee et al., 2007).

Our major concern is whether the finding from the manufacturing industry applies to the service industry as well. In other words, does process innovation show better performance than product innovation in the service industry? Most of the literature on innovation in services highlights the peculiarities of the service industry in innovation[4]. For example, there exists close interaction between production and consumption in the service innovation. In addition, innovation in services is characterized by high information content and intangibleness of the output. Due to the features, researchers tend to focus on information technologies in analyzing innovation in services. The significant role of organizational factors in firms' performance is also often mentioned as peculiarity of service innovation. Lastly, heterogeneity within the service industry is known to be high.

[4] For the peculiarities of innovation in services, see Sirilli and Evangelista (1998) and Hipp et al. (2000).

If innovation in services has unique characteristics compared to the manufacturing industry, the relative importance of innovation types on performance might be different between the manufacturing industry and the service industry. Of the above features of innovation in services, close interaction between production and consumption seems to provide clue that product innovation might have larger impact on performance than process innovation in the service industry, while in the manufacturing industry process innovation has better performance. Second, high degree of heterogeneity within the service industry might produce differences in the relation between innovation type and firms' performance. One innovation type can have relatively higher importance for one sector but little importance for another sector since different sector might have different innovation pattern. For instance, product innovation might have significance for wholesale trade services but it might not be important for transport services.

Of firms' performance, employment shows somewhat fuzzy relation to innovation, whereas sales growth and productivity growth effect is generally shown in many empirical studies. On the one hand, innovation activities can increase employment when innovation leads to higher sales. On the other hand, innovation might decrease employment when it is possible to produce with less number of employees, in particular through process innovation. If product innovation is more significant for the service industry, innovation activities might increase employment through sales increase.

3. Descriptive Analysis

We use the data of「Korean Innovation Survey 2003: Service Sector」, which were surveyed by Science and Technology Policy Institute (STEPI) and Korea Information Strategy Development (KISDI) in 2003, following the guidelines of the Oslo manual. The number of responding service firms is 2,000, which is around 10.2 percent out of the total number of establishments (19,603), which is based on「2001 Census on Basic Characteristics of Establishments」by Korea National Statistical Office. In order to see the sectoral differences, we divide the sub sectors of the service industry into six groups applying two-digit standard

industrial code (Table 1); wholesale trade (Code 51), transport (Code 60,61,62,63), telecommunications (Code 64), financial services (Code 65,66,67), knowledge-intensive business service (Code 72,73,74) and motion picture & broadcasting (Code 87). The sample size is 1,977 firms excluding electricity supply (Code 40).

Table 2 presents the ratio of innovative firms for each type of innovation. As to absolute ratio, product innovation is more dominant for all the sectors. The result also shows that technological innovation has significance, in particular for financial services and knowledge-intensive business services. In order to see relative importance of each innovation type, we compute relative ratio. According to the result, product innovation is relatively more important in wholesale trade, financial services and KIBS and process innovation has more importance in transport, telecommunications and motion picture & broadcasting sectors. This result might have relevance to the differences between innovation type and its impact on performance.

As a variable for firms' performance, three indicators – sales growth, labor productivity growth, and employment growth – are used. Labor productivity is computed by dividing sales into number of employees. The growth rate is calculated using the data of 2000 and 2002.[5]

Table 3 presents average growth rate of the three performance indictors for the service industry overall. It shows that innovative firms that conduct either product innovation or process innovation achieved better performance. Then, we compute the rate in terms of innovation type. The results show that for the service industry overall product innovation has better performance for all the three indicators supporting our hypothesis. The results, however, vary by sector (Table 4, 5, 6). As to sales growth, in financial services and transport services, process innovation has better performance. For wholesale trade and telecommunication services, product innovation shows better performance. As to employment growth, financial services and transport services show opposite results each other. Employment growth rate increased for process

[5] De Vany and Walls (2004) argue that outliers should not be excluded in estimation when some observations in dataset show extremely high performance. Their argument is based on box office revenues of movies but the data of service innovation also shows similar characteristic without following normal distribution.

innovative firms in transport services but the figure decreased in financial services. The average employment growth rate in financial services sector is -3 percent per year for the firms that carried out process innovation, which seems to be associated with active labor-saving process innovation activities in this sector. As the result, labor productivity growth increased in financial services sector. For telecommunication sector, both sales growth and employment growth increased but sales growth effect was so large that labor productivity also increased for product innovative firms. For KIBS sector, both product and process innovation have strong impact on all the three performance indicators.

To sum up, our hypotheses that innovative firms achieve better performance and unlike manufacturing industry, for the service industry product innovation has larger impact on performance are supported through the descriptive analysis. This analysis, however, does not control other firm and industrial characteristics that can affect firms' performance. Hence, it is required to conduct additional empirical analysis controlling for the other factors than innovation variables.

4. Empirical Analysis

4.1. The Model

In this section, we present the models to be estimated. Basically, since this paper attempts to shed empirical light on the relationship between service innovation and firm performance, the dependent variable in the model is a firm performance variable. Three indicators used here for performance are sales growth, growth in the number of employees and the growth of labor productivity (sales per employee as a proxy variable) over the period, 2000-2002. The equation (1) is a basic model for analyzing firm performance determinants.

$$\Delta \log(perf)_i = \alpha + \beta \cdot Inno + \mathrm{X}'_{t-1}\gamma + \vartheta \log(perf)_{i,t-1} + \lambda \cdot Ind + \varepsilon_i \qquad (1)$$

where $(perf)_i$ stands for firm performance (sales, employment and labor productivity) and $\Delta \log(perf)_i = \log(perf)_{i,t} - \log(perf)_{i,t-1}$ is performance growth of a representative service firm. *Inno*

denotes a set of innovation dummies representing innovation types and X'_{t-1} is the vector of measurable firm characteristics in the previous period. Firm characteristics used here in the paper are firm age in 2003 and firm size in terms of number of employees or the volume of sales. Those two characteristics are most commonly used for firm-level empirical studies as control variables. Besides, the reason why the firm characteristics of previous period are used here is to avoid the endogeneity problem arising from the interrelationship between dependent and independent variables. The present period of firm size, for instant, can affect the firm performance, and conversely may also be affected by the firm performance at the same time. By using previous term of firm size, our empirical model can be free from the endogeneity issue.

$\log(perf)_{i,t-1}$ represents the performance level of the previous period. That variable is employed for two purposes. One is to control the unobservable firm characteristics which affect firm performance. Those unobservable firm characteristics have been already reflected in the previous period of performance. Second purpose is to measure the speed of catch-up, ϑ. If ϑ is above zero, it means that higher performance level at the previous time had higher performance growth over the current period, implicating that performance gap among firms diverges. If ϑ turns out less than -1, firms with lower performance level achieved much higher performance growth so that they have one period later surpassed firms with higher performance level of the previous period. In general, the ϑ is expected to be between 0 and -1, suggesting that firms with higher performance level in the previous term will have a little lower growth rate of the performance, but not as low as the performance level will be reverse among firms one period later. Lastly, Ind stands for a set of industry dummies, which is included for controlling for industrial specifics.

4.2 Empirical results

The empirical results are presented in Table 7 through Table 13. Table 7 covers sample of the overall service sectors. Table 8 through Table 13 concerns each of the corresponding sub sectors. All of the models from Table 7 to Table 13 were estimated using GLS with consideration of heteroskedasity because we used

cross section dataset which is known to cause a heteroskedasity problem. All the t-values for coefficients presented in the tables, therefore, are calculated based on white heteroskedastic robust variance. F-values for all the models suggest that the model specification is significant at 1 percent or 5 percent significant level. As a dependent variable, all the three performance indictors are used. For each performance indicator, two equations are estimated; one with innovation dummy variable and the other with dummy variable for each innovation type (product and process innovation). Equations with an odd number adopts innovation dummy variable, which is 1 if a firm conducted either product or process innovation. If a firm does not involve any innovative activities, it is 0. The estimation for the equations is to find out whether innovative firms show better performance than non-innovative firms. Equations with an even number include innovation type dummy variable, which is 1 if a firm conducted a specific type of innovation and 0 otherwise. It is to know how different innovation type has different impact on performance.

Equation 1 to Equation 6 show the innovation impact on performance for the service industry overall. According to the results, innovative firms turn out to be better than non-innovative firms, showing better sales growth, employment growth and productivity growth. As to innovation type, product innovation has significant relation to firms' performance for the industry overall supporting our hypothesis. Firm size is positively associated with firms' performance, indicating that bigger firms have better performance. Firm age has negative relation to all types of performance, implying that new firms have better performance. As might be expected, the magnitude of the catch up effect variable is between -1 and 0 and statistically significant for all the indicators. As to sector dummy variable, electricity supply sector and transport sector have significant relation to sales growth but positive relation for electricity supply and negative relation for transport sector. As to employment growth, transport, telecommunication and KIBS sector have significantly positive relation. As to productivity growth, electricity, transport and telecommunication sector are significantly related but it is positive for electricity and negative for transport and telecommunication.

Equation 7 to Equation 42 presents the estimation results for each sector. First, the relation between innovation dummy and performance varies sector by sector. The relation is insignificant for wholesale trade and telecommunication sector. However, in transport, financial services and KIBS sector the conducting innovation has significantly positive relation to sales growth. In relation to employment, innovation in KIBS and motion picture & broadcasting sector has significantly positive relation, which seems to have relevance to the fact that motion picture & broadcasting is labor-intensive sector.

Our key finding from Equation 7 to Equation 42 is the heterogeneity among sectors in the relation between innovation type and performance, which supports our hypothesis and probably reflects sectoral differences in service innovation. For instance, product innovation is significantly associated with the performance indicators in wholesale trade, telecommunication, KIBS and motion picture & broadcasting sector. In detail, in wholesale trade sector, product innovation has positive relation to sales growth. For telecommunication sector, product innovation is positively related to productivity growth. For KIBS sector, product innovation is positively associated with sales growth and employment growth, implying that innovation activities tend to increase both sales and number of employees. However, productivity growth effect is insignificant for this sector. Product innovation in motion picture & broadcasting sector has employment growth effect but it has negative relation to productivity growth. It might be because product innovation in this sector has (insignificant but) negative relation to sales growth.

For some sectors, process innovation has higher importance. For transport and financial services, process innovation has significant relation to performance. For instance, process innovation is positively associated with sales growth and productivity growth in financial service sector. Process innovation has negative relation to employment growth for this sector even though it is statistically insignificant. This might be due to active labor-saving process innovation in financial services sector. As innovation activities reduce employment in this sector, productivity tends to increase. For transport sector, process innovation has

positive relation to sales growth but the relation is shown to be insignificant for employment growth and productivity growth.

Firm size has positive relation to performance by and large across sectors and firm age has negative effect on performance. The finding is consistent with that from the service industry overall. The magnitude of θ, which indicates a catch-up effect, is between -1 and 0 for all the performance indicators as expected. Interestingly, the magnitude of θ is high and significant for sales growth and productivity growth in KIBS sector, around 20 percent per year. This implies the significance of technological innovation for knowledge-intensive services, which is often mentioned and highlighted in innovation studies.

Lastly, we compare the expected results from findings from Table 2 and actual results from Table 7 to Table 42, mainly focusing on sales growth (Table 14). From the results of Table 2, we expect that product innovation is relatively more important in wholesale trade, financial services and KIBS sector, which is denoted as A in the type box, whereas B indicates that process innovation has relatively higher importance in the corresponding sectors. Interestingly, the results from the two analyses are almost consistent, with only one exception (financial services).

To sum up, we find that innovative firms show better performance for the service industry overall. Second, the innovation impact on firms' performance varies by innovation type. For the service industry overall, product innovation is significantly related to all the performance indicators, while the relation is insignificant for process innovation. Third, the relation between innovation type and performance varies between the manufacturing industry and the service industry. For the manufacturing industry, process innovation has larger impact on performance but for the service industry product innovation has more significance. It is probably due to the close interaction between production and consumption in service innovation. Lastly, we find there exists strong heterogeneity among sectors in relation to innovation type and performance. Our findings from the estimation results are consistent with those from Prajogo (2006) in that product innovation

has relatively higher importance to firms' performance, while they are against the results from Hipp et al. (2000).

5. Conclusions

In this paper, we explore the relation between innovation and performance for the Korean service industry focusing on innovation type. For firms' performance, three indicators are used; sales growth, labor productivity growth and employment growth. In order to take into account heterogeneity within the service industry, we divide the sub sectors into six groups; wholesale trade, transport, telecommunication, financial services, knowledge-intensive business services and motion picture & broadcasting. Through the estimation and descriptive analysis, we find the followings. First, innovative firms show better performance for the service industry overall. Second, the innovation impact on firms' performance varies by innovation type. For the service industry overall, product innovation is significantly related to all the performance indicators, while the relation is insignificant for process innovation. Third, the relation between innovation type and performance varies between the manufacturing industry and the service industry. For the manufacturing industry, process innovation has larger impact on performance but for the service industry product innovation has more significance. It is probably due to the close interaction between production and consumption in service innovation. In addition, we find there exists strong heterogeneity among sectors in relation to innovation type and performance. Firm size has positive relation to all the performance indicators and firm age has negative effect on performance. The magnitude of θ, which indicates a catch-up effect, is between -1 and 0 for all the performance indicators as expected.

This paper attempts to contribute to relevant innovation studies by adding the empirical evidence for the relation between innovation type and performance for the service industry. However, it might have some limitations. First, this study does not take into account innovation intensity, including dummy variable only

for both innovation and innovation type. Second, the impact of innovation tends to appear in the long-term. However, in this paper we consider short-term effect. Those limitations can be considered in the next study.

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Appendix

Table 1. Standard Industrial Code (two-digit)

40	Electric, gas, steam and hot water supply	65	Financial institutions
51	Wholesale trade	66	Insurance and pension funding
60	Land transport and transport via pipelines	67	Activities auxiliary to financial intermediation
61	Water transport	72	Computer and related activities
62	Air transport	73	Research and development
63	Supporting and auxiliary transport activities & travel agencies	74	Professional, scientific and technical services
64	Post and telecommunications	87	Motion picture, broadcasting and performing arts industries

Table 2. Ratio of Innovative Firms by Sector (%)

Sector	# of obs	product innovation	process innovation	relative ratio	type
wholesale trade	241	19.5	11.2	1.74	A
transport	702	7.4	4.7	1.57	B
telecommunication	65	23.1	20.0	1.15	B
finance	113	29.2	12.3	2.37	A
KIBS	744	35.0	17.8	1.96	A
movie & broadcasting	112	23.2	14.3	1.62	B
total	1,977	22.9	13.38	1.71	

Note: 1) ratio = (number of innovative firms ÷ number of total firms) × 100

2) relative ratio = product innovation ratio ÷ process innovation ratio

3) type: A if relative ratio > relative ratio of industry overall (1.71), B otherwise.

Table 3. Descriptive statistics for performance indicators (mean)

	Sales growth (%)	Employment growth (%)	Productivity growth (%)
all firms	27.31	8.62	21.10
S.D	61.22	36.46	61.81
Innovating firms	48.54	17.02	36.96
Non-innovating firms	19.85	5.54	15.62
Sub sector			
Wholesale trade	19.23	7.36	12.17
Transport	9.15	0.12	9.32
Telecommunication	33.78	27.01	10.22
Finance	19.34	4.75	16.86
KIBS	45.85	16.22	35.11
Movie & broadcasting	36.11	4.69	30.53

Table 4. Sales growth rate by sector (%)

Sector	No innovation	Product innovation	Process innovation
Wholesale trade	16.10	31.72	20.26
transport	8.75	11.41	19.46
telecommunication	31.72	39.58	1.10
finance	8.04	34.19	52.40
KIBS	34.40	61.95	55.37
movie & broadcasting	35.13	38.76	50.01
Average	19.76	48.34	42.29

Table 5. Employment growth rate by sector (%)

Sector	No innovation	Product innovation	Process innovation
Wholesale trade	7.03	6.98	2.45
transport	-0.13	-1.53	4.93
telecommunication	28.20	17.97	11.70
finance	8.87	0.96	-7.58
KIBS	11.16	24.34	17.08
movie & broadcasting	1.26	13.94	15.06
Average	5.62	16.84	11.86

Table 6. Labor productivity growth rate by sector (%)

Sector	No innovation	Product innovation	Process innovation
Wholesale trade	9.21	25.74	18.05
transport	9.37	12.10	11.78
telecommunication	9.87	24.41	-17.07
finance	3.06	34.81	55.57
KIBS	25.91	47.68	47.84
movie & broadcasting	32.59	24.99	35.21
Average	15.47	37.77	34.75

Table 7. Estimation Results: Industry overall

dependent variable	sales growth		productivity growth		employment growth	
	Eq 1	Eq 2	Eq 3	Eq 4	Eq 5	Eq 6
constant	1.90***	1.90***	1.59***	1.59***	0.31***	0.31***
	(11.532)	(11.397)	(9.867)	(9.762)	(5.886)	(5.889)
d_inno	0.27***		0.19***		0.17***	
	(5.111)		(3.765)		(2.753)	
d_product inno		0.21***		0.14**		0.07**
		(3.274)		(2.236)		(2.116)
d_process inno		0.07		0.09		-0.02
		(0.912)		(1.192)		(-0.418)
firm size	0.19***	0.19***	0.05***	0.05***	0.02***	0.03***
	(5.857)	(5.849)	(2.779)	(2.814)	(3.570)	(3.616)
firm age	-0.28***	-0.28***	-0.20***	-0.20***	-0.07***	-0.08***
	(-8.426)	(-8.562)	(-5.839)	(-5.925)	(-5.053)	(-5.155)
θ	-0.21***	-0.20***	-0.23***	-0.23***	-0.09***	-0.09***
	(-7.047)	(-6.971)	(-8.205)	(-8.180)	(-5.850)	(-5.752)
d_electricity	0.46***	0.47***	0.47***	0.48***	-0.01	-0.01
	(3.481)	(3.595)	(3.531)	(3.613)	(-0.201)	(-0.135)
d_wholesale	0.13	0.14	0.09	0.09	0.05	0.05
	(1.459)	(1.535)	(0.903)	(0.969)	(1.258)	(1.269)
d_transport	-0.25***	-0.25***	-0.34***	-0.33***	0.08**	0.08**
	(-2.839)	(-2.820)	(-3.529)	(-3.499)	(2.267)	(2.223)
d_telecommuni	-0.05	-0.03	-0.30**	-0.29**	0.25**	0.26**
	(-0.386)	(-0.252)	(-2.253)	(-2.193)	(2.436)	(2.513)
d_finance	0.08	0.09	0.03	0.04	0.05	0.05
	(0.757)	(0.840)	(0.288)	(0.362)	(1.097)	(1.123)
d_kibs	-0.03	-0.02	-0.13	-0.13	0.10***	0.10***
	(-0.437)	(-0.310)	(-1.504)	(-1.425)	(2.826)	(2.905)
R-squared	0.243932	0.239985	0.217592	0.216610	0.129806	0.127829
D.W. stat	2.007945	2.010062	1.973418	1.979063	1.997281	1.992442
F-statistic	48.104***	42.771***	41.465***	37.453***	22.285***	19.892***
# of Obs	1502	1502	1502	1502	1505	1505

Note: 1) ***, **, and * denote significance level 1%. 5% and 10%, respectively.

2) t-value is presented in the parenthesis.

Table 8. Wholesale trade

dependent variable	sales growth		productivity growth		employment growth	
	Eq 7	Eq 8	Eq 9	Eq 10	Eq 11	Eq 12
constant	1.56***	1.59***	1.18***	1.20***	0.38**	0.39**
	(4.059)	(4.153)	(3.223)	(3.266)	(2.073)	(2.116)
d_inno	0.14		0.11		0.04	
	(1.309)		(1.265)		(0.653)	
d_product inno		0.22		0.18*		0.05
		(1.624)		(1.698)		(0.645)
d_process inno		-0.16		-0.08		-0.04
		(-1.068)		(-0.787)		(-0.399)
firm size	0.12**	0.12**	0.03	0.03	0.02	0.02
	(2.214)	(2.179)	(1.114)	(1.080)	(1.101)	(1.099)
firm age	-0.23***	-0.24***	-0.13*	-0.14*	-0.10***	-0.10***
	(-2.915)	(-3.049)	(-1.844)	(-1.949)	(-3.051)	(-3.130)
θ	-0.14***	-0.14***	-0.16***	-0.16***	-0.06**	-0.06**
	(-2.775)	(-2.750)	(-3.308)	(-3.283)	(-2.579)	(-2.588)
R-squared	0.166412	0.172766	0.160689	0.165461	0.083492	0.083671
D.W. stat	1.660188	1.733245	1.898157	1.944484	2.787878	2.815931
F-statistic	9.632***	8.019***	9.237***	7.613***	4.418***	3.524***
# of Obs	198	198	198	198	199	199

Note: 1) ***, **, and * denote significance level 1%. 5% and 10%, respectively.

2) t-value is presented in the parenthesis.

Table 9. Transport

dependent variable	sales growth		productivity growth		employment growth	
	Eq 13	Eq 14	Eq 15	Eq 16	Eq 17	Eq 18
constant	0.738***	0.74***	0.42***	0.42***	0.31***	0.31***
	(4.222)	(4.239)	(2.683)	(2.678)	(3.226)	(3.212)
d_inno	0.08*		0.02		0.06	
	(1.671)		(0.346)		(1.000)	
d_product inno		-0.01		0.05		-0.06
		(-0.247)		(0.736)		(-0.835)
d_process inno		0.17**		0.02		0.14
		(2.336)		(0.168)		(1.049)
firm size	0.02	0.02	0.06***	0.068***	0.02**	0.02**
	(0.568)	(0.575)	(2.924)	(2.886)	(2.130)	(2.134)
firm age	-0.19***	-0.19***	-0.15***	-0.15***	-0.03*	-0.03*
	(-4.433)	(-4.438)	(-3.512)	(-3.542)	(-1.934)	(-1.839)
θ	-0.02	-0.02	-0.04**	-0.04**	-0.08***	-0.08***
	(-1.010)	(-1.079)	(-2.004)	(-2.038)	(-3.015)	(-3.037)
R-squared	0.088098	0.090827	0.057004	0.058414	0.113628	0.117030
D.W. stat	1.154043	1.162241	1.596624	1.593484	1.820934	1.874684
F-statistic	12.631***	10.429***	7.903***	6.476***	16.825***	13.890***
# of Obs	528	528	528	528	530	530

Note: 1) ***, **, and * denote significance level 1%. 5% and 10%, respectively.

2) t-value is presented in the parenthesis.

Table 10. Telecommunication

dependent variable	sales growth		productivity growth		employment growth	
	Eq 19	Eq 20	Eq 21	Eq 22	Eq 23	Eq 24
constant	2.30***	2.19***	1.79***	1.56**	0.51	0.62*
	(3.401)	(3.022)	(3.082)	(2.469)	(1.519)	(1.925)
d_inno	0.22		0.12		0.09	
	(0.976)		(0.489)		(0.393)	
d_product inno		0.31		0.52*		-0.20
		(1.207)		(1.796)		(-0.684)
d_process inno		-0.26		-0.37		0.10
		(-0.950)		(-0.942)		(0.272)
firm size	-0.02	-0.03	0.01	0.01	0.15	0.15*
	(-0.201)	(-0.202)	(0.067)	(0.097)	(1.630)	(1.830)
firm age	-0.42**	-0.39**	-0.25	-0.19	-0.16	-0.20
	(-2.389)	(-2.171)	(-1.401)	(-1.016)	(-1.235)	(-1.546)
θ	-0.12	-0.11	-0.28**	-0.26**	-0.32*	-0.30*
	(-1.280)	(-1.039)	(-2.415)	(-2.446)	(-1.742)	(-1.804)
R-squared	0.310811	0.318726	0.232930	0.286579	0.203868	0.211854
D.W. stat	0.956577	0.925995	2.759241	2.181014	0.625379	0.369144
F-statistic	5.411***	4.397***	3.643**	3.775***	3.072**	2.526**
# of Obs	53	53	53	53	53	53

Note: 1) ***, **, and * denote significance level 1%. 5% and 10%, respectively.

2) t-value is presented in the parenthesis.

Table 11. Finance

dependent variable	sales growth		productivity growth		employment growth	
	Eq 25	Eq 26	Eq 27	Eq 28	Eq 29	Eq 30
constant	1.94***	1.97***	1.67***	1.70***	0.27**	0.27**
	(5.356)	(5.205)	(4.535)	(4.401)	(2.139)	(2.195)
d_inno	0.58**		0.65***		-0.06	
	(2.596)		(2.976)		(-0.823)	
d_product inno		0.39		0.36		0.02
		(1.550)		(1.542)		(0.269)
d_process inno		0.46*		0.54*		-0.08
		(1.984)		(1.929)		(-0.560)
firm size	0.24**	0.23**	-0.02	-0.02	0.03	0.03
	(2.253)	(2.064)	(-0.333)	(-0.452)	(1.160)	(1.074)
firm age	-0.21*	-0.21*	-0.05	-0.05	-0.16***	-0.15***
	(-1.757)	(-1.733)	(-0.461)	(-0.465)	(-3.697)	(-3.577)
(	−0.25***	−0.25***	−0.29***	−0.28***	-0.02	-0.02
	(−4.138)	(−3.940)	(−4.195)	(-3.972)	(-0.614)	(-0.648)
R-squared	0.402271	0.407569	0.409108	0.405787	0.186621	0.185765
D.W. stat	0.367452	0.486070	0.046213	0.131556	1.787993	1.912577
F-statistic	11.104***	8.943***	11.423***	8.877***	3.785***	2.965**
# of Obs	71	71	71	71	71	71

Note: 1) ***, **, and * denote significance level 1%. 5% and 10%, respectively.

2) t-value is presented in the parenthesis.

Table 12. KIBS

dependent variable	sales growth		productivity growth		employment growth	
	Eq 31	Eq 32	Eq 33	Eq 34	Eq 35	Eq 36
constant	2.76***	2.80***	2.25***	2.29***	0.51***	0.51***
	(10.270)	(10.078)	(8.846)	(8.727)	(5.561)	(5.606)
d_inno	0.30***		0.22***		0.07**	
	(3.692)		(2.775)		(1.996)	
d_product inno		0.23**		0.12		0.11**
		(2.415)		(1.335)		(2.400)
d_process inno		0.03		0.09		-0.06
		(0.286)		(0.866)		(-1.212)
firm size	0.44***	0.44***	0.11***	0.11***	0.03**	0.03**
	(6.235)	(6.209)	(3.125)	(3.206)	(2.293)	(2.265)
firm age	-0.34***	-0.36***	-0.26***	-0.27***	-0.08**	-0.08**
	(-4.447)	(-4.712)	(-3.389)	(-3.625)	(-2.260)	(-2.293)
θ	-0.43***	-0.42***	-0.46***	-0.46***	-0.13***	-0.13***
	(-6.406)	(-6.322)	(-7.115)	(-7.063)	(-4.542)	(-4.436)
R-squared	0.360701	0.354800	0.361574	0.357728	0.101927	0.105332
D.W. stat	1.946433	1.960275	2.014688	2.024253	2.518459	2.508304
F-statistic	76.592***	59.601***	76.882***	60.375***	15.406***	12.762***
# of Obs	548	548	548	548	548	548

Note: 1) ***, **, and * denote significance level 1%. 5% and 10%, respectively.

2) t-value is presented in the parenthesis.

Table 13. Motion picture & broadcasting

dependent variable	sales growth		productivity growth		employment growth	
	Eq 37	Eq 38	Eq 39	Eq 40	Eq 41	Eq 42
constant	0.95***	0.95***	0.71*	0.71*	0.24	0.24
	(2.801)	(2.758)	(1.779)	(1.753)	(1.601)	(1.591)
d_inno	-0.02		-0.21		0.19**	
	(-0.190)		(-1.273)		(2.232)	
d_product inno		-0.23		-0.40*		0.16**
		(-1.351)		(-1.891)		(2.091)
d_process inno		0.38*		0.34		0.04
		(1.742)		(1.452)		(0.427)
firm size	0.38**	0.37**	0.18**	0.18*	0.03	0.03
	(2.149)	(2.214)	(2.001)	(1.958)	(1.304)	(1.323)
firm age	-0.03	-0.03	0.07	0.08	-0.11*	-0.11*
	(-0.262)	(-0.236)	(0.430)	(0.445)	(-1.960)	(-1.944)
θ	-0.23**	-0.22**	-0.26**	-0.26**	-0.06**	-0.06**
	(-2.137)	(-2.217)	(-2.514)	(-2.593)	(-2.045)	(-2.087)
R-squared	0.255329	0.273344	0.264225	0.275584	0.158426	0.159903
D.W. stat	1.689651	1.762558	1.180303	1.226868	0.822555	0.818640
F-statistic	6.771***	5.868***	7.092***	5.934***	3.717***	2.969**
# of Obs	84	84	84	84	84	84

Note: 1) ***, **, and * denote significance level 1%. 5% and 10%, respectively.

2) t-value is presented in the parenthesis.

Table 14. Relative Importance of Innovation Type by Sector

Sector	Type	Relative Dominance (1)	Estimation result for sales growth (2)	Comparison (1) and (2)
wholesale trade	A	Product innovation	Parameter insignificant	
transport	B	Process innovation	Process innovation	Consistent
telecommunication	B	Process innovation	Parameter insignificant	
finance	A	Product innovation	Process innovation	Not consistent
KIBS	A	Product innovation	Product innovation	Consistent
Films & broadcasting	B	Process innovation	Process innovation	consistent

Note: Type & relative dominance (1) are from Table 2.

Figure 1. Ratio of each innovation type (manufacturing industry versus service industry)