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Dynamic Analysis of the Employment Effect of Innovation in Different Market Structure: -Korean manufacturing firms and sectors-

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Abstract

Dynamic Analysis of the Employment Effect of Innovation in Different Market Structure: Korean Manufacturing Firms and Sectors

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How does technological innovation impact job creation? While the influence of technological innovation on growth is relatively clear, but the discussion of its influence on job creation fails to cease. This is because while technological innovation has a substitution effect towards job creation, also a compensating effect through demand creation; while the compensating effect through demand creation of the firm is determined by the characteristics and the importance of the technological innovation, it is also partially determined by the market environment and the demand conditions to which the firm belongs. Therefore, the job creation effect of technological innovation has been examined through studies of empirical analyses rather than theoretical discussions, and studies at the firm-level have been used as the most basic study

methods in the aspect that it allows for examination of the mechanism through which technological innovation impacts actual job creation.

Therefore, this study has utilized the Korean Innovation Study (KIS), gathered by the Science and Technology Policy Institute (STEPI) to support the making of better technological innovation support policies for job creation, and analyzed the influence of technological innovation of Korean manufacturing firms on job creation. The study model and analytical methods of Harrison et al. (2008, 2014) were utilized for a firm-level analysis, and the industry-level study methods of Greenan and Guellec (2000) were utilized jointly to overcome the limitations of firm-level analyses.

On the other hand, this study is different from previous studies in the following ways. First, this study has utilized approximately 10 years of large data of Korean manufacturing firms from 1999 to 2009 to jointly conduct firm-level and industry-level analyses, and the results were compared thereof. Secondly, the previous studies focused on the short-term job creation effects of technological innovation due to the limitations of research data whereas this study has formed separate panels of data by extracting the firms that continue to exist through each period and analyzed both the short- and long-term effects on job creation by technological innovation, despite its limitations. Lastly, the competitive effects in the product markets, only suggested in theory in previous studies, were applied in the empirical analysis, and the job creation effects of technological innovation depending on the market structure were expressly observed.

The results of the empirical analysis showed that first, the technological innovation of Korean manufacturing firms showed a short-term positive influence on the firm-level job creation, and second, these short-term job creation effects on the firm-level were confirmed to pass over to long-term job creation effects on the industry-level. Moreover, increasingly monopolistic market structures reduced the job creation effects of process innovation, and these observations imply the following considerations on countries that are striving for growth strategies similar to Korea.

First, the reason why technological innovation of Korea did not reduce jobs is not because the product innovation of Korea has a large job creation effect, but the process innovation of Korea did not work towards the direction of lowering the number of jobs for Korean manufacturing firms. Second, for highly-concentrated Korean manufacturing firms, the job creation substitution effect through process innovation should have been very large; the reason why this did not occur is because the environment that the Korean firms face is extremely competitive. Lastly, the reason why Korean manufacturing firms continue to create demand and jobs through process innovation is because they have price competitiveness through economies of scale, and continue to expand imports and constant foreign demand thereof.

Ultimately, the technological innovation of Korean manufacturing firms was successful in acquiring price competitiveness through economies of scale, and led to the

successes in foreign demand creation in export markets, with an overall positive effect on job creation by Korean manufacturing firms. However, it seems inevitable that the job creation substitution effect through technological innovation would grow ever larger, if Korean manufacturing firms only seek to compete in the domestic markets, following the lowering of their influence in foreign export markets due to rapid advances by new emerging nations such as China. Therefore, this paper asserts that foreign demand creation through product innovation is the only response strategy to increase job creation for domestic manufacturing firms and to achieve this, the government should reinforce policy devices for fair competition to invigorate competition within the industry in the Korean markets, characterized by high aggregate concentration ratios.

Key words: technological innovation, process innovation, product innovation, job creation, increase in job creation, short term job creation effects, long term job creation effects, market structure, firm-level analysis, industry-level analysis, Ordinary Least Squares Method(OLS), 2-stage Least Squares Method (2SLS), Korean manufacturing firm

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I. Introduction

1.1. Motivation

The impact of innovation on employment has since long been a debated issue (Vivarelli, 2012). However, although the relationship between innovation and employment has not been clearly identified, the former is known to have a strong positive relationship with employment growth. Meanwhile, the related theory explains that innovations have two distinctive effects on employment; a) displacement effect (-) and b) compensation effect (+)[1]. Unlike the former, the latter results from mixed and complex procedures, occurring inside and outside the firms. Therefore, economic theory does not indicate the exact sign for this occurrence, since it is determined by the relative size of these two effects. Accordingly, the potential employment effect of innovation is not determined theoretically, but rather empirically.

On one hand, empirical analyses are largely dependent on their research on firm-level analysis (Entorf and Pohlmeier, 1990; Doms, Dunne and Robert, 1994; Van Reenen, 1997; Klette and Forre, 1998, Piva and Vivarelli, 2004, 2005; Coad and Rao,

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[1] Innovation has displacement effect, which displaces the workers by capital. For this reason, displacement effect of innovation gives negative influence on jobs. On the other hand, innovation also has compensation effect, which stimulate the sales of innovating firms and hence to create more production and labor demand for the production. Therefore, compensation effect gives positive influence on jobs.

2011). This is because firms are the actual source of innovation, as it can provide basic ideas on how innovation affects employment. Normally, previous literatures divide innovations into two categories, a) process innovation and b) product innovation, and estimate each separately. Thus, process innovation with the purpose of cost-saving, is known to have a negative influence on employment, while product innovation, which is important for demand expansion, is considered to have a positive impact. However, only few studies agree with process innovation's negative effect on employment, whereas product innovation is known to have a positive relationship in most empirical findings. Thus, this study distinguishes the innovation type and estimates the effect of each type.

On the other hand, Schumpeter (1950) argued that firm size and market concentration are critical elements for a firm's innovative activities. This is because a) firms in monopolistic markets can expect higher returns from innovations, and b) they have extra money for investing research and development (R&D)[2]. Furthermore, Vivarelli (2012) argued that the effectiveness of the mechanism "via decrease in prices" depends on the hypothesis of perfect competition. Therefore, this paper additionally considers the "market structure" and how it differently affects the employment effect of each type of innovation.

[2] Of course, there are opposite views that competition is good for innovation. Arrow and his followers insist that a competitive market is better for firms' innovations. They explained that firms in competitive markets have strong incentives to increase their market share through innovations for attaining monopolistic power in a market. Recent studies indicate that there are strong inverted- U shape relation between competition and innovation. According to their findings, innovation increases as a market becomes more competitive, but decreased if it is too competitive.

Moreover, the necessity of studies on the long-term employment effect of innovations has been continuously raised, since compensation effect does not occur directly and sometimes takes time to be reflected (Van Reenen, 1997; Jaanika, 2008; Lachenmeir and Rotteman, 2012; Shin et al., 2012).Van Reenen (1997) used British firm-level panel data from 1976-1982 and showed that innovation has a positive effect on employment and persists over several years. Shin et al. (2012) also used the same methodology as Van Reenen (1997), but did not provide the long-term employment effect of innovation; they found that process innovation has positive effect on employment, while product innovation does not have any significant effect. Thus, this study indicates both short-term and long-term effects of innovation on employment. However, we use different econometric model and estimation strategy than that of Shin et al. (2012).

Finally, we use the Greenan and Guellec (2000) method for the sector-level analysis. There has already been considerable research on the macro-economic level of analysis (Kang, 2006; Ha and Moon, 2009; Kim, 2012). They normally showed that there is a positive relationship between innovation and employment in case of Korea even at the macro-economic level. However, they mostly use R&D expenditure, which is not a direct measurement for innovation, as a proxy for innovation. Therefore, we would expect that this study, using firm-level direct measurement for innovation, could provide a complementary evidence for their findings.

1.2. Objectives

The aim of this paper is to determine both theoretical and empirical evidence for the effect of innovation on employment in Korean manufacturing industry. For this, we use three different approaches for the completeness of the study. First, this paper divides innovations into two, a) process innovation and b) product innovation, and provides both a) firm- and b) sector-level effects of innovation on employment separately. Second, this paper additionally considers the "market structure" as a major determinant of the employment, and shows how market structure differently affects the employment effect of each type of innovation. Third, this paper shows the dynamic and long-term effect of innovation on employment.

This paper uses Korean manufacturing firm data from 1999-2009. The same econometric model and estimation strategies are used as per Harrison et al. (2008, 2014) and Greenan and Guellec (2000) for firm- and sector-level analysis respectively. From the various regression analyses, we hope to indicate that a) product innovation has a positive employment effect, while that of process innovation is negative, b) product innovation in a monopolistic market has a greater job creating effect, while process innovation has a greater job displacement effect, and c) process innovation has different employment effects between short-term and long-term, while product innovation has the same employment effect.

1.3. Structure

The remainder of this paper is divided into seven chapters. Chapter1 explains the motivation ad purpose of the research. Chapter 2 introduces a theoretical background for the relationship between innovation and employment, and suggests the proposed hypothesis for the research. Chapter 3 explains the methodology, econometric model and estimation strategy, for both firm- and sector-level analysis respectively. Specifically, this study uses both firm and sector-level analysis, and uses Harrison et al.(2008, 2014)'s methodology for firm-level analysis and Greenan and Gullec (2000)'s methodology for sector-level analysis. Chapter4 describes the data and variables for the research. Chapter 5 and 6 describe the empirical results and their appropriate explanations. Specifically, chapter 5 describes the firm-level employment effect of innovation and chapter 6 describes the sector-level effect. Based on the various regression results, chapter 7 finally concludes the paper and suggests potential avenues for future research, as well as the limitations of the study.

II. Theoretical Backgrounds

Theoretically, innovation has two distinctive effects on employment, a) displacement effect (-) and b) compensation effect (+). Displacement effect occurs when new technology displaces workers and hence renders a negative influence on employment. On the other hand, innovation also has a positive influence on employment, since new technology creates new demand for products and subsequently more workers are required to produce these new products. We refer to this as the compensation effect, and it is dependent on the size of demand enlargement, which can vary due to several reasons.

Overall, the final employment effect of innovation is determined by the relative size of these two effects. Nevertheless, the size of employment effect is not determined theoretically, but rather empirically. Thus, the effect of innovation on employment has been developed by empirical analyses. Specifically, firm-level analysis is used as the basic methodology for this study.

Figure 2-1. Employment effect of innovation

Employment effect of innovation

(1) First effect		(2) Secondary effect	(1)+(2) Potential effect
Displacement effect:	>	Compensation effect:	(-)
Negative effect (-)	<	Positive effect (+)	(+)

2.1 Employment effect of different type of innovation

Many investigations have recently focused on categorizing innovation and depict the different effects on employment. Harrison et al. (2008, 2014) argued that there are two types of innovations, process innovation and product innovation, and it is advisable to distinguish the types in order to better understand their effect on employment. This is because each type of innovations has distinctive characteristics that show a well-defined employment effect, whereas the comprehensive effect of innovations is not decisive.

On one hand, process innovation is directed at improving the production process and hence has a direct impact on productivity and unit cost. For this reason, process innovation directly displaces workers, but its job-creating effect is not certain, since it is not definite whether they create new demand and employment[3]. On the contrary, product innovation directly increases the product demand and employment for new products. Thus, it has definite compensation effect. However, the displacement effect of product innovation is not certain, because it depends on the substitution rate or productivity differences between old and new products. Figure 2-2 shows the detailed mechanisms of the employment effect of process and product innovations.

[3] Compensation effect of process innovation occurs only when the process innovating firms lower their price in order to achieve more market share. Hence, it is more likely to occur in more competitive markets.

Figure 2-2. Employment effect of process and product innovation (Harrison et al., 2008)

		Employment effect of innovation		
		Displacement effect	Compensation effect	
R&D expenditure =>	Process innnovation	Productivity effect: less labor for a given output	Price effect: cost reduction, passed on to price, expands demand	<= Depends on firm agent's behavior
	Product innovation	Productivity differences of the new product?	Demand enlargement effect	<= Depends on competition

Most firm-level empirical evidences clearly show that product innovation has a positive employment effect, while process innovation does not have a decisive effect on employment. Entorf and Polhmeir (1990), using 2,276 German manufacturing firms in 1984, found a positive relationship between product innovation and employment. However, they fail to find a significant effect of process innovation. Smonly (1998) observed a positive employment effect of product innovation in West German manufacturing firms using 2,405 firms from 1980-1992. On the other hand, Greenan and Guellec (2000) analyzed 15,186 French manufacturing firms from 1986-1990 and found interesting results; process innovation has a greater job-creating effect than product innovation does at the firm-level, but the converse is true at the sector-level. Harrison et al. (2005, 2008, 2014) devised the dual product market model for reflecting the sales growth of old and new products and observed a positive employment effect of product innovation and negative or insignificant effect of process innovation. They provide evidence for four European countries (France, Germany, Spain, and the UK). Hall et al. (2008) used the similar econometric model and estimation strategy as per Harrison et al.

(2008, 2014) and found no significant employment effect of process innovation and a less positive impact of product innovation in Italian firms. Moreover, Lachenmaier and Rottman (2012) found a positive employment effect of both product and process innovation in German manufacturing firms from 1982-2002, but they also found that process innovation has a greater job-creating effect than product innovation has, which is slightly in contrast with the previous findings.

On the other hand, there have been some related researches on Korean manufacturing firms. Moon and Juhn (2008) used Korean manufacturing firm data from 1999-2001 (KIS2002) and observed a positive employment effect of product innovation on employment and no significant effect of process innovation. However, Shin et al. (2012) used the same database, but for a different period, Korean manufacturing firm data from 2000-2007 (KIS2008), and found an opposite regression result with Moon and Juhn (2008), that is process innovation has a positive impact on employment, whereas product innovation has no significant effect. Finally, Kwon et al. (2015) used the latest dataset, KIS2012, and found as similar estimation result as Moon and Juhn (2008). However, they found no significant effect on organizational innovation and user-centred innovation. Thus, we only consider the employment effect of process and product innovation, which is already proven to be significant for employment growth.

H1-1: Product innovation has a positive influence on employment.

H1-2: Process innovation has a negative influence on employment.

Table 2-1. Literatures for firm-level employment effect of innovation

Authors	Data	Results
Entorf and Pohlmeier (1990)	- 2276 West German manufactruring firms - Cross-section data: 1984	- Product innovation: (+) significant effect
Brower, Kleinknecht and Reijnen (1993)	- 859 Dutch manufacturing firms - Cross-section data	- R&D expenditure: (-) significant effect
Doms, Dunne and Robert (1994)	- US manufacturing firms - Period: 1987-1997	- Advanced manufacturing technologies: (+)
Klette and Forre (1998)	- 4333 Norwegian manufacturing firms - Period: 1982-1992	- R&D intensity: no siginifant (+) effect
Van Reenen (1997)	- 598 British manufacturing firms - Period: 1976-1982	- Innovation : (+) significant effect
Blanchflower and Burgess (1998)	- British fims: 1990 - Australian firms: 1989	- Innovation: (+) significant effect
Smonly (1998)	- West German 2405 manufactruring firms - Period: 1980-1992	- Product innovation: (+) significant effect
Greenan and Guellec (2000)	- 15186 French manufacturing firms - Period: 1986-1990	- process innovation : (+) significant effect at firm-level - product innovation: (+) significant effect at sector-level
Piva and Vivarelli (2004 and 2005)	- 575 Italian manufacturing firms - Period: 1992-1997	- Innovation: (+) significant effect
Harrison, Jaumandreu, Mairesse and Peters (2008)	- CIS data from 4 European countries - Germany, France, UK, Spain	- Process innovation: (-) significant effect - Product innovation: (+) significant effect
Hall, Lotti and Mairesse (2008)	- Italian firms - Period: 1995-2003	- Process innovation: no signifant effect - Product innovation: (+) significant effect
Lachenmaier and Rottmann (2011)	- German manufacturing firms - Period: 1982-2002	- Process innovation: (+) significant effect - Product innovation: (+) significant effect
Coad and Rao (2011)	- US high-tech manufacturing firms - Period: 1963-2002	- Innovativeness index (R&D, patents): (+) significant effect
Bongliacino, Piva and Vivarelli (2011, 2012)	- 677 European manufacturing & service fir - Period: 1990-2008	- R&D expenditure: (+) in service & high-tech manufacturing indus - R&D expenditure: no significant in traditional industries
Moon and Juhn (2008)	- 1874 Korean manufacturing firms - Period: 1999-2001	- process innovation: no significant effect - product innovation: (+) sigificant effect
Shin, Song and Choi (2012)	- 841 Korean manufacturing firms - Period: 2000-2007	- process innovation: (+) significant effect - product innovation: no significant effect
Kwon et al. (2015)	- 532 Korean manufacturing firms - Period: 2009-2011	- process innovation: (-) sigificant effect - product innovation: (+) significant effect

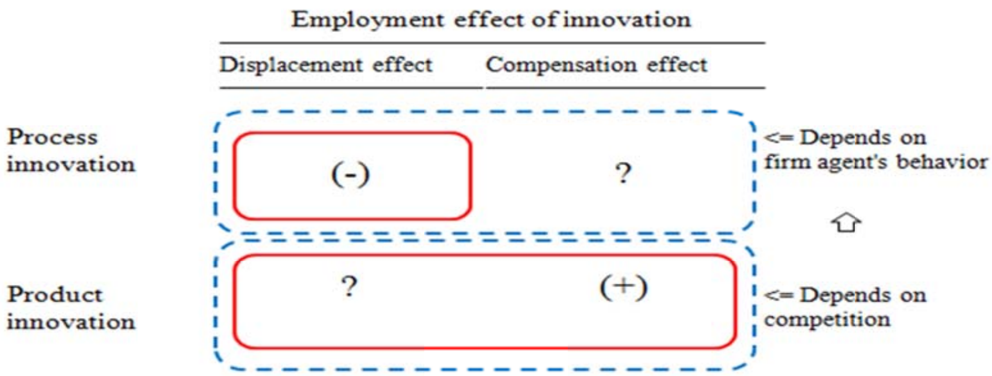
2.2 Dynamic effect of innovation on employment

Due to the lack of information on the innovative activities of firms, most firm-level studies are based on their research on the short-term employment effect. However, the necessity of studies on the long-term employment effect of innovations has been continuously raised, since compensation effect does not occur directly and sometimes takes time to be reflected (Van Reenen, 1997; Jaanika, 2008; Lachenmeir and Rotteman, 2012; Shin et al., 2012).

Specifically, process innovation can have a different employment effect between short-term and long-term. This is because process innovation takes time for implementation and its compensation effect cannot be captured in a short period. Accordingly, this innovation type can have a positive employment effect in the long-term even though its short-term effect is not positive.

On the other hand, the long-term effect of product innovation on employment may or may not have the same effect as its short-term effect. However, it can be different if the product market competition is so severe that its compensation effect does not last long. In this case, we can conjecture that product innovation does not have a long-term employment effect, since it is easily imitable by competing firms that cannot create new demand continuously.

Figure 2-3. Short-term and long-term employment effect of innovation[4]



Only few research works (Van Reenen, 1997; Jaanika, 2008; Lachenmeir and Rotteman, 2012; Shin et al., 2012) have recognized the importance of the long-term effect of innovation on employment and shown its dynamic effect at the firm-level. Van Reenen (1997) used British firm-level panel data from 1976-1982 and showed that innovation has a positive effect on employment and it persists over several years. Moreover, he clarified that product innovation has a greater employment effect than that of process innovation. Jaanika (2008, 2010) used Van Reenen (1997) and Greenan and Guellec (2000)'s methods for both firm- and industry-level analyses on the effect of innovation on employment. He adopted the idea of Van Reenen (1997) in his firm-level

[4] The red line indicates the short-term employment effect of innovations, while the blue, dotted line indicates the long-term employment effect. Short-term employment effect of process innovation definitely has a displacement effect, but may not have the compensation effect, whereas the short-term employment effect of product innovation has both displacement and compensation effects simultaneously. The compensation effect of product innovation is occurs directly.

analysis and considered the adjustment time for innovation. He considered a year after the effect of innovation on employment and reported that innovation variables tend to take effect more strongly one year after the innovation period. Shin et al. (2012) used the same methodology as Van Reenen (1997), but could not provide the long-term effect of innovation on employment. They used Van Reenen (1997)'s panel data econometric model and estimation strategy in order to control the endogeneity problem of the model.

Overall, this paper suggests that process innovation can have a positive employment effect in the long-term even though its short-term effect is not positive. However, product innovation can have no significant effect in long-term though it has positive effect in the short-term.

H 2-1: Process innovation has a negative employment effect in the long-term..

H 2-2: Product innovation has a positive employment effect in the long-term.

2.3 Employment effect of innovation in different market structure

Even though there is a strong tendency for negative employment effect of process innovation and positive employment effect of product innovation, they can be varied according to the size of their compensation effect. Thus, process innovation, which tends to have a negative employment effect, can have a positive influence if the size of the compensation effect is so large that it exceeds the displacement effect.

According to Marx's compensation theory, compensation mechanisms are divided into six different categories; a) "via decrease in prices.", b) "via new investments.", c) "via new products.", d) "via decrease in wages.", e) "via increase in incomes.", f) "via additional employment in the capital goods sector.", and these are strongly influenced by 1) demand elasticity, 2) degree of market competition, 3) capital-labor substitution, 4) demand expectations, etc[5].

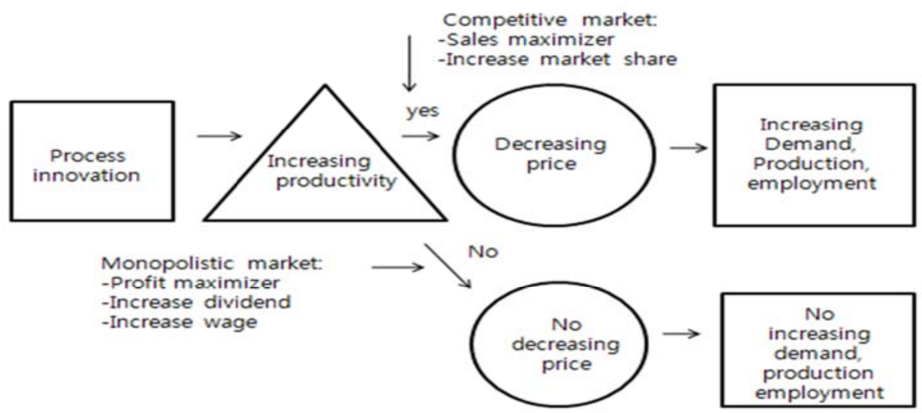
Thus, the "market structure" could be one of the most influencing factors for determining the relative size of the compensation effect, since it relates with the factors mentioned above. However, most firm-level analyses do not explicitly consider the role of "market structure" and provide the empirical evidence for this; that is, how it

[5] For more details, you can refer Vivarelli (2012).

differently affects the employment effect of each type of innovation.

According to Vivarelli (2012), the effectiveness of the mechanism "via decrease in prices" depends on the hypothesis of perfect competition. He explains that the entire compensation effect is strongly weakened in a monopolistic market, since cost savings are not necessarily and entirely translated into decreasing prices if an oligopolistic regime is dominant (see Sylos Labini, 1969). Therefore, we can expect that process innovation in monopolistic markets may have a greater job displacement effect than that in non-monopolistic markets, since cost savings from process innovation do not necessarily decrease sales and the compensation effect is weakened in this case.

Figure 2-4. Market structure and compensation mechanisms of process innovation



On one hand, Schumpeter (1950) argued that firm size and market concentration are critical elements for a firm's innovative activities. This is because a) firms in monopolistic markets can expect higher returns from the innovation and b) they have extra money for investing in R&D[6]. Furthermore, Jung and Lee (2010) empirically showed that Korean manufacturing firms in monopolistic markets achieved better productivity catch-up than those in non-monopolistic markets, since they have the market power to sell the new products and have a strong incentive for innovation. Furthermore, they argued that this pattern can be more likely to be captured in firms that have the monopolistic power in their domestic market, but are exposed to global competition. They explained that firms in monopolistic markets spend more money on R&D, undertake more innovations, and hence achieve better productivity catch-up when they are exposed to global competitions.

For the same reason, we can expect that this high appropriability of innovation in monopolistic markets can lead to more employment, since these firms can invest more in R&D, produce better quality products, which can globally compete, and eventually increase the demand for the products and employment for the production[7].

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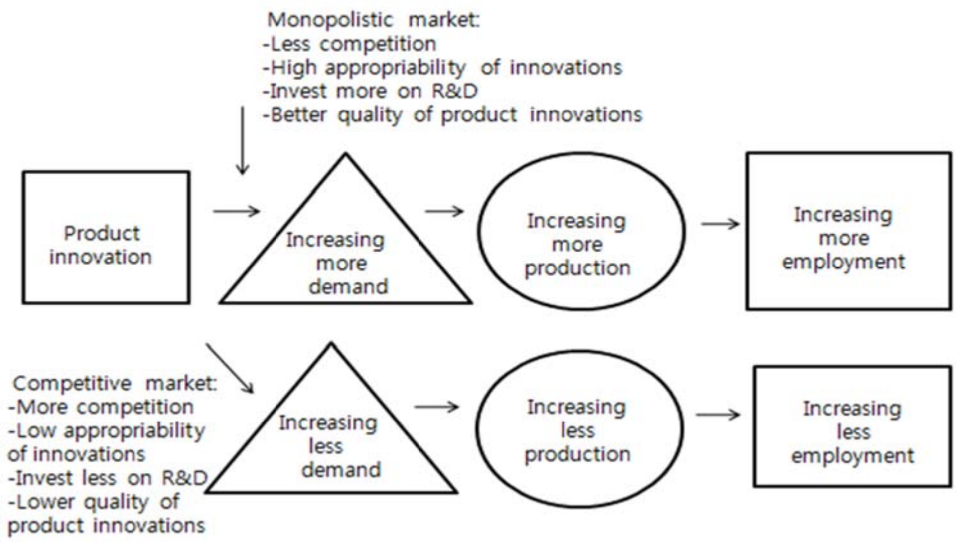
[6] Of course, there are opposite views that competition is good for innovation. Arrow and his followers insist that competitive market is better for firms' innovations. They explained that firms in competitive markets have a strong incentive to increase their market share through the innovation for attaining the monopolistic power in a market. Recent studies point out that there are strong inverted-U-shaped relations between competition and innovation. According to their findings, innovation increases as a market becomes more competitive, but decreases if it is too competitive.

[7] These firms can increase the demand not only from the domestic market but also from foreign markets. Hence, they can achieve more demand than the firms in non-monopolistic markets can.

Figure 2-5. Market structure and compensation mechanisms of product innovations



On the other hand, the sales growth of new products can cannibalize a certain amount of firms' existing sales. Thus, product innovation in monopolistic markets may not create more demand than that in non-monopolistic markets if the new products heavily displace the old ones[8]. In this case, the final employment effect of product innovation in a monopolistic market is not certain, since it depends on 1) the increased demand and 2) the substitution rate between old and new products.

8 Here, the biggest competitors of firms in monopolistic markets may not be other firms, but the firms themselves. In this case, new products effectively replace the old and the compensation effect may be cannibalized by decreasing sales of old products.

Therefore, we hypothesize that process innovation in monopolistic markets has a greater job displacement effect than that in non-monopolistic markets, while product innovation in monopolistic markets has a greater job-creating effect than that in non-monopolistic markets.

H3-1: Process innovation in monopolistic markets has a greater job displacement effect than that in non-monopolistic markets.

H3-2: Product innovation in monopolistic markets has a greater job-creating effect than that in non-monopolistic market.

2.4. Necessity of sector-level analysis

Finally, according to Harrison et al. (2008), there are two main reasons why firm-level effects of innovation cannot be generalized as the aggregate employment effect of innovations. First, the firm-level compensation effect that we observe does not distinguish between the pure market expansion component and the business stealing component. Second, we do not observe entering or existing firms in our sample of continuing firms. Therefore, full industry-level analysis can be the solution for this, explicitly incorporating entry, exit and competition between rival firms.

However, full-industry level analysis is not in our interests, since firms' decision for entry or exit is more likely affected by economy wide shocks rather than sector-specific shocks. Moreover, it has already been studied by many macro-economic research papers (Kang, 2006; Ha and Moon, 2009; Kim, 2012), which showed that there is a positive relationship between innovation and employment even at the macro-economic level in case of Korea.

Therefore, we use Greenan and Guellec (2000)'s method for sector-level analysis. They provide a useful methodology to calculate sector-level variables from the firm-level database. Accordingly, we can directly use firm-level direct mapping innovation variables, which are proper measurements for innovation, for sector-level analysis and this estimation result can confirm the employment effect of innovation in a more aggregate way, especially where the "Business Stealing Effect" is considered.

To conclude, firm-level analysis may have advantages from the perspective of choosing proper measurements for innovation. However, this can vary with time and conditions and has the possibility to over-estimate the effect of innovation on employment by not considering the employment effect of other firms. Thus, this study considers "the market structure" and "the long-term employment effect of innovation" at the firm-level, and confirms the firm-level estimation results by checking with sector-level analysis.

Table 2-2. Proposed Hypothesis for empirical analysis

Innovation type	Employment effect by type of innovation	Firm-level	Sector-level
H1-1	Process innovation has negative effect on employment	FH1-1	SH1-1
H1-2	Product innovation has positive effect on employment	FH1-2	SH1-2
Long-term	Employment effect by type of innovation in long-term		
H2-1	Process innovation has negative effect on employment in long-term	FH2-1	SH1-1
H2-2	Product innovation has positive effect on employment in long-term	FH2-2	SH1-2
Market structure	Employment effect by type of innovation in different market structure		
H3-1	Process innovation in monopolistic market has bigger job displacement effect on employment	FH3-1	
H3-2	Product innovation in monopolistic market has bigger job creating effect on employment	FH3-2	

III. Methodology

While theoretical economists may develop clear model for the employment effect of innovation, applied economists have to “measure” a) the innovation, b) compensation mechanisms, and c) the final employment impact of innovation (Vivarelli, 2012). Therefore, the micro-econometric approach is preferably used, since macro-economic analyses are often severely constrained by the difficulty to find a proper measurement for technological change.

In this aspect, micro-econometric study has great advantages to allow a direct and precise firm-level mapping of innovation variables. This implies that only micro-econometric analysis can grasp the very nature of a firm’s innovative activities. Moreover, firm-level analysis provides essential information on the micro-mechanisms that explain aggregate employment growth. Therefore, recent studies mostly focus their research on firm-level analysis and then use sector-level analysis for explaining the micro-mechanisms of innovation and confirming the results.

3.1 Firm-level analysis

In order to estimate the firm-level employment effect of different types of innovation, this paper uses the similar econometric model and estimation strategy as Harrison et al. (2008, 2014). We use this methodology for the following two reasons:

(1) Measurement

Harrison et al. (2008, 2014) used ‘sales growth due to new products’[9] as a proxy for product innovation. This variable can measure the intensity of product innovation of firms, to provide more information about its importance rather than simply using a product innovation dummy.

(2) Comparability

Harrison et al. (2008, 2014) already investigated the case of four European countries, such as France, Spain, German and the UK, in their research paper. Thus, we can directly compare the regression results with the four European countries using the same methodology as per Harrison et al. (2008, 2014).

[9] The data provide us the percentage of new product sales in total sales. Thus, we can decompose total sales in sales of “new” and “old” product and calculate the sales growth due to new and old product separately. Then, we use “sales growth due to new products” as a new proxy for product innovations and subtract the “sales growth due to old products” from the “employment growth” in order to calculate the pure employment growth due to the innovation, which will be used as dependent variable of the research.

3.1.1 Econometric model

Harrison et al. (2008) assumed that there are two periods (t=1, 2) and a firm can produce two types of products: Old and new (i=1, 2). They assumed that the production technology for old and new products follows constant returns to scale (CRS) in capital K, labor L, and intermediate inputs M, and can be written as two separable production functions with different Hicks-neutral technological productivity. In addition, they assumed that firms may deviate from common technology by idiosyncratic advantages modeled by means of a firm fixed effect. Finally, production of old and new products in the second period is subject to unanticipated productivity shocks.

$$Y_{it} = \theta_{it} F(K_{it}, L_{it}, M_{it}) e^{\eta + \omega_{it}} \quad i = 1, t = 1, 2 \text{ and } i = 2, t = 2$$

Y_{1t} : *outputs of old products*
Y_{2t} : *outputs of new products*
K_{it} : *capital*
L_{it} : *labor*
M_{it} : *intermedia te consumptio n*

θ_{it} : *Hicks - neutral technology parameter*
η : *unobserved firm - idiosyncra tic " fixed" effect*
ω_{it} : *product and time - specific productivi ty shocks*

On the other hand, they assumed that employment and other decisions about inputs are made according to cost minimization given the individual productivity effects and productivity shocks. Given the technology, the relevant cost functions have the form:

$$C(\omega_{it}, Y_{it}, \theta_{it}) = c(\omega_{it}) \frac{Y_{it}}{\theta_{it} e^{\eta + \omega_{it}}} + F_i$$

According to Shephard's lemma, labor demand for the old and new products can be written as:

$$L_{1t} = c_{wL}(w_{1t}) \frac{Y_{1t}}{\theta_{1t} e^{\eta + \omega_{1t}}} \quad \textit{for } t = 1{,}2$$

$$L_{22} = c_{wL}(w_{22}) \frac{Y_{22}}{\theta_{22} e^{\eta + \omega_{22}}} \quad \textit{if } Y_{22} > 0 \textit{ and } L_{22} = 0 \textit{ otherwise}$$

To proceed, they made the simplifying assumptions that

$$c_{wL}(w_{11}) = c_{wL}(w_{12}) = c_{wL}(w_{22})$$

They decomposed the growth of employment between the two years t=1 and t=2, into the growth of employment due to production of old and new products in the following way:

$$\frac{\Delta L}{L} = \frac{L_{12} + L_{22} - L_{11}}{L_{11}} = \frac{L_{12} - L_{11}}{L_{11}} + \frac{L_{22}}{L_{11}} \cong \ln \frac{L_{12}}{L_{11}} + \frac{L_{22}}{L_{11}}$$

Based on this decomposition and the labor demand equations with the simplifying assumptions, they write the following employment growth equation:

$$\frac{\Delta L}{L} \cong -(\ln \theta_{12} - \ln \theta_{11}) + (\ln Y_{12} - \ln Y_{11}) + \frac{\theta_{11}}{\theta_{22}} \frac{Y_{22}}{Y_{11}} - (\omega_{12} - \omega_{11})$$

Finally, they obtained the last employment growth equation, which can be rewritten as the following econometric regression:

$$l = \alpha_0 + \alpha_1 d + y_1 + \beta y_2 + u$$

l : rate of employment growth over the time
y_1 *: rate of output growth of old products*
y_2 *: rate of output growth of new products*
d : process innovation only dummy(0/1)

However, they have to substitute the growth in nominal sales for the growth in real production in order to estimate the above equation.

$$l = \alpha_0 + \alpha_1 d + y_1 + \beta y_2 + u$$
$$l - y_1 = \alpha_0 + \alpha_1 d + \beta y_2 + u$$
$$l - g_1 = \alpha_0 + \alpha_1 d + \beta g_2 + v$$

$$g_1 = \left(\frac{P_{12}Y_{12} - P_{11}Y_{11}}{P_{11}Y_{11}}\right) \cong y_1 + \pi_1, \text{where } \pi_1 = \left(\frac{P_{12} - P_{11}}{P_{11}}\right)$$
$$g_2 = \left(\frac{P_{22}Y_{22}}{P_{11}Y_{11}}\right) = y_2(1+\pi_2) = y_2 + \pi_2 y_2, \text{ where } \pi_2 = \left(\frac{P_{22} - P_{11}}{P_{11}}\right)$$

Thus, they substitute g1 and g2 instead of y1 and y2 and obtain the following equation:

$$l - g_1 = \alpha_0 + \alpha_1 d + \beta g_2 + v$$

$$where, v = -\pi_1 - \beta\pi_2 y_2 + u$$

However, this econometric model has two additional problems:

$$(1)\, g_2\, (= y_2 + \pi_2 y_2)\, is\, correlated with\, v\, (= -\pi_1 - \beta\pi_2 y_2 + u)$$
$$(2)\, v\, (= -\pi_1 - \beta\pi_2 y_2 + u)\, includes\, \pi_1$$

3.1.2 Estimation strategy

To consistently estimate the true parameters of the model, we have to solve the endogeneity problem between g2 and v. Therefore, the estimation strategy relies on the choice of instrumental variables that can be considered to be 1) correlated with g2 and 2) uncorrelated with v. We use a) the purpose of innovation is replacement of old products: 0-5, and b) the purpose of innovation is to increase the range of products: 0-5 as instrument variables (IVs) for g2 and use 2SLS (2 Stage Least Square) method for the estimation.

$$l - (g_1 - \pi) = \alpha_0 + \alpha_1 d + \beta g_2 + v$$

$$where, v = -\pi_1 - \beta\pi_2 y_2 + u$$

(1) Dependent variable :
employment growth due to innovation only $(l - (g_1 - \pi))$
(2) Independent variables :
process innovation only dummy (d)
sales in new products/ sales in old products (g_2)

For the 2SLS methods, we use two IVs instead of g2:

(1) the purpose of innovation is replacement of old products : 0 - 5
(2) the purpose of innovation is to increase the range of the products : 0 - 5

On the other hand, the proxy for process innovation (*d*) is a dummy variable for firms that implement only process innovation. Accordingly, β can be biased, since *d* does not capture the employment effect of process innovation of product innovators. Hence, we add *d**, which represents a dummy variable for firms that implement both process and product innovation, for controlling the effect of process innovation of product innovators. Finally, we have an equation, which considers the effect of both process and product innovators:

$$l-(g_1-\pi)=\alpha_0+\alpha_1 d+\beta g_2+\alpha_2 d^*+v$$

$$where, v = -\pi_1 - \beta\pi_2 y_2 + u$$

(1) Dependent variable :
employment growth due to innovation only $(l-(g_1-\pi))$
(2) Independent variables :
process innovation only dummy (d)
sales in new products/ sales in old products (g_2)
process and prooduct innovation dummy (d)*

For the 2SLS methods, we use two IVs instead of g2:

(1) the purpose of innovation is replacement of old products : 0 - 5
(2) the purpose of innovation is to increase the range of the products : 0 - 5

Dynamic effect of innovation on employment

Innovation can directly create jobs, but it can takes time to result in employment. In order to show the long-term effect of innovation on employment, we add lagged innovation variables into the model and estimate the long-term effect of innovation on employment; subscript *"t"* represents the present period, thus *"t-1"* represents the previous period[10].

$$l_t - (g_{1,t} - \pi_t) = \alpha_0 + \alpha_1 d_t + \alpha_2 d_t{}^* + \beta g_{2,t} + \delta_1 d_{t-1} + \delta_2 d_{t-1}{}^* + \omega g_{2,t-1} + v_t$$

$$where, v_t = -\pi_{1,t} - \beta\pi_{2,t} y_{2,t} + u_t$$

(1) Dependent variable :

employment growth due to innovation only at period t $(l_t - (g_{1,t} - \pi_t))$

(2) Independent variables :

process innovation only dummy at period t (d_t)

sales in new products/ sales in old products at period t $(g_{2,t})$

process and prooduct innovation dummy at period t $(d_t{}^*)$

(3) Added independent variables :

process innovation only dummy duing at period t - 1 (d_{t-1})

sales in new products/ sales in old products at period t - 1 $(g_{2,t-1})$

process and prooduct innovation dummy at period t - 1 $(d_{t-1}{}^*)$

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[10] Each period is three years, so the lagged innovation variables are varied from one to three years.

Market structure and employment effect of innovation

In order to consider the 'market structure' in the model, we divide the industry as monopolistic and non-monopolistic, and estimate the employment effect of each type of innovation in different market structures. However, we additionally show whether these differences are significant or not. Thus, we generate a) a new variable for measuring "market structure (m)" and make the interaction term between b) market structure and process innovation (m*d), and 3) market structure and product innovation (m*g2) in the existing model. Then, we check the significance of the differences between the employment effect of innovation in monopolistic and non-monopolistic markets:

$$l-(g_{1}-\pi)=\alpha_0+\alpha_1 d+\beta g_2+\alpha_2 d^{*}+\gamma_1 m+\gamma_2 m\times d+\gamma_3 m\times g2+v$$

$$where, v = -\pi_1 - \beta\pi_2 y_2 + u$$

(1) Dependent variable :

employment growth due to innovation only $(l - (g_1 - \pi))$

(2) Independent variables :

process innovation only dummy (d)

sales in new products/ sales in old products (g_2)

process and prooduct innovation dummy (d)*

(3) Added independent variables :

market structure (m)

process innovation in monopolistic market $(m \times d)$

product innovation in monopolistic market $(m \times g2)$

3.2 Sector-level analysis

Greenan and Guellec(2000) provide a useful methodology for sector-level analysis. They calculate the industry-level variables by calculating the weighted average of firm-level variables. Thus, we can consistently estimate the sector-level employment effect of innovation using the same dataset with firm-level analysis.

3.2.1 Econometric model

In order to estimate the sector-level employment effect of different types of innovation, we use the following econometric model. We have three dependent variables, representing the industry-level employment growth: a) job-creating rate (*y1*), b) job destruction rate (*y2*), and c) job growth rate (*y3*); and two independent variables for different types of innovation, a) intensity of process innovations (procs), and b) intensity of product innovations (prods).

$$\mathrm{y} = \alpha + \alpha_1 procs + \alpha_2 prods + u$$

(1) Dependent variable :

job creating rate (y_1), *job destruction rate* (y_2), *net employment growth rate* (y_3)

(2) Independent variables :

intensity of process innovations (procs)

intensity of product innovation (prods)

3.2.2 Estimation strategy

However, Greenan and Gullec (2000) found that there is a strong decreasing pattern in job flow rates, a) job-creating rate, b) job destruction rate, and c) job growth rate, by firm-size. Thus, they recommend calculating the industry-level job flow rates by firm-size and controlling the size bias using size dummy variables.

Table 3-1. Various job flow rates, by firm-size

Number of employees	g_pos	g_neg	g_net	Employment level	Employment share
0-19	0.2068	0.0768	0.1300	9115	2.17
20-49	0.1572	0.0621	0.0951	39702	9.44
50-299	0.1168	0.0522	0.0646	152394	36.23
300-999	0.1084	0.0749	0.0335	87963	20.91
1000+	0.0523	0.0593	-0.0070	131501	31.26
Total	0.1006	0.0606	0.0400	420674	100.00

Therefore, industry-level dependent variables are now calculated as group-level variables (21 industries and five firm-sizes), but no size criterion is used for independent variables[11]. Accordingly, the total number of groups for the sector-level analysis is 399 (21 industries, five firm-size, and four periods), and we include four size dummies and three period dummies, so as to control the size and time effect. Finally, we estimate the previous econometric model using the OLS estimation method.

[11] No size criterion is used for independent variables, since there is no tendency on the degree of process or product innovation by firm size. Therefore, independent variables are calculated as industry-level variables.

Dynamic effect of innovation on employment

In order to estimate the long-term employment effect of innovations at the sector-level, we use the following econometric models for the analysis. Lagged innovation variables are added into the model: a) lagged intensity of process innovations (procs, t-1) and b) lagged intensity of product innovations (prods, t-1). All variables are calculated as group-level variables[12] and the OLS estimation method is used.

$$y_t = \alpha_0 + \alpha_1 \cdot procs_t + \alpha_2 \cdot prods_t + \beta_1 \cdot procs_{t-1} + \beta_2 \cdot prods_{t-1} + u$$

(1) Dependent variable :

job creating rate $(y_{1,t})$, *job destruction rate* $(y_{2,t})$, *net employment growth rate* $(y_{3,t})$

(2) Independent variables :

intensity of process innovations $(procs_t)$

intensity of product innovation $(prods_t)$

lagged intensity of process innovations $(procs_{t-1})$

lagged intensity of product innovation $(prods_{t-1})$

4 size dummies are included

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[12] The same methodology used for calculating the industry-level of dependent and independent variables is used for the estimation of the dynamic effect of innovation on employment.

IV. Data and Variables

4.1 Data

KIS (Korea Innovation Survey) data established by STEPI (Science Technology Policy Institution) from 1999-2009 is used for the research. KIS is a firm-level and cross-section dataset survey, carried out every 2-3 years and has had five waves until now (KIS 2002, 2005, 2008, 2010, and 2012)[13]. All samples are representative of industry size strata, but sampling firms are different at each period. Most questionnaires are similar, but some are added or excluded.

Questionnaires are based on the innovation activities of firms and their financial information for the last three years. Dependent variables are calculated as a form of growth rate for two years and the independent variables are the firms' innovation activities during this period. The biggest advantage of this data is the comparability of other datasets. The questionnaires are based on *Oslo manuals*, so we can compare the regression results with those of other countries*;* Europe, Japan and the USA have similar innovation survey data based on the *Oslo manuals.*

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[13] The first survey is initiated in 2002 and the last was undertaken in 2012. The survey is conducted on both manufacturing and service firms separately. KIS for manufacturing firms was undertaken in 2002, 2005, 2008, 2010, and 2012 and that for service firms in 2003, 2006, 2010, and 2012. KIS 2002 is the survey performed in 2002, referring to the period from 1999-2001. Similarly, KIS 2005 is for 2002-2004, KIS 2008 for 2005-2007, KIS 2010 for 2007-2009 and KIS 2012 for 2010-2012.

We use KIS 2002-2010 for the analysis[14] and calculate the dependent and independent variables according to the methodologies we used. We use the same variables as Harrison et al. (2008) and Greenan and Guellecs(2000) for firm- and sector-level analysis respectively. To define the outliers, we use the same standard as Harrison (2008, 2014) and exclude the firms that exceed over 300% sales growth for two years or 300% employment growth for two years (1999-2001, 2002-2004, 2005-2007, and 2007-2009). We also exclude the firms that have missing values for dependent or independent variables. Finally, we have 11,368 sample firms from 1999-2009. Table 3-1 shows how firms are distributed according to time and industries.

Table 4-1. Sample firms by sector and period

Industry code	Industry name	KIS2002	KIS2005	KIS2008	KIS2010	Total
15	Food and Beverages	115	151	157	268	691
17	Textiles	137	138	145	158	578
18	Apparel, Clotheing Accessories and Fur Articles	33	57	126	133	349
19	Leathers, Luggage and Footwear	35	31	94	82	242
20	Wood Products of Wood and Cork	29	43	121	124	317
21	Paper and Paper Products	26	65	129	158	378
22	Printing and Reproduction of Recorded Media	41	63	129	124	357
23	Coke, Hard-coal and Lignite Fuel Briquettes and Refined Petroleum Products	13	31	41	41	126
24	Chemicals and Chemical Products	293	234	238	427	1192
25	Rubber and Plastic Products	148	146	140	212	646
26	Other Non-metallic Mineral Products	134	92	165	205	596
27	Basic Metal Products	187	110	160	200	657
28	Fabricated Metal Products	135	164	161	217	677
29	Machinery and Equipment	296	273	195	250	1014
30	Office Machinery and Equipment	11	34	69	14	128
31	Other Electric Equipment and generators	131	179	136	212	658
32	Electronic Components and Communication Equipment and Apparatuses	326	196	152	185	859
33	Medical, Precision and Optical Instruments, Watches and Clocks	55	58	114	146	373
34	Motor Vehicles, Trailers and Semitrailers	259	170	178	213	820
35	Other Transport Equipment	63	56	79	113	311
36	Furniture and others	67	63	136	134	400
Total		2,534	2,354	2,865	3,616	11,369

[14] KIS 2012 is excluded because the important questionnaires for the research are different at this period.

4.2 Variables

Dependent and independent variables are calculated according to the methodology they used. Firm-level variables are calculated as per Harrison et al. (2008, 2014) and sector-level variables are calculated as per Greenan and Guellec (20000).

4.2.1 Firm-level variables

We calculate the firm-level variables according to Harrison et al. (2008, 2014)'s method. The dependent variable is employment growth rate minus real sales growth rate of the old products (i.e., the dependent variable is $\left(l-(g_1-\pi)\right)$ and the key explanatory variables are the process innovation only dummy *(d)* and sales growth due to new products *(g2)* variables. In all regression, we include a full set of industry and time dummies.

From now on, we present the descriptive statistics for variables by the purpose of the research. First, we show them by different periods; second, by different countries; and third, by different market structures. We additionally show the descriptive statistics for three sets of panel datasets, which are constructed for the dynamic effect of innovations.

(1) Korean manufacturing firms from 1999-2009

During 1999-2009, the average share of non-innovating firms in Korea was 52.6%, which means that the average share of innovating firms was 47.4%. Among these, process innovators were 31.9 % and product innovators were 41.0%[15].

The average employment growth rate of Korean manufacturing firms was 6.7% for two years, which means 3.35% per year. Obviously, the employment growth rate of innovating firms is greater than that of non-innovating firms and this is caused by process innovators. Employment growth of process innovators is even greater than that of product innovators (Table 4-2).

This seems to be caused by the sales growth rate of firms. The average sales growth rate of process innovators is 28.9% for 2 years, which is 14.5% per year. This is the highest-level in three different types of firms (non-innovators, process innovators, and product innovators) and it could be due to the efficient production system of process innovators in Korea. The productivity growth of process innovators is also the highest in Korea.

[15] The share of process innovators is 31.9%, since the share of firms that only implement the process innovations is 6.4% and those that implement both types of innovation is 25.5%. On the other hand, the share of product innovators is 41.0%. Thus, the share of firms that only implement product innovation is 15.5%.

Table 4-2. Descriptive statistics for the variables; Korean manufacturing firms from 1999-2009

	Korean manufacturing firms				
	KIS 2002	KIS 2005	KIS 2008	KIS 2010	Total
No of firms	**2534**	**2354**	**2865**	**3616**	**11369**
Non-innovators (%)	53.9	50.3	60.9	46.6	52.63
Process only (%)	4.8	6.3	5.9	7.9	6.4
Product innovators (%)	41.4	43.3	33.1	45.5	41.0
[Of which product & process innovators]	[23.5]	[25.5]	[21.5]	[29.9]	[25.5]
Employment growth (%)					
All firms	6.7	9.0	6.7	6.1	7.0
Non-innovators	2.6	7.2	6.1	4.4	5.0
Process only	6.1	17.4	9.0	8.5	10.0
Product innovators	12.2	10.0	7.5	7.4	9.1
Sales growth (%)					
All firms	23.1	29.5	22.4	22.4	24.0
Non-innovators	18.3	26.1	21.4	17.5	20.5
Process only	27.9	37.1	29.7	24.5	28.9
Product innovators	28.7	32.4	23.0	27.0	27.8
of which:					
Old products	-38.0	-35.5	-19.0	-14.4	-25.3
New products	66.7	67.9	42.0	41.5	53.0
Productivity growth (%)					
All firms	16.3	20.5	15.7	16.3	17.0
Non-innovators	15.7	18.9	15.4	13.1	15.5
Process only	21.8	19.7	20.8	16.1	18.9
Product innovators	16.5	22.4	15.5	19.6	18.7
Price growth (%)					
All firms	-2.1	5.9	-0.9	11.4	4.2
Non-innovators	-1.8	6.2	-0.1	12.8	4.4
Process only	0.1	5.9	-0.3	11.7	5.8
Product innovators	-2.8	5.6	-2.3	10.0	3.7

** KIS 2002 is for Korean manufacturig firms from 1999-2001*

**KIS 2005 is for Korean manufacturing firms from 2002-2004*

**KIS 2008 is for Korean manufacturing firms from 2005-2007*

**KIS 2010 is for Korean manufacturing firms from 2007-2009*

(2) Korea vs. Four European countries

Harrison et al. (2008, 2012) already did the same econometric works for four European countries from 1998 to 2000. Therefore, we use KIS2002, which is for Korean manufacturing firms from 1999 to 2001, and compare the descriptive statistics of variables with them.

During this period, the share of innovating firms in Korea is 46.1%, which is not that high but not that low as well compared to other European countries. Korea innovates more than Spain and the UK, but less than Germany and France. The average employment growth rate of Korea is 6.7%, which is normal, but the average sales growth rate of Korea is high (23.1%) compared to other countries.

This is a very significant result, since Spain has a similar sales growth rate (23.2%) as Korea (23.1%) but also has a high employment growth rate (14.2%) in contrast with Korea (6.7%). This high productivity growth of Korean manufacturing firms (16.3%) is caused by that of process innovators (21.8%). Of course, other types of firms in Korea also have higher productivity growth than the same types of firms in other countries, but that of process innovators has the highest level of productivity growth in other types of Korean manufacturing firms.

Table 4-3. Descriptive statistics for the variables; Korea vs. Europe

	Korea (1999-2001)	France	Germany (1998-2000)	Spain	UK
No of firms	**2534**	**4631**	**1319**	**4548**	**2533**
Non-innovators (%)	53.9	47.7	41.5	55.4	60.5
Process only (%)	4.8	7.1	10.2	12.2	11.0
Product innovators (%)	41.4	45.2	48.4	32.4	28.5
[Of which product & process innovators]	[23.5]	[24.3]	[27.4]	[20.0]	[14.1]
Employment growth (%)					
All firms	6.7	8.3	5.9	14.2	6.6
Non-innovators	2.6	7.0	2.4	12.6	5.4
Process only	6.1	7.5	6.0	16.2	8.0
Product innovators	12.2	9.8	8.9	16.2	8.5
Sales growth (%)					
All firms	23.1	13.0	15.2	23.2	12.3
Non-innovators	18.3	11.0	10.8	21.7	10.8
Process only	27.9	13.4	21.7	23.6	16.3
Product innovators	28.7	15.0	17.5	25.7	13.9
of which:					
Old products	-38.0	-2.3	-17.0	-13.7	-21.2
New products	66.7	17.3	34.5	39.4	35.1
Productivity growth (%)					
All firms	16.3	4.7	9.3	9.0	5.7
Non-innovators	15.7	4.0	8.4	9.1	5.3
Process only	21.8	5.9	15.7	7.4	8.3
Product innovators	16.5	7.5	8.7	9.5	5.4
Price growth (%)					
All firms	-2.2	2.5	1.3	3.9	-1.7
Non-innovators	-1.8	2.5	1.1	4.0	-1.0
Process only	0.2	3.1	2.4	4.2	-0.4
Product innovators	-2.9	2.4	1.3	3.7	-3.3

(3) Monopolistic vs. Non-monopolistic industry

We calculate the industry-level CR3[16] and define the industry as monopolistic and non-monopolistic by using this. Table 4-4 shows the industry-level CR3 from 1999-2009. We classify the industries, that is, which industry-level CR3 is over 0.7 as monopolistic industries.

Finally, industry numbers 21, 23, 30, and 35 are classified as monopolistic in 1999-2001 and industry numbers 23 and 35 have to be kept classified as monopolistic industries until 2009. Industry number 17 is newly classified as a monopolistic industry in 2007-2009.

Table 4-4. CR3 by industry; Korean manufacturing firms from 1999-2009

Industry code	Industry name	CR3			
		KIS2002	KIS2005	KIS2008	KIS2010
15	Food and Beverages	35.28%	47.24%	25.53%	14.35%
17	Textiles	23.48%	39.06%	78.99%	72.94%
18	Apparel, Clotheing Accessories and Fur Articles	40.49%	41.10%	25.27%	28.85%
19	Leathers, Luggage and Footwear	46.46%	44.32%	43.92%	29.78%
20	Wood Products of Wood and Cork	62.64%	60.40%	61.52%	37.61%
21	Paper and Paper Products	76.86%	50.07%	34.78%	28.49%
22	Printing and Reproduction of Recorded Media	34.78%	38.72%	28.20%	19.54%
23	Coke, Hard-coal and Lignite Fuel Briquettes and Refined Petroleum Products	97.77%	97.05%	95.42%	98.19%
24	Chemicals and Chemical Products	33.88%	35.34%	24.48%	33.55%
25	Rubber and Plastic Products	52.60%	48.54%	56.64%	41.88%
26	Other Non-metallic Mineral Products	48.29%	32.12%	27.06%	21.27%
27	Basic Metal Products	30.84%	58.29%	56.63%	53.57%
28	Fabricated Metal Products	59.20%	11.39%	24.63%	20.47%
29	Machinery and Equipment	34.74%	32.92%	52.07%	41.53%
30	Office Machinery and Equipment	75.72%	54.26%	51.75%	81.17%
31	Other Electric Equipment and generators	34.77%	24.25%	38.47%	40.06%
32	Electronic Components and Communication Equipment and Apparatuses	14.38%	42.18%	35.60%	63.22%
33	Medical, Precision and Optical Instruments, Watches and Clocks	51.54%	39.04%	43.95%	60.89%
34	Motor Vehicles, Trailers and Semitrailers	36.50%	14.69%	66.88%	23.00%
35	Other Transport Equipment	92.88%	73.91%	72.77%	68.84%
36	Furniture and others	36.85%	33.20%	34.80%	35.68%
Total		37.60%	37.52%	43.70%	38.11%

[16] The standard tools of competition used by economists and competition authorities to measure market concentration are the Herfindahl index (HHI) and the concentration ratios (CR(n)).These two are known as the traditional structural measures of market concentration (based on market shares).

Table 4-5 shows the descriptive statistics of variables by different market structures. Among 11,369 manufacturing firms, 10,984 are classified as firms in the competitive market and 385 as those in the monopolistic market.

According to the Table 4-5, as opposed to Schumpeterian hypothesis, firms in the competitive market innovate more than those in the monopolistic market do. Specifically, the competitive market has more product innovators. The average employment growth rate of firms in the competitive market is greater than that of firms in the monopolistic market. However, that of non-innovators is similar, and that of innovators in the competitive market is greater than that in the monopolistic market.

An interesting fact is that the average sales growth rate of process innovators in the competitive market is lower than that in the monopolistic market. Previously, we found that the average employment growth rate of process innovators in the competitive market is higher than that in the monopolistic market. This indicates that process innovators in the latter market are highly efficient and productive, which leads to more sales but use less employment than that in the competitive market.

Therefore, we can conjecture that process innovation in monopolistic markets has a greater job displacement effect than that in non-monopolistic market.

Table 4-5. Descriptive statistics for the variables by different market structure

	Korean manufacturing firms from 1999-2009		
	Competitive	Monopolistic	Total
No of firms	**10,984**	**385**	**11,369**
Non-innovators (%)	52.3	62.3	52.6
Process only (%)	6.4	6.8	6.4
Product innovators (%)	41.4	30.9	41.0
[Of which product & process innovators]	[25.8]	[16.9]	[25.5]
Employment growth (%)			
All firms	7.1	4.5	7.0
Non-innovators	5.0	4.8	5.0
Process only	10.2	6.3	10.0
Product innovators	9.2	3.5	9.1
Sales growth (%)			
All firms	24.1	21.7	24.0
Non-innovators	20.5	20.4	20.5
Process only	28.4	43.0	28.9
Product innovators	28.0	19.7	27.8
of which:			
Old products	-25.2	-28.1	-25.3
New products	53.2	47.8	53.0
Productivity growth (%)			
All firms	17.0	17.2	17.0
Non-innovators	15.5	15.6	15.5
Process only	18.2	36.7	18.9
Product innovators	18.8	16.2	18.7
Price growth (%)			
All firms	4.1	7.5	4.2
Non-innovators	4.3	6.5	4.4
Process only	5.6	8.9	5.8
Product innovators	3.5	9.2	3.7

(4) Consecutive firms in two different time periods

In order to determine the long-term effect of innovation, this paper constructs the balanced panel datasets. We collect the consecutive firms in two different periods and make the panel datasets using these firms. Therefore, we have three different panel datasets (KIS 2002-2005, KIS 2005-2008, and KIS 2008-2010) from four different cross-section datasets (KIS 2002, 2005, 2008, and 2010). Then, we make lagged independent variables of each type of innovation and check whether the former period of innovations affects the latter period of employment growth or not. Thus, total 1,220 firms are used for estimating the long-term effect of innovation

According to Table 4-6, non-innovating firms are decreased from period1 to period2; process innovators are increasing, but product innovators are decreasing. From period 1 to period 2, average employment growth rate, sales growth rate and even productivity growth rate have decreased. An interesting fact is that innovating firms have similar productivity growth at periods 1 and 2, but productivity growth of non-innovating firms has decreased.

Table 4-6. Descriptive statistics for the variables; consecutive firms in two different periods

	KIS 2002-2005		KIS 2005-2008		KIS 2008-2010	
	KIS 2002	KIS 2005	KIS 2005	KIS 2008	KIS 2008	KIS 2010
No of firms	**308**	**308**	**356**	**356**	**556**	**556**
Non-innovators (%)	33.8	39.9	42.7	33.7	38.7	33.1
Process only (%)	6.2	8.1	7.0	9.0	7.7	9.7
Product innovators (%)	60.1	52.0	50.3	57.3	53.6	57.2
[Of which product & process innovators]	[40.3]	[31.5]	[33.7]	[42.7]	[40.7]	[40.8]
Employment growth (%)						
All firms	10.7	2.5	9.7	1.5	5.3	0.2
Non-innovators	7.7	-1.7	9.6	0.7	5.8	-1.3
Process only	12.3	6.9	20.8	1.9	8.2	7.2
Product innovators	12.2	5.1	8.2	1.9	4.6	-0.1
Sales growth (%)						
All firms	31.3	20.7	30.7	15.7	23.6	18.3
Non-innovators	28.9	13.8	31.6	11.2	24.7	12.0
Process only	29.4	25.1	47.1	30.6	38.4	21.2
Product innovators	32.9	25.2	27.5	16.0	20.6	21.5
of which:						
Old products	-33.2	-38.1	-35.7	-17.2	-14.3	-12.1
New products	66.0	63.3	63.2	33.2	34.9	33.5
Productivity growth (%)						
All firms	20.6	18.1	21.0	14.2	18.2	18.1
Non-innovators	21.2	15.5	22.0	10.5	18.9	13.4
Process only	17.1	18.2	26.3	28.8	30.2	14.0
Product innovators	20.7	20.1	19.4	14.1	16.1	21.5
Price growth (%)						
All firms	-1.3	7.9	6.8	-0.4	-0.9	10.6
Non-innovators	-0.1	8.2	5.6	-1.4	-0.1	11.8
Process only	0.6	6.1	8.8	-0.4	-0.5	11.3
Product innovators	-2.3	7.8	7.6	0.1	-1.4	9.8

4.2.2 Sector-level variables

As we previously mentioned, we use the same dataset with firm-level analysis, KIS 2002-2010, for the sector-level analysis. Hence, we calculate the industry-level variables using firm-level database and the followings are the specific methods, which is illustrated in Greenan and Guellec (2000).

(1) Dependent variable: job flow indicators; $g_{st}^{pos}, g_{st}^{neg}, g_{st}^{net}$

Let E_{et} be the size of the firm or the establishment e at a date t.
We measure x_{et}, which is the average employment between t and $t-1$:

$$x_{et} = \frac{E_{et} + E_{et-1}}{2}.$$

Let g_{et} be the time t growth rate of employment :

$$g_{et} = \frac{E_{et} - E_{et-1}}{x_{et}}.$$

We then have three different measures of job flow within a given category s that can be the sector, age, size etc.:

$$g_{st}^{pos} = \sum_{\substack{e \in E_{st} \\ g_{et} > 0}} \frac{x_{et}}{x_{st}} g_{et}$$

$$g_{st}^{neg} = \sum_{\substack{e \in E_{st} \\ g_{et} > 0}} \frac{x_{et}}{x_{st}} \left| g_{et} \right|$$

$$g_{st}^{net} = g_{st}^{pos} - g_{st}^{neg}$$

The first measure is a job-creating rate(g_{st}^{pos}) , which is the size weighted means of positive growth rates of employment. The second measure is a job destruction rate (g_{st}^{neg} ,) which is size weighted means of negative growth rates of employment. The third measure is job growth rate (g_{st}^{net} .) which is an aggregated net employment growth rate. The job growth rate can be decomposed as job-creating rate and job destruction rate.

Table 4-7 shows the industry average of various job flow rates. The average job -creating rate is 8.4% and average job destruction rate is 6.7% for two years. Thus, the average job growth rate is 1.6% for two years, which means 0.8% per year. According to Table 4-7, we can divide the sectors into four different groups. The first group is that of the industries, that have both high job-creating rate and high destruction rate; the industry codes for these industries are 25, 30, 32, and 33. The second group includes the industries, that have a high job-creating rate but low job destruction rate; and their industry codes are 29 and 34. The third group comprises the industries, that have a low job-creating rate but high job destruction rate; and their industry codes are 19, 22, 24, 26, 31, and 36. Finally, the fourth group includes the industries, which have low job creating rate and low job destruction rates; and their industry codes are 15, 17, 21, 23, 27, 28, and 35.

An interesting fact is that industries that have high job growth are industry codes 19, 22, 25, 29, 30, 32, 33, and 34 and most of them belongs to groups 1 and 2 and partly to group3. Group4, which has low job-creating and job destruction rates, has the lowest job growth rate among these. From this fact, we can conclude that a high job-creating rate is a necessary condition for a high job growth rate, but a low destruction rate is not necessary for a high job growth rate[17].

Table 4-7. Industry average of dependent variables

Industry code	Industry name	Job creating rate	Job destruction rate	Net employment growth rate
15	Food and Beverages	0.0480	0.0510	-0.0031
17	Textiles	0.0579	0.1130	-0.0551
18	Apparel, Clotheing Accessories and Fur Articles	0.0946	0.1054	-0.0107
19	Leathers, Luggage and Footwear	0.1059	0.1119	-0.0060
20	Wood Products of Wood and Cork	0.0461	0.0815	-0.0355
21	Paper and Paper Products	0.0558	0.0519	0.0039
22	Printing and Reproduction of Recorded Media	0.0835	0.0683	0.0152
23	Coke, Hard-coal and Lignite Fuel Briquettes and Refined Petroleum Products	0.0426	0.0149	0.0277
24	Chemicals and Chemical Products	0.0802	0.0452	0.0350
25	Rubber and Plastic Products	0.0995	0.0677	0.0318
26	Other Non-metallic Mineral Products	0.0640	0.0741	-0.0101
27	Basic Metal Products	0.0504	0.0489	0.0015
28	Fabricated Metal Products	0.0931	0.0477	0.0453
29	Machinery and Equipment	0.1068	0.0537	0.0532
30	Office Machinery and Equipment	0.1276	0.0793	0.0483
31	Other Electric Equipment and generators	0.0830	0.0757	0.0073
32	Electronic Components and Communication Equipment and Apparatuses	0.1089	0.1184	-0.0094
33	Medical, Precision and Optical Instruments, Watches and Clocks	0.1717	0.0820	0.0897
34	Motor Vehicles, Trailers and Semitrailers	0.0966	0.0366	0.0600
35	Other Transport Equipment	0.0775	0.0220	0.0555
36	Furniture and others	0.0793	0.0747	0.0046
Total		0.0844	0.0678	0.0166

[17] Normally, people consider low destruction rate as being better for the employment growth. However, Table 4-7 shows that a high destruction rate is better if industries do not have a high job-creating rate. In other words, stagnant industries, neither creating jobs nor destroying jobs, are the worst for the employment growth of an industry. Dynamics within industries are important for employment growth of an industry.

(2) Independent variables; *procs, prods, innovs, innorels*

We calculate the two indicators of innovation at the sector level. 1) "*prod*" and 2) "*procs*" measure the intensity of product innovation and process innovation respectively. These variables represent the share, in the sector employment, of firms that have implemented at least one product innovation *(prods)*, or process innovation *(procs)*.

On the other hand, we additionally calculate two other variables for the research: "*innovs*" and "*innorels.*" 3) "*innovs*" meaures the intensity of innovation and is the share of firms that have implemented at least one product or process (either type of) innovation *(innovs).* 4) '*innorels*' is the sector ratio of "*prods*" on "*procs*", which measures the orientation of an innovation. Therefore, when "*innorels*" is greater than 1, product innovation prevails in the sector and viceversa when it is lesser than one.

Table 4-8 shows the industry-level innovation variables for this. The average employment share of product innovators is 66.92% and that of process innovators is 51.04%. Thus, the average employment share of innovators is 60.59% and that of product innovators to process innovators is 1.33 on average. Here, we divide the sectors into four groups by the degree of innovation intensity. The first group includes industries, that have both high share of product and process innovators; and their industry codes are 23, 24, 28, 30, 33, and 35. The second group comprises, that have a high share of product innovators but low share of process innovators; their industry codes are 15, 29, 31, and 34. The third group includes the industries, that have a low share of product innovators but high share of process innovators; and their industry codes are 26 and 27. Finally, the fourth group comprises the industries that have both low share of product innovators and process innovators; and their industry codes are 17, 18, 19, 20, 21, 22, 25, 32, and 36.

As a result, industries that generally have a high intensity of innovation are the industry codes 15, 23, 24, 28, 29, 30, 31, 33, 34 and 35 and they belong to groups 1 and 2. Therefore, we can predict that industries that have more product innovators innovate more. Moreover, we find that the most prominent industries from the perspective of the job growth rate, group 2 in previous section, have a high share of product innovators but low share of process innovators. Therefore, we can conjecture that product innovation may have a positive employment effect, while process innovations may not.

Table 4-8. Industry average of independent variables

KISC code	industry name	(1)	(2)	(1)+(2)	(1)/(2)
15	Food and Beverages	0.7973	0.6203	0.7627	1.2707
17	Textiles	0.5769	0.4622	0.5384	1.2504
18	Apparel, Clotheing Accessories and Fur Articles	0.3626	0.2184	0.3176	1.5994
19	Leathers, Luggage and Footwear	0.5657	0.3734	0.5190	1.3864
20	Wood Products of Wood and Cork	0.4188	0.2369	0.3628	2.6107
21	Paper and Paper Products	0.5112	0.4110	0.4353	1.5470
22	Printing and Reproduction of Recorded Media	0.2557	0.2062	0.1824	0.9182
23	Coke, Hard-coal and Lignite Fuel Briquettes and Refined Petroleum Products	0.8475	0.7045	0.6977	1.0892
24	Chemicals and Chemical Products	0.8105	0.6336	0.7637	1.2107
25	Rubber and Plastic Products	0.7314	0.5885	0.6646	1.1877
26	Other Non-metallic Mineral Products	0.6266	0.4469	0.5253	1.2279
27	Basic Metal Products	0.8070	0.7053	0.7220	1.0318
28	Fabricated Metal Products	0.6951	0.5518	0.6303	1.1638
29	Machinery and Equipment	0.7593	0.5608	0.6994	1.2838
30	Office Machinery and Equipment	0.7260	0.5964	0.6425	1.1085
31	Other Electric Equipment and generators	0.7881	0.6614	0.7150	1.0963
32	Electronic Components and Communication Equipment and Apparatuses	0.7743	0.5762	0.7205	1.4265
33	Medical, Precision and Optical Instruments, Watches and Clocks	0.7708	0.5671	0.7055	1.2824
34	Motor Vehicles, Trailers and Semitrailers	0.7365	0.4747	0.6791	1.5471
35	Other Transport Equipment	0.8626	0.7320	0.8180	1.1467
36	Furniture and others	0.6284	0.3901	0.6212	1.5998
Total		0.6692	0.5104	0.6059	1.3326

** (1): Employment share of firms who implement the product innovation in an industry*
** (2): Employment share of firms who implement the process innovation in an industry*
** (3): Employment share of firms who implement product or process innovation in an industry*
** (4): Employment share of firms who implement product innovation/ process innovation in an industry*

V. Firm-level employment effect of innovation

In order to estimate the employment effect of different types of innovation at the firm-level, we use Harrison et al. (2008, 2014)'s econometric model and estimation strategies for the estimation. However, we use Korean manufacturing firm data from 1999-2009 and additionally considers the long-term effect of innovation on employment. Moreover, we recognize the importance of "product market competition" and show the employment effect of innovation in different market structures.

5.1 Employment effect of different type of innovation in Korea

The purpose of process innovations is to increase the productivity by reducing the production cost. Thus, it reduces the quantities of input factors, including the labor input and is known to have a negative effect on employment. In contrast, the purpose of product innovation is to directly increase the demand. Therefore, it is known to have a positive employment effect through the compensation mechanism of the new products.

H1-1: Process innovation has a negative impact on employment.

H1-2: Product innovation has a positive impact on employment.

Table 5-1 shows the OLS and 2SLS estimation results for Korean manufacturing firms from 1999-2009[18]. According to these results, product innovation has a positive and significant effect, but process innovation has a negative and insignificant effect on the employment growth of Korean manufacturing firms.

In particular, the OLS estimates of *g2* are lower than its 2SLS estimates, since sales growth due to new product sales (*g2*), which is a proxy for product innovation, is correlated with the price growth of *g2* that can lower the effect of product innovation on employment. In this case, OLS estimates can under-estimate the effect of product innovation on employment and we need to control the endogeneity problem of *g2*. Hence, we use proper IVs for g2 and estimate the parameters using the 2SLS estimation method. As a result, 2SLS estimates of g2 (0.96) have a greater job-creating effect than OLS estimates (0.93) do, but still it is less than one. This means that employment growth increases less than 1%p when the sales share of new to the old products increases 1%p.

On the other hands, the Hausman test statistic is 64.91, which rejects the null hypothesis (H0: variables are exogenous). In other words, this model has an endogeneity problem that has to be controlled. We use a) the importance of diversification and b) replacement of old products from the perspective of innovation purpose as IVs for

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[18] We use four different sets of cross-section datasets, which are KIS 2002, 2005, 2008, and 2010, and do the pooled OLS

product innovation (g2). The Sargan test justifies that IVs are not weak instruments, since it could not reject the null hypothesis; H0: instruments are weak.

Table 5-1. Firm-level employment effect of innovations; Korean manufacturing firms from 1999-2009

	Dependent variables: Employment growth- Real sales growth due to old products *(l-(g1-p))*			
	OLS		2SLS	
process innovation *(d)*	-0.02	-0.03+	-0.01	-0.02
	(-1.15)	(-1.69)	(-0.58)	(-1.22)
product innvation *(g2)*	0.71**	0.71**	0.93**	0.95**
	(42.41)	(41.57)	(30.33)	(29.37)
process and product innovation *(d*)*	0.11**	0.10**	0.02	0.00
	(9.60)	(8.65)	(1.15)	(0.02)
year dummy_2005		0.03*		0.03*
		(2.14)		(2.24)
year dummy_2008		-0.04**		-0.01
		(-3.24)		(-0.76)
year dummy_2010		0.08**		0.11**
		(6.65)		(8.57)
_cons	-0.03	-0.05*	-0.05**	-0.10**
	(-1.40)	(-2.39)	(-2.68)	(-4.53)
N	11369	11369	11369	11369
Hausman test			0.0000	0.0000
Sargan test			0.3002	0.5097
r2_a	0.33	0.34	0.31	0.31
rmse	0.47	0.46	0.47	0.47

** Industry dummies are included*
** process innovation is measured by process innovation dummy (d)*
** product innovation is measured by sales growth due to new products (g2)*
** process and product innovation is measured by process and product innovation dummy (d*)*

This result is consistent with the previous empirical findings and partly supports the hypotheses. To conclude, we can say that innovation of Korean manufacturing firms has a positive relationship with employment in general, since product innovation creates jobs, but process innovation does not displace the jobs.

H1-1: process innovation has negative effect on employment **is rejected.**

H1-2: product innovation has positive effect on employment **is supported**.

On one hand, Table 5-2 shows the estimation results according to different periods. Overall, the regression results are similar across periods; a) product innovation has a positive and significant effect on employment, and b) process innovation does not have any significant effect. However, the effect of product innovation on employment seems to have decreased from 2002 to 2009[19]; since the coefficient of *g2* has decreased from 2002 to 2009. There could be various reasons, but one of the possible explanations for this can be the intensified global competition after 2000s, faced by the Korean manufacturing firms.

Table 5-2. Firm-level employment effect of innovations by different time periods; Korean manufacturing firms from 1999-2009

	Dependent variable: employment growth due to innovation (l-(g1-p))							
	OLS				2SLS			
	KIS2002	KIS2005	KIS2008	KIS2010	KIS2002	KIS2005	KIS2008	KIS2010
process innovation (d)	0.01	-0.04	-0.07+	-0.05	-0.06	0.01	-0.05	-0.03
	(0.13)	(-0.80)	(-1.84)	(-1.61)	(-1.12)	(0.28)	(-1.33)	(-1.03)
Sales growth due to new products (g2)	0.76**	0.74**	0.70**	0.63**	0.99**	1.06**	0.94**	0.79**
	(24.00)	(24.31)	(13.71)	(19.42)	(17.51)	(13.39)	(13.72)	(13.10)
product and process innovation (d*)	0.09**	0.12**	0.12**	0.08**	-0.04	-0.05	0.03	0.03
	(3.23)	(4.74)	(5.20)	(4.36)	(-0.90)	(-1.05)	(1.06)	(1.24)
_cons	-0.09	-0.01	-0.06+	0.03	-0.13**	-0.04	-0.08*	0.01
	(-1.63)	(-0.34)	(-1.75)	(0.79)	(-2.75)	(-0.98)	(-2.07)	(0.42)
N	2534	2354	2865	3616	2534	2354	2865	3616
r2_a	0.41	0.44	0.23	0.24	0.39	0.39	0.22	0.23
rmse	0.49	0.46	0.45	0.44	0.5	0.49	0.46	0.44

** industry dummies are included*
*** KIS2002 is based on firms in 1999-2001*
**** KIS2005 is based on firms in 2002-2004*
***** KIS2008 is based on firms in 2005-2007*
****** KIS2010 is based on firms in 2007-2009*

[19] The robustness check for the decreasing pattern of product innovation’s effect on employment is illustrated in Appendix-B.

On the other hand, Table 5-3 compares the regression results of Korea and four European countries: France, Germany, Spain, and the UK[20]. According to the results, Korean firms are different from European ones in mainly two aspects. First, Korean manufacturing firms do not have a significant effect of process innovation on employment, whereas German and UK firms have a negative and significant effect. Second, product innovation of Korean manufacturing firms creates more employment than in France and the UK, but less than in Spain and Germany. The coefficient of g2 for Korea is 0.99, which is greater than that of France (0.90) and the UK (0.92), and less than that of Spain (1.06) and Germany (1.04). Accordingly, we can say that process innovation of Korea is more job-friendly than that of other European countries and product innovation of Korea is less job-friendly than that of other European countries.

Table 5-3 Firm-level employment effect of innovations; Korea vs. European firms

	Dependent Variable: Employment growth due to innovation				
	Korea	France	Germany	Spain	UK
process innovation (*d*)	-0.06	-1.26	-6.20*	2.47	-3.50+
	(-1.12)	(-0.81)	(-2.12)	(1.38)	(1.89)
product innovation (*g2*)	0.99**	0.90**	1.04**	1.05**	0.92**
	(17.51)	(10.00)	(14.86)	(15.00)	(13.14)
process and product innovation (*d**)	-0.04	2.59+	-1.98	-1.49	4.94+
	(-0.90)	(1.81)	(-0.71)	(-0.56)	(1.93)
_cons	-0.13**	-3.51**	-6.96**	-6.14**	-6.33**
	(-2.75)	(4.50)	(5.08)	(6.75)	(7.19)
N	2534	4631	1319	4548	2533

* *Note: industry dummies are included*

** *Korea is based on KIS2002, which is conducted in 1999-2001.*

*** *Other European countries (France, Germany, Spain, UK) are based on CIS3, which is conducted in 1998-2000.*

[20] We compare the regression results of Korean manufacturing firms to that of European manufacturing firms using Harrison et al. (2008, 2014) paper.

5.2 Dynamic effect of innovation on employment

Most firm-level researches is based on the short-term effect of innovation on employment. However, the compensation effect of innovation can take time to be reflected and it may not possibly be detected in a very short period. Thus, short-term employment effect of innovation can mislead the true employment effect of innovations and possibly under-estimate the true parameters[21]. Therefore, the necessity of long-term effect of innovation has been continuously raised and this paper tries to depict this.

In this aspect, process innovation can have a positive effect on employment in the long-term, if its compensation effect occurs in the long-term. Specifically, process innovation takes time to be implemented, and demand enlargement due to it should be followed by firms' decision to lower the price that should need more time to be transferred to increase the employment.

H2-1: Process innovation has a positive employment effect in the long-term.

H2-2: Product innovation has a positive employment effect in the long-term.

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[21] Displacement effect is directly occurred compared with compensation effect. Since compensation effect is indirectly occurred through the market mechanisms, it takes more time to show the employment effect.

In order to estimate the long-term effect of innovation on employment, we construct three sets of panel datasets using consecutive firms in two different periods. Accordingly, we have 1,220 firms from three different sets of panel datas: KIS2002-2005 (308 firms), KIS2005-2008 (356 firms), KIS2008-2010 (556 firms).

Table 5-4 shows the regression results for this. The short-term model only has the present value of either type of innovations and the long-term model has both present and former values of the innovations. According to the estimation results, we find that the former period of innovations does not have any significant effect on the latter period of employment growth. This indicates that firm-level innovation does not have any significant effect in the long-term.

On the other hand, the present value of product innovation is consistently positive and significant and that of process innovation is consistently negative and insignificant in both the short-term and long-term employment growth models. Moreover, here, the process and product innovation dummy (d*), which represents the effect of process innovation of product innovators, has a positive and significant effect on employment. It suggests that process innovation has a positive and significant effect on employment when it is accompanied with product innovation. Therefore, we can conclude that the firm-level innovation has an only short-term employment effect, which does not last for a long time.

Table 5-4. Firm-level employment effect of innovation; short-term vs. long-term

	Dependent variable: Employment growth due to innovation only			
	OLS		2SLS	
	Short-term	Long-term	Short-term	Long-term
process innovation (*d*)	-0.06	-0.06	-0.04	-0.06
	(-1.50)	(-1.26)	(-1.39)	(-1.64)
product innovation (*g2*)	0.76**	0.71**	0.92**	0.69**
	(28.37)	(17.10)	(12.29)	(6.49)
process and product innovation *(d*)*	0.07**	0.07**	0.02	0.08*
	(3.87)	(2.93)	(0.74)	(1.97)
L3. process innovation (*d*)		0.01		0.01
		(0.23)		(0.24)
L3. product innovation (*g2*)		0.02		0.02
		(0.69)		(0.92)
L3. process and product innovation *(d*)*		0.00		0.00
		(0.18)		(0.18)
_cons	-0.02	0	-0.11*	-0.02
	(-0.67)	(0.06)	(-2.24)	(-0.33)
N	2440	1220	2440	1220
r2_a	0.41	0.39	0.4	0.39
rmse	0.4	0.36	0.4	0.36

** industry and time dummies are included*

H2-1: Process innovation has positive employment effect in long-term **is rejected**.

H2-2: Product innovation has positive employment effect in long-term **is rejected.**

Robustness check

Table 5-5 shows the regression results for three different periods separately. Overall, we cannot find any specific period, having a long-term effect of innovation on employment. Both product and process innovation do not have a long-term employment effect, even though they have a similar sign for their short-term employment effect. Thus, we can conclude that the job-creating effect of product innovation in Korea is weak, since a) it creates less employment than firms in other countries do, and b) this effect does not lasted for a long time.

Table 5-5. Firm-level employment effect of innovation by different time periods; short-term vs. long-term

	Dependent variable: Employment growth due to innovation only					
	OLS			2SLS		
	KIS2002-2005	KIS2005-2008	KIS2008-2010	KIS2002-2005	KIS2005-2008	KIS2008-2010
process innovation (*d*)	-0.02	-0.17+	-0.02	-0.03	-0.16*	-0.02
	(-0.19)	(-1.94)	(-0.26)	(-0.40)	(-2.25)	(-0.34)
product innovation (*g2*)	0.76**	0.74**	0.65**	0.67**	0.85**	0.65**
	(14.93)	(11.45)	(8.35)	(3.91)	(5.09)	(3.81)
process and product innovation (*d**)	0.12*	0.08+	0.04	0.16+	0.05	0.04
	(2.31)	(1.93)	(0.93)	(1.75)	(0.84)	(0.67)
L3. process innovation (*d*)	0.09	-0.02	-0.01	0.08	-0.02	-0.01
	(1.12)	(-0.19)	(-0.21)	(0.98)	(-0.22)	(-0.18)
L3. product innovation (*g2*)	0.04	0.00	0.03	0.05	0.00	0.03
	(0.56)	(0.10)	(0.61)	(1.11)	(0.06)	(0.56)
L3. process and product innovation (*d**)	0.05	-0.05	0.00	0.04	-0.05	0.00
	(1.01)	(-1.04)	(0.11)	(0.91)	(-1.10)	(0.10)
_cons	-0.08	0.03	-0.03	-0.08	0.01	-0.03
	(-0.85)	(0.47)	(-0.65)	(-0.66)	(0.13)	(-0.49)
N	308	356	556	308	356	556
r2_a	0.56	0.36	0.28	0.55	0.35	0.28
rmse	0.35	0.35	0.37	0.33	0.34	0.36

** industry and time dummies are included*

5.3 Market structure and employment effect of innovation

Finally, we estimate the employment effect of innovation by considering different market structures. This is because firms' decision for employment is not only influenced by inside the firms, but also outside. For this reason, we have to consider firms' environmental conditions, which can affect their innovative activities and the ensuing employment decisions. Here, we choose "market structure" as a major determinant of firms' employment decision and employment effect of innovations. We hypothesize that a) product innovation in monopolistic markets has a greater job-creating effect than that in non-monopolistic markets,[22] whereas b) process innovation in monopolistic markets has a greater job destruction effect than in non-monopolistic markets.

H3-1: Process innovation in monopolistic markets has a greater job displacement effect than that in non-monopolistic markets.

H3-2: Product innovation in monopolistic markets has a greater job creating effect than that in non-monopolistic markets.

[22] For more details, please refer to Chapter 2-3.

Table 5-6 shows the regression results by market structure. In order to estimate how the different market structure affects the employment effect of innovations, this paper generates the industry-level CR3 and defines the monopolistic industry as its CR3 is greater than 0.75, and non-monopolistic industry as vice versa.

According to Table 5-6, process innovation has no significant effect on employment in non-monopolistic markets, but is significant in monopolistic markets. Moreover, product innovation in monopolistic markets has a greater job-creating effect than that in non-monopolistic markets, but the difference is not substantially large.

Table 5-6. Firm-level employment effect of innovations; non-monopolistic market vs. monopolistic market

	Dependent Variable: Employment growth due to innovation			
	OLS		2SLS	
	Non-monopolistic	Monopolistic	Non-monopolistic	Monopolistic
process innovation (*d*)	-0.03	-0.18	-0.02	-0.20*
	(-1.45)	(-1.43)	(-0.87)	(-2.16)
product innovation (*g2*)	0.71**	0.85**	0.95**	0.98**
	(40.74)	(9.89)	(28.82)	(5.81)
process and product innovation (*d**)	0.10**	0.08	0.00	0.04
	(8.52)	(1.45)	(-0.06)	(0.44)
year dummy_2005	0.03*	0.00	0.03*	0.02
	(2.30)	(-0.04)	(2.29)	(0.16)
year dummy_2008	-0.04**	0.09	-0.01	0.13
	(-2.94)	(0.93)	(-0.62)	(0.98)
year dummy_2010	0.09**	0.03	0.11**	0.08
	(6.72)	(0.38)	(8.51)	(0.65)
_cons	-0.06*	-0.19+	-0.10**	-0.24+
	(-2.45)	(-1.95)	(-4.56)	(-1.71)
N	10984	385	10984	385
r2_a	0.34	0.38	0.31	0.37
rmse	0.46	0.43	0.47	0.43

** Industry dummy is included*

However, the difference between these two markets does not imply that this difference is statistically significant. Therefore, we do the additional regression for this and find a) process innovation in monopolistic markets has a greater job displacement effect and is statistically significant, but b) product innovation in monopolistic markets does not have a greater job-creating effect and is not statistically significant.

In order to prove this, we generate two types of monopolistic industry variables; a) industry-level CR3 and b) monopolistic industry dummy, which is one, if industry-level CR3 of a firm is over 0.75, and zero otherwise. Then, we make the interaction term between these and either type of innovation variables and show whether they are statistically significant or not.

Table 5-7 shows the estimation result for this; model1 uses industry-level CR3 and model2 uses a monopolistic industry dummy as a proxy for the monopolistic industry. As a result, model1 confirms that a) process innovation in monopolistic markets has a significant greater job displacement effect than that in non-monopolistic markets, but does not confirm that b) product innovation in monopolistic markets has a greater job-creating effect than that in non-monopolistic markets. However, model2 does not confirm the employment effect of either type of innovation in monopolistic markets. Therefore, we can conclude that process innovation in monopolistic markets has a greater job displacement effect, but product innovation in monopolistic markets does not have a greater job creating effect.

Table 5-7. Firm-level employment effect of innovation in different market structure

	Dependent Variable: Employment growth due to innovation			
	OLS		2SLS	
	(1)	(2)	(1)	(2)
process innovation (*d*)	0.04	-0.03	0.07	-0.02
	(0.86)	(-1.45)	(1.35)	(-0.85)
product innovation (*g2*)	0.71**	0.71**	0.97**	0.95**
	(19.82)	(40.87)	(14.16)	(29.45)
process and product innovation (*d**)	0.10**	0.10**	0.00	0.00
	(8.64)	(8.67)	(-0.01)	(0.02)
Monopolistic Industry (m)	0.03	-0.02	0.04	-0.01
	(0.71)	(-0.47)	(0.78)	(-0.28)
MI*process innovation (m*d)	-0.18	-0.14	-0.22+	-0.18
	(-1.64)	(-1.19)	(-1.94)	(-1.54)
MI*product innvoation (m*g2)	0.01	0.15*	-0.04	0.06
	(0.09)	(2.06)	(-0.26)	(0.60)
_cons	-0.06*	-0.06*	-0.11**	-0.10**
	(-2.50)	(-2.42)	(-3.81)	(-4.09)
N	11369	11369	11369	11369
r2_a	0.34	0.34	0.34	0.34
rmse	0.46	0.46	0.46	0.46

** Industry and year dummies are included.*

** Model (1): Monopolistic industry (m) is measured by CR3, the sales share of Top 3 firms in an industry.*

** Model (2): Monopolistic industry (m) is measured by dummy varaible = 1, if CR3>0.75 and 0 , otherwise.*

H3-1: Process innovation in monopolistic markets has a greater job displacement effect than that in non-monopolistic markets **is supported**.

H3-2: Product innovation in monopolistic markets has a greater job-creating effect than that in non-monopolistic markets **is rejected.**

Robustness check

Is this the effect of monopolistic firms?

However, one may ask whether this monopolistic market effect is based on sector-level effect or not. If this effect is not derived from monopolistic sectors, but rather from monopolistic firms, then this effect may be the result of economies of scale, and not of product market competition.

In order to confirm the estimation result above, we make the monopolistic firm (MF) variables and follow the same econometric approach as with the previous analysis. Table 5-8 shows the result for this, which indicates that the more negative employment effect of process innovation in monopolistic markets is not based on the individual firm-level effect, like scale economy, but rather the industry-level effect, like product market competition.

This is because the interaction term between monopolistic firm variables and either type of innovation variables does not provide the significant effect on employment; a) neither process nor product innovation in monopolistic firms has any significant effect on employment, b) these estimation results are equivalent when we use a monopolistic firm variable as a) market share of a firm within an industry or b) monopolistic firm dummy variable, which is one if the market share of a firm is greater than 0.25, and zero otherwise.

Table 5-8. Firm-level employment effect of innovation in different firm size

	Dependent variable: Employment growth due to innovation			
	OLS		2SLS	
	(1)	(2)	(1)	(2)
process innovation (*d*)	-0.03	-0.03+	-0.02	-0.02
	(-1.62)	(-1.70)	(-1.05)	(-1.20)
product innovation (*g2*)	0.71**	0.71**	0.96**	0.95**
	(40.09)	(41.44)	(29.34)	(29.87)
process and product innovation *(d*)*	0.10**	0.10**	0.00	0.00
	(8.57)	(8.62)	(-0.05)	(-0.00)
Monopolistic Firms (*m2*)	-0.24	-0.02	-0.09	0.12
	(-1.23)	(-0.20)	(-0.28)	(0.79)
MF*process innovation (*m2*d*)	-0.02	0.1	-0.24	-0.01
	(-0.04)	(0.96)	(-0.39)	(-0.08)
MF*product innvoation (*m2*g2*)	0.50+	0.07	0.2	-0.26
	(1.95)	(0.62)	(0.37)	(-1.01)
_cons	-0.05*	-0.05*	-0.09**	-0.10**
	(-2.30)	(-2.39)	(-4.05)	(-4.08)
N	11356	11369	11356	11369
r2_a	0.34	0.34	0.34	0.34
rmse	0.46	0.46	0.46	0.46

** Industry and year dummies are included.*

** Model (1): Monopoly Firms (m2) is measured by market share of a firm= sales of firm/ sales by an industy*

** Model (2): Monopoly Firms (m2) is measured by dummy varaible = 1, if marketshare>0.25 and 0 , otherwise.*

5.4 Summary

From the firm-level analysis on the employment effect of innovation, we determine the following:

(1) Product innovation has a positive employment effect, while process innovation does not have any significant effect.

(2) Product innovation has a positive employment effect in the short-term, but not in the long-term.

(3) Process innovation in monopolistic markets has a greater job displacement effect than that in non-monopolistic markets.

Table 5-9. Proposed hypothesis and estimation results

Short-term	Employment effect by type of innovation	Firm-level
H1-1	Process innovation has negative effect on employment	FH1-1
H1-2	Product innovation has positive effect on employment	FH1-2
Long-term	Employment effect by type of innovation in long-term	
H2-1	Process innovation has negative effect on employment in long-term	FH2-1
H2-2	Product innovation has positive effect on employment in long-term	FH2-2
Market structure	Employment effect by type of innovation in different market structure	
H3-1	Process innovation in monopolistic market has bigger job displacement effect on employment	FH3-1
H3-2	Product innovation in monopolistic market has bigger job creating effect on employment	FH3-2

VI. Sector-level employment effect of innovation

The firm-level analysis cannot be generalized, since it does not consider the effect of other competing firms. Thus, this chapter analyzes the sector-level employment effect of innovation from the perspective of showing more aggregate employment effect of innovation. However, here, we do not analyze the industry-level effect of innovation in different market structure, since that is not related with sector-level analysis. Thus, here, we focus on the a) sector-level employment effect of different type of innovation and b) the dynamic effect of innovation on sector-level employment.

6.1 Employment effect of different type of innovation

At the firm-level analysis, we hypothesized that a) process innovation has a negative effect on employment, while b) product innovation has a positive effect. However, sector-level employment effect can be different, since the increased demand of innovating firms can forcibly decrease the demand of other firms. We refer to this as the Business stealing effect (BSE) and it can reduce the employment-level of other firms to reduce the sector-level employment.

H1-1: Process innovation has a negative effect on employment.

H1-2: Product innovation has a positive effect on employment.

In order to estimate the sector-level effect of innovation on employment, we use the Greenan and Guellec (2000)'s method. Accordingly, dependent variables are a) the job-creating rate, b) job destruction rate, and c) job growth rate. We regress these three types of different employment growth rates on either type of innovation variables; intensity of a) product and b) process innovation or intensity of innovation.

On the other hand, we calculate the industry-level job flow rates by considering different firm-size[23]. Thus, we have 399 industries in four different periods (five firm-sizes of 21 industries in four different periods) and we estimate the sector-level employment effect of innovation using the OLS estimation method.

According to Table 6-1, neither process nor product innovation has any significant influence on sector-level job growth rate. However, an interesting fact is that both types of innovation have a similar employment effect, which increases the job-creating rate, decreases the job destruction rate and finally increases the job growth rate, - even though they are not statistically significant.

Therefore, these estimation results suggest that there could be a multi-collinearity problem of the model. High correlation between two independent variables, intensity of process and product innovation, can lower the explanation power of the variables. Thus,

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[23] However, we also do the sector-level analysis using pure industry-level dependent variables. The estimation results are depicted in Appendix-C. Most results, although common, are weak in many ways.

we make two additional variables, a) intensity of innovation *(innovs)* and b) product-orient innovation *(innorels)* and estimate the effect of innovation itself and the type of innovation on employment separately.

Table 6-1. Sector-level employment effect of innovation; process vs. product innovation

	Dependent variables		
	Job creation rate	Job destruction rate	job growth rate
Process innovation	0.03	-0.02	0.05
	(1.18)	(-0.89)	(1.32)
Product innovation	0.04	-0.02	0.06
	(1.45)	(-0.99)	(1.60)
size dummy_1	-0.04**	0.02**	-0.06**
	(-3.08)	(2.76)	(-3.72)
size dummy_2	-0.04**	0.02**	-0.06**
	(-3.28)	(2.64)	(-4.00)
size dummy_3	-0.07**	0.03**	-0.09**
	(-4.62)	(3.02)	(-5.10)
size dummy_4	-0.10**	0.01	-0.11**
	(-8.27)	(0.73)	(-5.92)
year dummy_2005	0.01	-0.01	0.02
	-0.81	(-0.83)	-1.03
yeardummy_2008	-0.03**	-0.02+	-0.01
	(-2.69)	(-1.83)	(-0.87)
year dummy_2010	-0.04**	-0.01	-0.03+
	(-3.24)	(-0.86)	(-1.77)
_cons	0.12**	0.08**	0.04+
	(7.36)	(6.89)	(1.87)
N	399	399	399
r2_a	0.19	0.04	0.12
rmse	0.07	0.06	0.1

Robustness check

Innovation intensity or innovation type?

Previously, we could not find any significant employment effect of innovation on sector-level employment. Thus, we consider the innovation intensity itself and estimate the effect of innovation itself and the type of innovation separately. Accordingly, both a) intensity of innovation *(innovs*) and b) product orient innovation (*innorel*) are used for estimation.

Table 6-2 depicts that innovation intensity itself has a positive influence on the job growth rate. Moreover, innovation intensity not only increases the job-creating rate, but also decreases the job destruction rate. However, product-orient innovation does not have any significant effect on employment growth. To conclude, it is not the innovation type but rather the innovation intensity that is important for sector-level employment growth.

Table 6-2. Sector-level employment effect of innovation; innovation intensity vs. innovation type

	Depemdent variables					
	Job creation rate		Job destruction rate		Net employment growth rate	
	(1)	(2)	(1)	(2)	(1)	(2)
Innovation	0.06**	0.06**	-0.05**	-0.05**	0.11**	0.11**
	(3.34)	(3.32)	(-2.81)	(-2.84)	(3.92)	(3.92)
Product-orient innovation		0.00		0.00		0.00
		(-0.65)		(-1.42)		(0.46)
_cons	0.12**	0.12**	0.09**	0.09**	0.03	0.03
	(6.91)	(6.92)	(7.15)	(7.18)	(1.19)	(1.17)
N	399	399	399	399	399	399
r2_a	0.19	0.19	0.05	0.05	0.13	0.13
rmse	0.07	0.07	0.06	0.06	0.1	0.1

* *size and year dummies are included*

* *'product-orient innovation' is the employment share of product innovators/process innovators in an industry*

6.2 Dynamic effect of innovation on employment

At the firm-level analysis, we could not find any long-term effect of innovation on employment. We only find the short-term effect of product innovation on employment, which is positive and significant. Therefore, here, we want to see that innovation has a long-term effect in the industry-level analysis even though it does not have one in the firm-level analysis.

On the other hand, we suppose that industry-level innovation may have a long-term effect on employment. This is because firms that are affected by the innovation do not directly re-act to the shocks, but rather try to cope with the innovation. They may slowly reduce their firm-size if they fail to cope with the innovation. Thus, process innovation would have negative influence in the long-term. However, product innovation may have a positive impact in the long-term, since it can facilitate the innovation within the same industry. Thus, it can raise the overall employment-level of an industry by increasing its overall competitiveness.

H2-1: Process innovation has a negative effect in the long-term.

H2-2: Product innovation has a positive effect in the long-term.

For comparing the short-term and long-term effects of innovation on employment, Table 6-3 shows the regression results for both. First three columns are for the short-term employment effect and the next three columns for the long-term employment effect.

According to Table 6-3, sectors with more product innovations have a higher job growth rate in the long-term through increasing the job-creating rate in the long-term. The lagged process innovation variable has a positive and significant effect on both the job-creating rate and job growth rate. However, sectors with more process innovation do not significantly increase the job growth rate in the long-term even though they significantly reduce the job destruction rate in the long-term.

To sum up, process innovation does not have any significant effect on sector-level employment in both short-term and long-term, whereas product innovation has positive and significant effect on sector-level employment in the long-term. An interesting fact is that process innovation in Korea is significant for lowering the job destruction rate, which is opposite against the convention, but fails to increase the job growth rate. On the other hand, product innovation in Korea creates new jobs in the long-term only.

Table 6-3. Sector-level employment effect of innovation; short-term vs. long-term

	Short-term effect			Long-term effect		
	(1)	(2)	(3)	(1)	(2)	(3)
process innovation (t)	0.03	-0.02	0.05	0.03	-0.01	0.04
	(1.18)	(-0.89)	(1.32)	(1.06)	(-0.42)	(0.96)
product innovation (t)	0.04	-0.02	0.06	0.01	0.00	0.00
	(1.45)	(-0.99)	(1.60)	(0.24)	(0.08)	(0.10)
process innovation (t-1)				-0.03	-0.06*	0.03
				(-1.25)	(-2.43)	(0.86)
product innovation (t-1)				0.08**	0.00	0.08*
				-2.94	(-0.11)	(2.01)
_cons	0.12**	0.08**	0.04+	0.10**	0.08**	0.02
	(7.36)	(6.89)	(1.87)	(5.11)	(6.32)	(0.85)
N	399	399	399	291	291	291
r2_a	0.19	0.04	0.12	0.19	0.1	0.16
rmse	0.07	0.06	0.1	0.06	0.05	0.09

** size and year dummies are included*

**Model (1): Dependent variable is job creation rate (t)*

**Model (2): Dependent variable is job destruction rate (t)*

**Model (3): Dependent variable is net employment growth rate (t)*

Robustness check

According to Table 6-4, the short-term effect of the innovation intensity on employment disappears when we consider the lagged innovation variables; a) lagged innovation intensity and b) lagged product-orient innovation. Furthermore, the former has a positive and significant effect on employment, but the latter does not have any significant effect. This regression result indicates that a) sector-level innovation has a long-term employment effect, and b) innovation intensity is more important than innovation type for increasing the sector-level employment.

Table 6-4. Sector-level employment effect of innovation; innovation intensity vs. innovation type

	Short-term effect			Long-term effect		
	(1)	(2)	(3)	(1)	(2)	(3)
innovation (t)	0.06**	-0.05**	0.11**	0.02	-0.01	0.02
	(3.32)	(-2.84)	(3.92)	(0.70)	(-0.22)	(0.59)
product-orient innovation (t)	0.00	0.00	0.00	0.00	0.00	0.00
	(-0.65)	(-1.42)	(0.46)	(-0.43)	(-0.01)	(-0.33)
innovation (t-1)				0.06*	-0.06*	0.12**
				(2.43)	(-2.32)	(3.17)
product-orient innovation (t-1)				0.00	0.00	0.00
				(1.00)	(0.63)	(0.02)
_cons	0.12**	0.09**	0.03	0.10**	0.09**	0.01
	(6.92)	(7.18)	(1.17)	(5.05)	(6.86)	(0.43)
N	399	399	399	291	291	291
r2_a	0.19	0.05	0.13	0.18	0.1	0.16
rmse	0.07	0.06	0.1	0.06	0.05	0.09

** size and year dummies are included*
**Model (1): Dependent variable is job creation rate (t)*
**Model (2): Dependent variable is job destruction rate (t)*
**Model (3): Dependent variable is net employment growth rate (t)*

6.3 Summary

From the sector-level analysis for the employment effect of innovations, we determine that:

(1) Product innovation has a positive employment effect, while process innovation does not have any significant effect.

(2) Product innovation has a positive employment effect in the long-term, but not in the short-term.

(3) However, innovation intensity is more important than innovation type.

Table 6-5. Proposed Hypothesis and estimation results

Short-term	Employment effect by type of innovation	Sector-level
H1-1	Process innovation has negative effect on employment	SH1-1
H1-2	Product innovation has positive effect on employment	SH1-2
Long-term	Employment effect by type of innovation in long-term	
H2-1	Process innovation has negative effect on employment in long-term	SH1-1
H2-2	Product innovation has positive effect on employment in long-term	SH1-2

VII. Conclusions

To estimate and evaluate the employment effect of innovation in Korea, we use Korean manufacturing firm data from 1999 to 2009. We distinguish the type of innovation and show their dynamic effect on employment. Specifically, we consider the market structure and how it differently affects the employment effect of each type of innovation. We use not only firm- but also sector-level analysis in order to confirm the estimation results. The methodologies of Harrison et al. (2008, 2014) and Greenan and Guellec (2000) are used for firm- and sector-level estimations respectively. The major research findings are described below.

First, this paper finds that innovation has a positive influence on jobs in general. Not only firm- but also sector-level analyses indicate that product innovation has a positive and significant effect on employment, whereas process innovation does not have any significant effect. This result confirms that the job-creating effect of product innovation is not dominated by the BSE of non-innovating firms and process innovation does not significantly displace the workers.

Table 7-1. Employment effect of innovations; process vs. product innovations

Type of innovations	Firms	Sectors
process innovations	(-)	(+)
Product innovations	(+)**	(+)*

Second, this paper reveals that a firm has a short-term but an industry has a long-term employment effect of innovation. Table 7-2 shows that process innovation does not have any employment effect in the long-term as well as the short-term. Product innovation increased the short-term employment-level of firms but increased the long-term employment-level of an industry. This estimation result indicates that firms do not necessarily consider the long-term effect of innovation but sectors should have considered both short-term and long-term employment effects of innovation.

Table 7-2. Employment effect of innovations; short-term vs. long-term

	Firms		Sectors	
	Short-term	Long-term	Short-term	Long-term
Process innovations	(-)	(+)	(+)	(+)
Product innovations	(+)**	(+)	(+)	(+)*

Finally, this paper shows that process innovation in monopolistic markets has a greater job displacement effect than that in non-monopolistic markets. Firms in monopolistic markets do not necessarily lower the price from the innovation that does not enlarge the large demand, production, and employment. They behave like profit maximizers and intend to achieve the monopolistic-rents coming from the innovation[24].

[24] We do the additional regression for market structure, since this additional effect may not be coming from market structure, monopolistic industry, but from the monopolistic firms. However, the regression result using monopolistic firm variable shows that this additional effect of process innovation is not coming from monopolistic firms, but from the monopolistic industry. The last column of Table 7-3 shows the regression result for this and it means that firms in monopolistic industries have this additional effect irrespective of the size of the firms.

However, the proposed hypothesis for product innovation- product innovation in monopolistic markets has a greater job-creating effect than that in non-monopolistic markets- from the perspective of Schumpeterian hypothesis[25] turns out to be false. This result is consistent with the argument of Juhn and Moon (2013). They argued that potential entrants are more innovative than incumbent firms in both product and process innovation in case of Korean manufacturing firms.

Table 7-3. Employment effect of innovations in different market structure.

	Firms		Firms
Process innovations (procs)	0.07	Process innovations (procs)	-0.02
Product innovations (prods)	0.97**	Product innovations (prods)	0.96**
Monopolistic Industry (MI)	0.04	Monopolistic Firms (MF)	-0.09
Interaction terms between procs*MI	-0.22+	Interaction terms between procs*MF	-0.24
Interaction terms between prods*MI	-0.04	Interaction terms between prods*MF	0.20
The pure employment effect of process innovations in monopolistic industy	-0.22+	The pure employment effect of process innovations in monopolistic firms	0.00
The pure employment effect of product innovations in monopolistic industy	0.97**	The pure employment effect of product innovations in monopolistic firms	0.96**

** Monopolistic industy is measured by industry-level CR3*

** Monopolistic firm is measured by market share of a firm in an industry*

Our results, however, still have some limitations. 1) This paper uses industry-level CR3 as a proxy for product market competition, but it may not reflect the actual product market competition of Korean manufacturing firms. 2) Moreover, this paper does not

[25] Schumpeter argued that firms in a monopolistic market have a greater incentive for R&D, and hence have more innovations. Thus, we hypothesized that firms in a monopolistic market have a greater job creating effect, since they invest more money on R&D and have better quality of product innovations, which creates more market demand.

reflect the quality aspect of employment, such as the problem of permanent and temporary, male and female, and young and old workers, etc. 3) Furthermore, this paper deals with the type of innovation, but not with other distinctive technological characteristics of innovations, such as changes in capital (or labor)- intensive way or skilled-bias characteristics, etc. 4) Finally, this study uses the number of employees as a proxy for employment. However, results can be different if one may consier working hours as a proxy for employment.

Despite these limitations, this paper shows that 1) innovation in Korean manufacturing firms from 1999-2009 has a positive influence on jobs in general, and 2) firms have short-term but industries have long-term employment effect of innovation. Specifically, this is the first study to consider product market competition and explicitly shows 3) process innovation in monopolistic markets has a greater job displacement effect than that in non-monopolistic markets.

Policy implication

Innovation in Korean manufacturing firms seems to have a positive relationship with employment. This is probably due to process innovation rather than product innovation. The former normally displaces jobs, but does not do so in case of Korean manufacturing firms. There could be two main reasons.

First, Korean manufacturing firms might have exposure to very competitive environmental conditions. Big Businesses (BBs) should globally compete and Small and Medium Enterprises (SMEs) should compete with BBs. We already proved that process innovation in monopolistic markets has a greater job displacement effect than that in non-competitive markets. Therefore, process innovation in Korean manufacturing firms would have lesser job displacement effect, since it occurs in a more competitive environment that has to lower the price in order to sell more products.

In contrast, second, the openness of Korea would provide unlimited foreign product market to sell. Accordingly, Korean manufacturing firms that achieve price-competitiveness through process innovation can sell their products in foreign product markets, so as to achieve a greater compensation effect than in case of normal and less BSE, from any industry wide perspective.

To conclude, innovation in Korean manufacturing firms could have a positive influence on employment for succeeding to achieve the price competitiveness using scale economy and create the foreign demand in the export market. However, we would expect that displacement effect of innovation would be significant in the near future if domestic firms would not compete with global competitors and try to create the domestic demand in domestic markets. They are still competitive in the domestic market, but lose their price competitiveness in foreign product markets to emerging countries such as China. Therefore, the only way to break through this employment problem of Korea could be to create a foreign demand through product innovation. In order to achieve this, the government should intensify the institutional aspect for fair competition between domestic firms, since Korea is highly concentrated to a small number of firms that can prevent inter-industry competition and product innovations.

Appendix-A

Definition of variables

KIS 2002, 2005, 2008, and 2010 are used for calculating the variables. Each dataset has firms' latest information for three years; for example, KIS 2002 has firms' information from 1999-2001. Thus, we can calculate the growth rate of some dependent and independent variables for two years and have 11,369 firms (2,534 firms in KIS2002, 2,354 in KIS2005, 2,865 in KIS2008, and 3,616 in KIS 2010) and 84 industries (21 industries for each period) for the analysis. However, firms' innovative activities are normally observed once during the period.

(1) Firm-level variables

Employment growth: Rate of change of the firms' employment for the whole period.

Process innovation (Process innovation only): Dummy which takes the value 1, if the firm reports having introduced new or significantly improved production process during the period but no new or significantly improved products.

Product innovation (Sales growth due to new products): Computed as the product of the fraction of turnover due to new or significantly improved products and one plus the rate of change of the firm’s turnover for the whole period

Process and product innovation: Dummy which takes the value 1, if the firm reports having introduced new or significantly improved production process during the period and new or significantly improved products.

Price indices at detailed industry levels: Computed at 2-digit level for manufacturing on the basis of the producer price indices published by Bank of Korea.

Industry dummies: System of industry dummies according to the list of industries given in Table 3-1.

Time dummies: System of time dummies from 2005 to 2010

Replacement of old products: Variables which takes value 0 if the firm reports that innovation purpose is not replacement of products and 1-5 if it has been of low importance to high importance.

Increased range: Variables which takes the value 0, if the firm reports that the effect of innovation has been irrelevant for the broadening of the range of the products, 1-5 if it has had a low impact to high impact.

(2) Sector-level variables

Job-creatinng rate: Size weighted means of positive growth rates of employment over an industry and firm-size

Job destruction rate: Size weighted means of negative growth rates of employment over an industry and firm-size

Job growth rate: An aggregated net employment growth rate of an industry and firm-size

Process innovation (procs): Employment share of firms that have implemented at least one process innovation of an industry

Product innovation (prods): Employment share of firms that have implemented at least one product innovation of an industry

Innovation (innovs): Employment share of firms that have implemented at least one type of innovation of an industry

Product-orient innovation (innorels): procs/prods

Size dummies: System of size dummies according to the list of firm-size given in Table 3-1.

Time dummies: System of time dummies from 2005 to 2010

Appendix-B

Dynamics of firm-level employment effect of innovation

According to Vivarelli (2012), the effect of innovation on employment can be differently determined by demand conditions and developmental status. Furthermore, Lee (2001) also emphasized that there are different learning mechanisms for successful catch-up as the stages of technological development. Therefore, the firm-level effect of innovation can be changed according to its different developmental status and here we expect to see that these differences can be captured by Korean manufacturing firms from 1999-2009.

Table 5-1 explicitly shows that firm-level employment effect of innovation has changed over time. More concretely, according to 2SLS regression results, the employment effect of product innovation has started to decrease from 2002 and has continued to decrease until 2009. This decreasing pattern would be caused by the increased production efficiency of new products.

The previous regression results are based on different sample firms by different periods. Accordingly, the different employment effect of innovation can be caused by different samples. Therefore, the analysis of the same sample firms that exist in two different periods can be an alternative way to solve this problem. We use 308 firms for 1999-2004, 356 for 2002-2007, and 556 for 2005-2009, which exist as two periods simultaneously. According to Table 5-10, we can find that this decreasing pattern has occurred; from KIS2002 to KIS2005, KIS2005 to KIS2008, and KIS 2008 to KIS2010, the estimate of g2 continues to decrease.

Table 5-10. Dynamics of firm-level employment effect of innovation; Korean manufacturing firms from 1999-2009

	Dependent variable: employment growth due to innovation only					
	2SLS					
	KIS 2002	KIS 2005	KIS 2005	KIS 2008	KIS 2008	KIS2010
process innovation only (*d*)	0.06	-0.01	-0.05	-0.16*	-0.09	-0.02
	(0.51)	(-0.18)	(-0.48)	(-2.18)	(-1.29)	(-0.27)
product innovation (*g2*)	1.00**	0.78**	1.17**	0.84**	0.95**	0.66**
	(5.63)	(4.25)	(4.44)	(4.86)	(6.61)	(3.79)
process and product innovation (d*)	-0.01	0.13	-0.11	0.04	0.05	0.04
	(-0.13)	(1.39)	(-0.83)	(0.71)	(0.91)	(0.71)
_cons	0.07	-0.04	0.01	-0.01	-0.1	-0.03
	(0.41)	(-0.37)	(0.12)	(-0.14)	(-1.53)	(-0.41)
N	308	308	356	356	556	556
r2_a	0.38	0.56	0.45	0.36	0.33	0.28
rmse	0.48	0.35	0.47	0.35	0.41	0.37

** industry dummies are included*

In order to confirm whether this decreasing pattern of innovational effect on employment is statistically significant, we make a new dataset, which has all the sample firms from KIS2002, 2005, 2008, and 2010 and make 1) year dummy variables and 2) the interaction term with year dummy and proxy for product innovation, sales growth due to new products. Using the interaction terms, we test whether the effect of product innovation has been significantly decreased over time and we find these differences to be statistically significant.

Table 5-11. Dynamics of firm-level employment effect of product innovation; Korean manufacturing firms from 1999-2009

	Dependent variable: employment growth due to innovation only					
	OLS			2SLS		
	(1)	(2)	(3)	(1)	(2)	(3)
process innovation only (d)	-0.02	-0.03+	-0.04*	-0.01	-0.02	-0.06**
	(-1.15)	(-1.69)	(-2.09)	(-0.58)	(-1.22)	(-2.74)
sales growth due to new product sales (g2)	0.71**	0.71**	0.77**	0.93**	0.95**	0.77**
	(42.41)	(41.57)	(27.91)	(30.33)	(29.37)	(30.92)
process innovation and product innovation dummy (d*)	0.11**	0.10**	0.10**	0.02	0.00	0.15**
	(9.60)	(8.65)	(8.94)	(1.15)	(0.02)	(9.91)
year_2005		0.03*	0.04*		0.03*	0.07**
		(2.14)	(2.46)		(2.24)	(3.16)
year_2008		-0.04**	-0.02		-0.01	-0.01
		(-3.24)	(-1.57)		(-0.76)	(-0.34)
year_2010		0.08**	0.12**		0.11**	0.17**
		(6.65)	(8.02)		(8.57)	(9.23)
year_2005*g2			-0.04			-0.14**
			(-0.97)			(-2.65)
year_2008_g2			-0.07			-0.18**
			(-1.33)			(-3.46)
year_2010*g2			-0.15**			-0.41**
			(-3.85)			(-8.26)
_cons	-0.03	-0.05*	-0.07**	-0.05**	-0.10**	-0.08**
	(-1.40)	(-2.39)	(-3.04)	(-2.68)	(-4.53)	(-3.32)
N	11369	11369	11369	11369	11369	11369
r2_a	0.33	0.34	0.34	0.31	0.31	0.26
rmse	0.47	0.46	0.46	0.47	0.47	0.49

** industry dummies are included*

Appendix- C

Robustness check for the industry-level employment effect of innovation

Previously, we generate the job flow rates by industry and firm-size. This is because job flow rates have a negative relationship with firm-size that need to be controlled. However, one may argue that it is not an industry-level analysis in a rigorous way. Therefore, here, we calculate the industry-level job flow rates and check the estimation result.

(1) Employment effect of different type of innovation

According to Table 6-6, not only process but also product innovation does not have any significant effect on sector-level employment growth, which is consistent with the previous analysis.

Table 6-6. Industry-level employment effect of innovation; process vs. product innovation

	Dependent variables		
	Job creation rate	Job destruction rate	Job growth rate
Process innovation	-0.02	-0.02	0.00
	(-0.60)	(-0.69)	(0.12)
Product innovation	0.01	-0.02	0.03
	(0.32)	(-0.48)	(0.67)
_cons	0.10**	0.09**	0.01
	(6.50)	(5.91)	(0.61)
N	84	84	84
r2_a	0.02	-0.02	-0.02
rmse	0.04	0.04	0.06

year dummies are included

However, innovation intenisty has a negative effect on job destruction rate even though it does not significantly increase the overall employment growth of an industry. On the othe hand, product-orient innovation does not have any significant effect on employment growth. These estimation results are similar with to the previous analysis, but weak in many ways. Employment growth is affected by innovation intensity, not by the type of innovation.

Table 6-7. Industry-level employment effect of innovation; innovation intensity vs. innovation type

	Depemdent variables					
	Job creation rate		Job destruction rate		Job growth rate	
	(1)	(2)	(1)	(2)	(1)	(2)
Innovation	-0.01	-0.01	-0.05*	-0.05*	0.04	0.04
	(-0.31)	(-0.33)	(-2.11)	(-2.14)	(1.30)	(1.29)
Product-orient innovation		0.00		0.00		0.00
		(-1.01)		(-1.07)		(0.05)
year dummy_2005	-0.01	-0.01	0.00	0.00	-0.01	-0.01
	(-0.45)	(-0.51)	(0.35)	(0.26)	(-0.62)	(-0.61)
yeardummy_2008	-0.03+	-0.03+	0.00	0.00	-0.03	-0.03
	(-1.81)	(-1.73)	(-0.00)	(0.07)	(-1.51)	(-1.47)
year dummy_2010	-0.03+	-0.03+	0.00	0.00	-0.03+	-0.03+
	(-1.90)	(-1.98)	(0.32)	(0.24)	(-1.87)	(-1.87)
_cons	0.10**	0.10**	0.10**	0.10**	0.01	0.01
	(6.43)	(6.60)	(5.92)	(6.01)	(0.34)	(0.33)
N	84	84	84	84	84	84
r2_a	0.03	0.02	0.01	0	0	-0.01
rmse	0.04	0.04	0.04	0.04	0.06	0.06

** 'product-orient innovation' is the employment share of product innovators/process innovators in an industry*

(2) Dynamic effect of different type of innovation on employment

We found that product innovation has long-term employment effect in sector-level analysis even though it does not have a short-term effect. Thus, we follow the same approaches on industry-level job flow rates and find that product innovation has a positive effect on the job-creating rate. According to Table 6-8, product innovation at period t does not have any significant effect on the job-creating rate at period t, but it can have a positive effec at period t+1. In other words, industry has a long-term employment effect of product innovation and creates employment in the future.

Table 6-8. Industry-level effect of innovation on employment; short-term vs. long-term

	Short-term effect			Long-term effect		
	(1)	(2)	(3)	(1)	(2)	(3)
process innovation (t)	-0.02	-0.02	0.00	-0.04	-0.02	-0.02
	(-0.60)	(-0.69)	(0.12)	(-1.10)	(-0.42)	(-0.45)
product innovation (t)	0.01	-0.02	0.03	-0.03	0.00	-0.03
	(0.32)	(-0.48)	(0.67)	(-0.69)	(0.07)	(-0.59)
process innovation (t-1)				-0.01	-0.06	0.05
				(-0.32)	(-1.64)	(1.09)
product innovation (t-1)				0.07+	0.00	0.07
				(1.71)	(-0.08)	(1.34)
_cons	0.10**	0.09**	0.01	0.09**	0.11**	-0.02
	(6.50)	(5.91)	(0.61)	(4.63)	(5.52)	(-0.69)
N	84	84	84	63	63	63
r2_a	0.02	-0.02	-0.02	0.04	0.04	0.02
rmse	0.04	0.04	0.06	0.04	0.04	0.06

** year dummies are included*
**Model (1): Dependent variable is job creation rate (t)*
**Model (2): Dependent variable is job destruction rate (t)*
**Model (3): Dependent variable is net employment growth rate (t)*

On the other hand, this positive employment effect of product innovation appears to be caused by innovation intensity, and not the type of innovation. According to Table 6-9, innovation intensity has a postive effect on employment growth in the long-term, but product-orient innovation does not have any significant effect on employment in both short-term and long-term. Overall, industry-level analysis using industry-level job flow indicators reports similar estimation results as with industry-level analysis using industry and firm-size job flow indicators. However, the estimation results are weak in general, as compared to the previous analysis.

Table 6-9. Industry-level effect of innovation on employment; innovation intensity vs. innovation type

	Short-term effect			Long-term effect		
	(1)	(2)	(3)	(1)	(2)	(3)
innovation (t)	-0.01	-0.05*	0.04	-0.07+	-0.02	-0.05
	(-0.33)	(-2.14)	(1.29)	(-1.92)	(-0.46)	(-1.26)
product-orient innovation (t)	0.00	0.00	0.00	0.00	0.00	0.00
	(-1.01)	(-1.07)	(0.05)	(-0.36)	(-0.38)	(0.02)
innovation (t-1)				0.07	-0.06	0.12*
				(1.62)	(-1.36)	(2.43)
product-orient innovation (t-1)				0.00	0.00	-0.01
				(-0.09)	(0.82)	(-0.65)
_cons	0.10**	0.10**	0.01	0.09**	0.12**	-0.02
	(6.60)	(6.01)	(0.33)	(4.58)	(5.62)	(-0.75)
N	84	84	84	63	63	63
r2_a	0.02	0.00	-0.01	0.04	0.04	0.03
rmse	0.04	0.04	0.06	0.04	0.04	0.06

** year dummies are included*

**Model (1): Dependent variable is job creation rate (t)*

**Model (2): Dependent variable is job destruction rate (t)*

**Model (3): Dependent variable is net employment growth rate (t)*

References

Blanchflower, D. G. and S. M. Burgess (1996). "Job creation and job destruction in Great Britain in the 1980s." Industrial & Labor Relations Review 50(1): 17-38.

Bogliacino, F. and M. Pianta (2010). "Innovation and employment: a reinvestigation using revised Pavitt classes." Research Policy 39(6): 799-809.

Bogliacino, F., et al. (2011). "R&D and employment: Some evidence from European microdata."

Bogliacino, F., et al. (2012). "R&D and employment: An application of the LSDVC estimator using European microdata." Economics Letters 116(1): 56-59.

Brouwer, E., et al. (1993). "Employment growth and innovation at the firm level." Journal of Evolutionary Economics 3(2): 153-159.

Coad, A. and R. Rao (2008). "Innovation and firm growth in high-tech sectors: A quantile regression approach." Research Policy 37(4): 633-648.

Doms, M., et al. (1997). "Workers, wages, and technology." The Quarterly Journal of Economics: 253-290.

Entorf, H. and W. Pohlmeier (1990). "Innovation, employment and export activity: evidence from firm-level data."

Evangelista, R. and M. Savona (2003). "Innovation, employment and skills in services. Firm and sectoral evidence." Structural Change and Economic Dynamics 14(4): 449-474.

Frey, C. B. and M. A. Osborne (2013). "The future of employment: how susceptible are jobs to computerisation." Retrieved September 7: 2013.

Greenan, N. and D. Guellec (2000). "Technological innovation and employment reallocation." Labour 14(4): 547-590.

Ha, T.J. and Moon, S.W. (2010). "The effect of innovation on structural unemployment: Panel data analysis." Labor Policy Review 10(1): 1-33.

Hall, B. H., et al. (2008). "Employment, innovation, and productivity: evidence from Italian microdata." Industrial and Corporate Change 17(4): 813-839.

Davis, S. J. and J. Haltiwanger (1991). Gross job creation, gross job destruction and employment reallocation, National Bureau of Economic Research.

Harrison, R., et al. (2008). Does innovation stimulate employment? A firm-level analysis using comparable micro-data from four European countries, National Bureau of Economic Research.

Harrison, R., et al. (2014). "Does innovation stimulate employment? A firm-level analysis using comparable micro-data from four European countries." International journal of industrial organization 35: 29-43.

Juhn, H.B. and Moon, S.B. (2013). "Competition and technological innovation: Incumbent and potential entrant" Industrial Organization Study 21(1): 1-25.

Jung, M. and K. Lee (2010). "Sectoral systems of innovation and productivity catch-up: determinants of the productivity gap between Korean and Japanese firms." Industrial and Corporate Change: dtp054.

Klette, J. and S. E. Førre (1998). "Innovation and job creation in a smallopen economy-evidence from norwegian manufacturing plants 1982–92." Economics of Innovation and New Technology 5(2-4): 247-272.

Kwon, S. J., et al. (2015). "Innovation activities and the creation of new employment: An empirical assessment of South Korea’s manufacturing industry." Social Science Information: 0539018415580190.

Lachenmaier, S. and H. Rottmann (2011). "Effects of innovation on employment: A dynamic panel analysis." International journal of industrial organization 29(2): 210-220.

Lee, K. and C. Lim (2001). "Technological regimes, catching-up and leapfrogging: findings from the Korean industries." Research Policy 30(3): 459-483.

Marx, K. (1867). Capital, volume I, Harmondsworth: Penguin/New Left Review.

Meriküll, J. (2008). The impact of innovation on employment: firm-and industry-level evidence from Estonia, Eesti Pank.

Meriküll, J. (2010). "The impact of innovation on employment: firm-and industry-level evidence from a catching-up economy." Eastern European Economics 48(2): 25-38.

Moon, S.B. and Juhn, H.B. (2008). "Empirical analysis on innovation activities and employment: Comparison between ICT firms and Non-ICT firms." Industrial organization study 16(1): 1-24.

Pianta, M. (2005). "Innovation and employment."

Piva, M. and M. Vivarelli (2005). "Innovation and employment: Evidence from Italian microdata." Journal of Economics 86(1): 65-83.

Schumpeter, J. A. (1934). The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle, Transaction publishers.

Shin, B.C., Song, C.W. and Choi, K.H. (2012). "Comparative analysis of different type of innovation and employment in firm-level." Corporation Manangement Review 46(1): 75-91.

Smolny, W. (1998). "Innovations, prices and employment: A theoretical model and an empirical application for West German manufacturing firms." Journal of Industrial Economics: 359-381.

Van Reenen, J. (1997). "Employment and technological innovation: evidence from UK manufacturing firms." Journal of labor economics: 255-284.

Vivarelli, M. (2012). "Innovation, employment and skills in advanced and developing countries: a survey of the literature."

Zimmermann, K. F. (1991). "The employment consequences of technological advance, demand and labor costs in 16 German industries." Empirical Economics 16(2): 253-266.

국문초록

시장구조를 고려한 기술혁신이 고용에 미치는 영향에 관한 동태연구 -한국제조기업 및 산업의 경우-

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기술혁신은 고용에 어떠한 영향을 미칠까? 기술혁신이 성장에 미치는 영향은 비교적 명백한데 반해, 기술혁신이 고용에 미치는 영향에 관한 논의는 끊이지 않고 계속되고 있다. 이는 기술혁신이 고용을 대체하는 대체효과를 가지고 있는 반면, 수요창출을 통한 보상효과도 함께 가지고 있기 때문인데, 기업의 수요창출을 통한 보상효과는 기술혁신의 특징 및 중요도에 의해 결정되기도 하지만, 해당 기업이 속한 시장환경 및 수요조건에 의해 결정되기 때문이다. 따라서, 기술혁신의 고용효과는 이론적인 논의 보다는 실증분석연구에 의존하여 발달되어 왔으며, 특히 기업차원에서의 연구는 기술혁신이 어떠

한 메커니즘을 통해 실제 고용에 영향을 미칠 수 있는지 살펴볼 수 있다는 측면에서 가장 기본적인 연구방법으로 활용되어왔다.

따라서, 본 연구는 고용창출을 위한 보다 나은 기술혁신지원정책의 수립을 도모하고자 과학기술정책연구소(STEPI)에서 주관하는 한국기술혁신조사자료 (KIS) 를 이용하여 한국제조기업의 기술혁신이 고용창출에 어떠한 영향을 주어왔는지 분석하였다. 기업차원에서의 분석을 위해 Harrison et al. (2008, 2014)의 연구모형 및 분석방법이 사용되었고, 기업차원에서의 분석이 가지는 한계점을 보완하기 위해 Greenan and Guellec (2000)의 연구방법을 이용한 산업차원의 분석이 병행되었다.

한편, 본 연구가 기존연구와 가지는 차이점은 다음과 같다. 첫째, 본 연구는 한국제조기업의 1999년부터 2009년까지 즉, 약 10년간에 걸친 방대한 조사자료를 사용하여, 기업 및 산업차원에서의 분석을 병행하였고, 각각의 결과를 비교 분석하였다. 둘째, 선행연구에서는 조사자료가 가지는 한계로 인하여 주로 기술혁신의 단기고용효과를 보는데 집중하고 있는 반면, 본 연구는 각각의 기간 동안 연속적으로 존재하는 기업들을 추출하여 별도의 패널데이터를 구성하고, 제한적이나마 기술혁신의 장단기고용효과를 모두 분석하였다. 마지막으로 셋째, 선행연구에서는 이론적으로만 존재하고 있는 제품시장에서의 경쟁효과를 최초로 실증분석에 도입, 시장구조에 따른 기술혁신의

고용효과를 명시적으로 살펴보았다.

실증분석 결과, 첫째, 한국제조기업의 기술혁신은 기업의 고용창출에 단기적으로 긍정적인 영향을 주고 있는 것으로 나타났으며, 둘째, 이러한 기업차원에서의 단기고용효과는 산업차원에서의 장기고용효과로 나타나고 있음을 확인할 수 있었다. 또한, 셋째, 시장구조가 더 독점적이 될수록 공정혁신의 고용창출효과는 줄어드는 것으로 나타났는데 이는 한국과 같은 성장방식을 지향하는 추격 국들에게 다음과 같은 시사점을 제공한다.

첫째, 한국의 기술혁신이 고용을 줄이지 않는 방향으로 작용한 데에는 한국의 제품혁신이 고용창출효과가 크다기 보다 한국의 공정혁신이 한국제조기업의 고용을 줄이는 방향으로 작용하지 않았기 때문이다. 둘째, 일반적으로 집중도가 높은 한국의 제조기업의 경우 공정혁신을 통한 고용대체효과가 매우 크게 나타나야 하는데 그렇지 않은 이유는 한국기업들이 직면한 실제 경쟁환경이 매우 경쟁적이라는 것을 의미한다. 마지막으로 셋째, 그럼에도 불구하고 한국의 제조기업들이 공정혁신을 통해 지속적으로 수요를 창출하고 또 고용을 창출하고 있는 까닭은 그들이 규모의 경제를 이용한 가격경쟁력을 가지고 있을 뿐 아니라, 이를 이용한 수출증대 및 지속적인 해외수요를 창출하고 있기 때문이다.

결론적으로 한국 제조기업의 기술혁신은 규모의 경제를 이용한 가격경쟁력 확보에 성공하여, 그 결과 수출시장에서 해외수요창출에 성공, 결과적으로 한국제조기업의 고용에 긍정적인 영향을 주었다. 하지만, 중국과 같은 신흥국의 추격으로 해외수출시장에서 입지가 줄어든 국내제조기업이 국내시장에서만 경쟁하려고 한다면 기술혁신으로 인한 고용대체효과는 앞으로 커질 수 밖에 없을 것으로 예상된다. 따라서, 제품혁신을 통한 해외수요창출만이 국내제조기업의 고용을 늘이기 위한 유일한 대응책이 될 수 있을 것이라고 생각하며, 이를 위해 정부는 일반집중도가 높은 우리나라 기업간 관계에 착안하여 산업 내 경쟁이 활발해 질 수 있도록 공정한 경쟁을 위한 제도적 장치를 더욱 강화해 나가야 할 것이라고 생각된다.

주요어: 기술혁신, 공정혁신, 제품혁신, 고용, 고용증가율, 단기고용효과,
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