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Employment effect of innovation under different market structures: Findings from Korean manufacturing firms☆

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ABSTRACT

This research provides empirical evidence on the employment effect of both process and product innovations under different market structures, using data from 1999 to 2009 on 11,369 manufacturing firms in Korea. Consistent to the literature, it first finds that the overall employment effect of innovations is positive, since process innovations do not have any significant effect but product innovations have positive and significant effects on employment. Then, our contribution is to estimate the employment effect of innovations in different market structure by adding interaction terms between proxies for market structure and each type of innovation. We find that process innovation has a greater negative effect in more monopolistic markets, and confirm no significant differences in the employment effect of product innovations across different market structure. Overall, we show that innovations have different effects on employment across different market structures, which implies that a competitive market is important for increasing employment through innovation.

1. Introduction

The impact of innovation on employment has long been a debated issue. While innovation is known to have a strong positive relationship with long term economic growth in general, the relationship between innovation and employment has not been clearly identified. This is because innovation has two distinctive effects on employment (Harrison et al., 2008; Vivarelli, 2014). On the one hand, innovation has a displacement effect, which displaces workers by capital, and has a negative influence on jobs. On the other hand, innovation has a compensation effect, which increases demand for workers in the production process. Thus, the overall employment effect of innovation cannot be predetermined. Given that economic theory does not ascribe an exact net effect of innovation, it has become a matter of empirical analyses.

Empirical analysis has largely been conducted at the firm-level, and typically categorizes innovations as process innovations and product innovations (Entorf and Pohlmeier, 1990; Doms et al., 1995; Van Reenen, 1997; Klette and Førre, 1998, Piva and Vivarelli, 2005; Coad and Rao, 2008. In particular, Harrison et al. (2008, 2014) argue that distinguishing the innovation type facilitates understanding the employment effect of innovations, and that each type of innovation has a different purpose and can have different employment effects. Firms introduce process innovation for cost-saving, but introduce product innovation for demand expansion. Thus, the former is expected to have a negative influence on jobs and the latter, a positive influence (Harrison et al., 2008, 2014). While a large volume of literature verifies the above reasoning, fewer studies consider the impacts of innovation in different market structures, namely when markets are more or less competitive or close to oligopoly. This paper is an attempt to fill this gap and show how the impacts of innovation are determined differently by the type of market structure.

Some theoretical explanations exist why the employment effect of innovation varies by market structure. According to Vivarelli (2014), the compensation effect is strongly weakened in a monopolistic market, since cost savings are not always and entirely translated into decreasing prices if an oligopolistic regime is dominant (see Labini, 1969). However, Schumpeter (1934) argues that firm size and market concentration are critical elements for a firm's innovative activities, and notes the

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impact of big businesses on innovations. To provide an empirical evidence on this issue of the employment effect of innovations in different market structures, we use data on 11,369 manufacturing firms in Korea, and first employ the econometric model and estimation strategies as in Harrison et al. (2008, 2014). Then, we take one step forward by adding a proxy variable of market structure, namely industry-level concentration ratio (CR3 = market shares of top 3 firms), and compare the estimation results under different market structures.

In what follows, Section 2 discusses the literature, and Section 3 describes the data, and estimation methods used. Section 4 explains the empirical results, and Section 5 concludes the paper.

2. The literature

2.1. Employment effect of process and product innovations

In the existing literature, firm-level studies categorize innovations as either process innovations or product innovations, and emphasize their different role in employment (Entorf and Pohlmeier, 1990; Doms et al., 1995; Van Reenen, 1997; Klette and Førre, 1998, Piva and Vivarelli, 2004, Piva and Vivarelli, 2005; Coad and Rao, 2011).[1] Process innovations intend to improve the production process; hence, they have a direct impact on productivity and unit cost. Since they directly displace workers, they have a negative influence on jobs. However, the compensation effect of such innovations is not certain since new employment may not be created if the productivity improvement of process innovations does not lead to price reduction; if there is no price reduction, no new demand will be created and no new production and employment follows. This occurs only when the price is decreased in order to achieve more market share. This is the reason we consider the market structure as one of the fundamental considerations, and further explanations for this are provided in the following part. By contrast, product innovations that directly increase product demand create more employment. However, the displacement effect of product innovations is not certain since it depends on the substitution rate and productivity differences between the old and new products. Thus, the employment effect of innovation is not clear and can be differ by time and conditions. Table 1 summarizes the employment effect of process and product innovations and aspects to be considered.

Typical firm-level empirical research shows that product innovations have a positive employment effect, while process innovations do not exhibit a decisive employment effect (See Table 2). Entorf and Pohlmeier (1990), studying 2276 German manufacturing firms in 1984, find a positive relationship between product innovation and employment, but do not find a significant effect of process innovation on employment. Harrison et al. (2008, 2014) devise the new proxy for product innovations, which is sales growth of new products and provide evidence from four European countries (France, Germany, Spain, and the UK). They find a positive employment effect for product innovations, but a varied effect for process innovations (negative or insignificant). Hall et al. (2008) use the similar econometric model and estimation strategy as Harrison et al. (2008, 2014) and find no significant effect of process innovations and a positive effect of product innovations for Italian firms. There is even some empirical evidence that supports process innovations having a positive relationship with employment. Greenan and Guellec (2000) use data on 15,186 French manufacturing firms from 1986 to 1990 and find that both product and process innovations have positive employment effects. Further, they determine that process innovations have a greater job creating effect than product innovations. Lachenmaier and Rottmann (2011) also find a positive employment effect from both types of innovations by studying German manufacturing firms from 1982 to 2002. Further, they find that process innovations have a greater job creating effect than product innovations.

Firm-level research on the employment effect of different types of innovations has also been conducted in Korea. Moon and Chun (2008) consider Korean manufacturing firms from 1999 to 2001 and find that process innovations have no significant effect on employment, whereas product innovations have a positive employment effect. In contrast, Shin et al. (2012) find process innovations have a positive impact on employment, whereas product innovations have no significant effect using Korean manufacturing firms from 2005 to 2007. Kwon et al. (2015) study data on Korean manufacturing firms from 2009 to 2011 and find similar estimation results as Moon and Chun (2008). While these studies show different results probably due to the differences in the time periods and estimation methodology, we propose that one important factor for the differences might be the market structures. Given the varying findings, it is worthwhile to analyze this issue with a rigorous methodology based on Harrison et al. (2008, 2014), also considering the impact of market structure as one of the influencing factors for the differing employment effects of innovations.

2.2. Market structure and innovation

A firm's innovational activities can be strongly influenced by market structure. According to the Schumpeterian hypothesis, firms in a monopolistic market expect higher returns from innovations; hence, they spend more money on R&D and achieve more innovations. Kraft (1989) uses 57 West German firms in 1979 and finds competition impedes innovations. He considers the three- or four- concentration ratio and Herfindahl-index as proxies for market structure, and shows how they significantly affect the percentage of sales that can be attributed to products newly developed during the last five years. Scherer (1965) also finds the interesting results that there is a positive correlation between innovation and concentration even after interindustry differences in technological opportunity are taken into account. However, he mentions technological vigor increases with a relatively low level of concentration. He shows additional market power is probably not conducive to more vigorous technological efforts when the four-firm concentration ratio exceeds 50 or 55%. On the other hand, Vossen (1999) finds a positive effect of industrial concentration on R&D spending, but fails on the number of innovations.

A contrasting view is that innovation is deterred in a more monopolistic market. Arrow (1962) insists that a competitive market is better for innovations since firms in a competitive market have more incentive to innovate in order to escape from the current competition-level. Geroski (1990) shows actual monopoly power has a negative effect on innovation since a negative direct effect is greater and absorbs the indirect positive effect. According to his argument, monopoly power can have a negative influence on firms' innovative activities because a) firms in a monopolistic market do not have active competitive forces, b) have less competitors to search for innovations, and c) have higher transaction costs turning from the old technology. He distinguishes the monopoly power as anticipated and actual monopoly power and emphasizes the importance of actual monopoly power on innovations.

Finally, recent studies indicate that there is a strong inverted-U shape relationship between competition and innovation; it means innovation increases as a market becomes more competitive, but decreases if a market becomes too competitive. Aghion et al., 2005 find the inverted- U shape relationship between product market competition and innovation, and explains that the escape competition effect dominates for low initial levels of competition, but the Schumpeterian effect dominates at higher levels of competition. However, there is still a lack of evidence for the employment effect of innovation in different market structures.

[1] Harrison et al. (2008, 2014) argue that the type of innovation should be distinguished to better understand the employment effect of innovation because each type of innovation has a different purpose for innovation and employment.

Table 1
Employment effect of process and product innovation (Harrison et al., 2008).

			Employment effect of innovation			
			Displacement	Compensation		
R&D innovation expenditures	⇨	Process innovation	Productivity effect: less labor for a given output	Price effect: cost reduction, passed on to price, expands demand	⇦	Depends on firm agents' behavior ⇧
		Product innovation	Productivity differences of the new product?	Demand enlargement effect	⇦	Depends on competition

Table 2
Literature for firm-level employment effect of innovation.

Authors	Data	Results
Entorf and Pohlmeier (1990)	- 2276 West German manufacturing firms - Cross-section data: 1984	- Product innovation: (+) significant effect
Brouwer et al. (1993)	- 859 Dutch manufacturing firms - Cross-section data	- R&D expenditure: (−) significant effect
Doms et al. (1995)	- US manufacturing firms - Period: 1987–1997	- Advanced manufacturing technologies: (+)
Klette and Førre (1998)	- 4333 Norwegian manufacturing firms - Period: 1982–1992	- R&D intensity: no significant (+) effect
Van Reenen (1997)	- 598 British manufacturing firms - Period: 1976–1982	- Innovation: (+) significant effect
Blanchflower and Burgess (1996)	- British firms: 1990 - Australian firms: 1989	- Innovation: (+) significant effect
Smolny (1988)	- West German 2405 manufacturing firms - Period: 1980–1992	- Product innovation: (+) significant effect
Greenan and Guellec (2000)	- 15,186 French manufacturing firms - Period: 1986–1990	- Process innovation: (+) significant effect at firm-level - Product innovation: (+) significant effect at sector-level
Piva and Vivarelli, (2004, 2005)	- 575 Italian manufacturing firms - Period: 1992–1997	- Innovation: (+) significant effect
Harrison et al. (2008)	- CIS data from 4 European countries - Germany, France, UK, Spain	- Process innovation: (−) significant effect - Product innovation: (+) significant effect
Hall et al. (2008)	- Italian firms - Period: 1995–2003	- Process innovation: no significant 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
Bogliacino, Piva, and Vivarelli (2011, 2012)	- 677 European manufacturing & service firms - Period: 1990–2008	- R&D expenditure: (+) in service & high-tech manufacturing industries - R&D expenditure: no significant in traditional industries
Moon and Chun (2008)	- 1874 Korean manufacturing firms - Period: 1999–2001	- Process innovation: no significant effect - Product innovation: (+) significant effect
Shin et al. (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: (−) significant effect - Product innovation: (+) significant effect

2.3. Employment effect of innovations in different market structure

As previously mentioned, innovation has both positive and negative employment effects. Unlike with a negative effect, the positive employment effect of innovation directly relates with the demand enlargement that could be possibly affected by market structures. Vivarelli (2014) refers to the compensation theory of Marx, and distinguishes the compensation mechanisms 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. He argues that they are influenced by 1) demand elasticity, 2) the degree of market competition, 3) capital-labor substitution, and 4) demand expectations, which are closely related with market structure.

However, most firm-level analyses do not either explicitly consider the role of market structure or provide rigorous empirical evidence. Exceptionally, Vivarelli (2014) mentions the role of market structure and emphasizes that the effectiveness of the mechanism “via decrease in prices” depends on there being perfect competition. He explains that the whole compensation mechanism 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 Labini, 1969). Therefore, we can suppose that process innovation in a monopolistic market could have a greater negative effect than in a non-monopolistic market, since cost savings from process innovations might not necessarily lead to decrease in price if the market is not that competitive. Fig. 1 shows a more detailed mechanisms for market structure and compensation mechanisms of process innovation.

The employment effect of product innovation in a monopolistic market is not as certain compared with that of process innovation. This is again because there is no consensus that a monopolistic market structure is good for firms' innovative activities or not, as we already discussed in Section 2.2. However, Jung and Lee (2010) show us that Korean firms in a monopolistic market achieve better productivity performance if they are oriented to export markets and thus exposed to world market discipline. It implies that firms that are monopolistic in their domestic market but are exposed to global competition are better motivated to innovate using monopoly rents. If this is true, we can

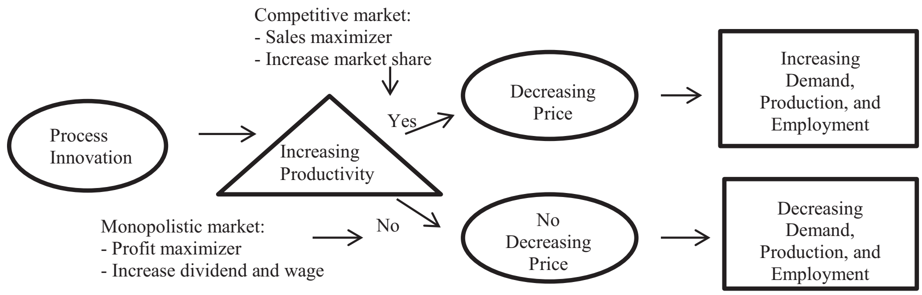

Fig. 1. Market structure and compensation mechanisms of process innovation.

expect that product innovation in a more monopolistic market achieves more employment if the firm is exposed to global competition. Nonetheless, there is one more thing to be considered: the substitution rate between old and new products. The sales growth of new products can cannibalize some of the firms' existing sales. Geroski (1990) points out that firms in a monopolistic market have less incentive to make entirely new products since it requires more new processes and equipment, which is costly and inefficient from the perspectives of monopolistic firms. Instead, they prefer to make improved products that can re-utilize the existing capital stocks. Accordingly, the product innovation in a monopolistic market would create less new demand than that in a non-monopolistic market and create less employment as follows.[2] Thus, the final employment effect of product innovation in a monopolistic market is not certain since we should consider a) the increased demand coming from the innovations, and b) the substitution rate between old and new products at the same time.

3. Data and method

To estimate the firm-level employment effect of process and product innovations in different market structures, this paper studies 11,369 Korean manufacturing firms from 1999 to 2009, and employs a similar econometric model and estimation strategy to Harrison et al. (2008, 2014). We generate an additional variable for market structure, which is industry-level CR3, and estimate the employment effect of both types of innovations in different market structures. Some more discussion follows, further describing this methodology.

3.1. Data and variables

Data from the Korea Innovation Survey (KIS) 2002, 2005, 2008 and 2010 is used for this analysis. This dataset is established by the Science and Technology Policy Institute (STEPI) under the Korean government to be used as a basis for innovation policies in Korea. Following the international standard of innovation surveys, it contains information on firms' innovation activities, besides financial performance information. It is conducted every two to three years, and thus seven iterations are available (KIS 2002, 2005, 2008, 2010, 2012, 2014).[3] However, they are not in the form of panel datasets, since each period of time is re-sampled.[4] All samples are representative of their industry size strata. From KIS 2002 to KIS 2014, we only use KIS 2002 to KIS 2010 since the data from KIS 2012 changed in many ways.[5]

KIS 2002, KIS 2005, KIS 2008 and KIS 2010 have 3775, 2743, 3081, and 3925 observations respectively. However, we exclude firms that exceed 300% sales growth for two years, or 300% employment growth for two years (1999–2001, 2002–2004, 2005–2007, 2007–2009). In addition, we exclude firms with missing dependent and independent variable values. Finally, we use 11,368 sample firms from 1999 to 2009. Table 3 shows how the sample firms are distributed according to time and industry.

All variables are calculated as growth rates for two years.[6] The dependent variable is the employment growth rate, which considers the real sales growth rate of old products,[7] and the independent variables are proxies for process innovation, product innovation, market structure, and interaction terms between market structure and each type of innovation variables. Additionally, industry dummy and time dummy variables are included to reflect the industry- and time-specific effects of employment growth. The following is more detailed information about the variables.

3.1.1. Employment growth rate (l)

The employment growth rate is calculated as the rate of change of a firm's employment for the whole period.[8] Harrison et al. (2008, 2014) explain that it is induced by increased demand, process innovations, and product innovations.[9] However, they assume that increased demand for old products has a one to one relationship with the employment growth rate of firms, and create the new dependent variable, "pure employment growth rate," which takes into account the increased demand of old products on employment growth. Therefore, it is only influenced by either process innovations or product innovations. Finally, the pure employment growth rate is calculated as:

Pure employment growth rate = employment growth rate − real sales growth rate of old products.

3.1.2. Sales growth rate (g = g1 + g2)

The sales growth rate of firms (g) can be divided into the sales growth rate of old products (g_1) and new products (g_2). Harrison et al. (2008, 2014) suggest using the sales growth rate of old products (g_1) for generating the new dependent variable, pure employment growth rate, and the sales growth rate of new products (g_2) to use as a proxy for product innovations.

[2] Here, the biggest competitors of firms in a monopolistic market may not be other firms, but rather the firm itself. In this case, new products effectively replace the old products and the compensation effect may be cannibalized by decreasing sales of the old products.

[3] The first survey began in 2002, and the last survey in 2014. The survey was conducted separately on both manufacturing firms and service firms; KIS 2002, 2005, 2008, 2010, 2012, and 2014 were for manufacturing firms, and KIS 2003, 2006, 2010, 2012, and 2014 was for service firms. KIS 2002 is the survey performed in 2002, but contains information of firms from 1999 to 2001. By the same reasoning, KIS 2005 is for 2002–2004, KIS 2008 is for 2005–2007, KIS 2010 is for 2007–2009, KIS 2012 is for 2009–2011 and KIS 2014 is for 2011–2013.

[4] Therefore, some firms may appear in the sample twice or more. In view of this nature of the data, we use estimation strategies with time dummy variables.

[5] KIS 2012 is excluded because the important question for this research changed at this point.

[6] Each dataset provides the financial information of firms for three years, so we can calculate the growth rates of variables for two years.

[7] The dependent variable is calculated as the employment growth rate minus the real sales growth rate.

[8] Each dataset provides the financial information of firms for three years, so we can calculate the growth rates of employment for two years.

[9] An increased demand for old products can occur from the process innovation of firms or other macro-economic conditions.

Table 3
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, clothing 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, 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, communication equipment, and apparatuses	326	196	152	185	859
33	Medical, precision, 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		2534	2354	2865	3616	11,369

3.1.3. Price growth rate of an industry (π)

To calculate the real sales growth of old products (g_1), Harrison et al. (2008, 2014) suggest using the price growth rate of an industry (π) instead of that of old products (π_1), which is impossible to detect and measure. Thus, we calculate the price growth rate of an industry using a two-digit producer price index (PPI) from the Bank of Korea and instead use the price growth rate of old products.

3.1.4. Process innovations (d)

Process innovations are measured as a dummy variable that equals 1 if a firm implements the process innovation only and 0 otherwise.[10] Process innovations are supposed to have a negative effect on employment since it is implemented for cost-saving, which reduces the workers required for production. However, it can have a positive impact on employment if the compensation effect of process innovations exceeds the displacement effect.

3.1.5. Product innovations (g2)

Product innovations are measured by the sales growth rate of new products.[11] Product innovations should have a positive impact on employment since it is implemented to enlarge the market, which can increase employment through market expansion. Harrison et al. (2008, 2014) decomposes the sales growth rate into two parts, the sales growth rate of old and new products, and uses the latter as a proxy for product innovations.

3.1.6. Market structure (m)

As we previously mentioned, the employment effect of innovations can be differently determined by market structure. We endogenously calculate and use the industry-level CR3[12] to measure the market structure of industries in which firms belong.[13] The industry-level $CR3_j$ (CR3 of j industry) is calculated by the sum of the sales of the top three firms ($Sales_{Top1,\ j} + Sales_{Top2,\ j} + Sales_{Top3,\ j}$) within an industry (j) divided by the total sales of an industry ($\sum_{i=1}^{n} Sales_{i,j}$).[14]

$$CR3_j = \frac{Sales_{Top1,j} + Sales_{Top2,j} + Sales_{Top3,j}}{\sum_{i=1}^{n} Sales_{i,j.}}$$

Table 4 shows the industry-level CR3 (concentration ratio of the top 3 firms) from 1999 to 2009. We classify the industries as monopolistic industries if the industry-level CR3 is over 0.75, and non-monopolistic industries if it is < 0.75. Finally, industry numbers 21, 23, 30, and 35 are classified as monopolistic industries from 1999 to 2001, and only industry numbers 23 and 35 remain classified as monopolistic industries until 2009. Industry number 17 is newly classified as a monopolistic industry from 2007 to 2009.

In summary, we classify the firms as existing in a monopolistic industry or a non-monopolistic industry, and compare the descriptive statistics of variables by different market structures. Among the 11,369 manufacturing firms, 10,984 firms are classified as firms in a non-monopolistic industry, and only 385 firms are classified as firms in a monopolistic industry.

According to Table 5, Korean manufacturing firms in a non-monopolistic market innovate more than the firms in a monopolistic market, which is opposed to the Schumpeterian hypothesis. Accordingly, a non-monopolistic market has more product innovators and greater employment growth. An interesting fact is that the employment growth rate of non-innovators does not differ greatly between the two types of markets.

[10] Therefore, we include an additional variable for controlling the effect of the process innovations of product innovators (d^*); d^* is a dummy variable that equals 1 if a firm implements both process and product innovations and 0 otherwise. More details are provided in Section 2.2.

[11] It is measured by the nominal sales growth rate of new products because it is impossible to measure the price growth of new products. Therefore, this can lead to an endogeneity problem with an omitted variable bias. This is considered in Section 2.2.

[12] The standard tools to measure the market concentration are the Herfindahl index (HHI) and the concentration ratios (CR(n)). These tools are the traditional structural measures of market concentration (based on market shares), and we use industry-level CR3 as a proxy for market structure.

[13] The Fair Trade Commission officially provides 5- and 8-digit-industry CR3 measures; however, our dataset is based on 2-digit-industry codes, which are a broader classification method. Further, the Commission's time of investigation does not perfectly match with our dataset. Therefore, official CR3 measurements are not applicable for use in our analysis, and thus, we generate our own 2-digit-industry CR3 using the unweighted average method.

[14] This industry-level CR3 is calculated by the shipments of domestic firms. However, some industries may have high export ratios such that a high industry-level CR3 based on domestic shipments may not properly reflect their actual competition. The impact of foreign sales on domestic employment may further depend on the degree of internationalization of production, namely, how much production is done in the overseas factories of Korean firms. Thus, we leave this challenging question as a topic for future research.

Table 4
CR3 by industry; Korean manufacturing firms from 1999 to 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, clothing 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, 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, communication equipment, and apparatuses	14.38%	42.18%	35.60%	63.22%
33	Medical, precision, 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%

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

	Korean manufacturing firms from 1999 to 2009		
	Competitive industry	Monopolistic industry	Total
Number 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

On the other hand, the average sales growth rate of process innovators in a non-monopolistic market is lower than that in a monopolistic market, even though the employment growth rate is vice-versa. This indicates that process innovators in a monopolistic market are highly efficient and productive, and can create more sales with less people than in a non-monopolistic market. Therefore, we expect that process innovations in a monopolistic market has a greater job displacement effect than in a non-monopolistic market, whereas product innovations in a monopolistic market does not have a greater job creation effect than in a non-monopolistic market.

3.2. Econometric model and estimation strategy

Harrison et al. (2008, 2014) suggests the two-period and two-good production model to explain the effect of different types of innovations on employment. They classify products as either old or new products, and decompose the sales growth of the products (g) into the sales growth of old products (g_1) and the sales growth of new products (g_2). Then, they use the sales growth rate of new products (g_2) as a proxy for product innovations and abstract the sales growth rate of old products (g_1) from the employment growth rate (l) to create the new dependent variable, pure employment growth rate. Thus, pure employment growth rate, employment growth rate minus real sales growth rate of old products, is influenced by either type of innovation variable. The sales growth rate of old and new products (g_1, g_2) are the nominal growth rates that need to be transformed into the real sales growth rates. Therefore, the price growth rate of an industry is used as a proxy for the price growth rate of old products. The dependent variable, pure employment growth rate, is finally expressed as $l - (g_1 - \pi)$[15] and is entirely influenced by both types of innovations: a) process innovation dummy (d), and b) sales growth rate of new products (g_2).[16]

$$l - (g_l - \pi) = \alpha_0 + \alpha_l d + \beta g_2 + v$$
$$where,\ v = -(\pi_l - \pi) - \beta\pi_2 y_2 + u \qquad (1)$$

However, the proxy for product innovations, which is the sales growth rate of new products (g_2), is not transformed into a real term as the real sales growth rate of new products. Thus, this can induce an endogeneity problem relating to omitted variable bias. The sales growth rate of new products can be decomposed into the real sales growth of

[15] The nominal sales growth rate of old products is g1 and π is the price growth rate of an industry to which a firm belongs.

[16] Process innovation is measured by a dummy variable that equals 1 if a firm implements the process innovation and 0 otherwise. Therefore, the dependent variable, which is measured by the employment growth minus the sales growth of old products, is influenced by both process and product innovations.

new products (y_2) and the price growth rate of new products (π_2). Unfortunately, we cannot detect the price information of new products (π_2). Thus, it is impossible to consider the price growth rate of new products (π_2) in the model, which could result in biased estimates of $g2$. To solve this endogeneity problem of g_2, we consider additional the instrument variables (IVs) for g_2, which are correlated with the real sales growth rate of new products (y_2) but uncorrelated with the price growth rate of new products (π_2). Accordingly, a) the purpose of innovation is the replacement of old products 0–5, and b) the purpose of innovation is to increase the range of products 0–5 are used as IVs for g_2. We estimate the employment effect of process and product innovations using the two stage least square (2SLS) estimation method together with the ordinary least square (OLS) method.

On the other hand, the proxy for process innovations (d) is measured by a dummy variable that is 1 for a firm who only implements the process innovations and 0 otherwise. Thus, it would provide biased estimates for d, because d does not take into account the process innovations of product innovators. Therefore, we add an additional variable (d^*) that equals 1 if a firm implements both process and product innovations, and 0 otherwise. It estimates the employment effect of process innovations of product innovators, and controls for the effect of process innovations of product innovators on employment.

Finally, we consider and try two different ways to investigate how market structure affects each type of innovation differently. In the first method, we divide the firms into two groups depending upon their market structures and estimate the employment effect of innovation by market structure. In the second method, we directly use the variable of representing market structure (m), *industry-level CR*3, to introduce the interaction term between the proxy for market structure and each type of innovation variable in the regressions. Thus, the final econometric model is as follows and γ_2 and γ_3 capture the effect of process and product innovations on employment in different market structures, respectively.

$$l - (g_1 - \pi) = \alpha_0 + \alpha_1 d + \beta g_2 + \alpha_2 d^* + \gamma_1 m + \gamma_2 m^* d + \gamma_3 m^* g_2 + v$$

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

(1) Dependent variable:

pure employment growth rate (l-($g_1 - \pi$))

(2) Independent variables:

proxy for process innovation (d)

proxy for product innovation (g_2)

proxy for process innovation of product innovators (d^*)

(3) Added independent variables:

market structure (m)

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

product innovation in monopolistic market ($m \times g_2$)

(2)

4. Results

We first estimate the employment effect of innovation in Korean manufacturing sector, and compare the results with that in European countries. The dependent variable is pure employment growth rate, which is employment growth rate considering the real sales growth rate of old products, and the independent variables are proxies for both product and process innovation. We use both ordinary least squares (OLS) and two stage least square (2SLS) methods for the estimation. Table 6 summarizes the estimation results for Korea, France, Germany, Spain, and the UK.

According to Table 6, product innovation of Korean manufacturing firms has positive and significant effect on employment, whereas process innovation has negative but insignificant effect on employment. Therefore, the overall employment effect of innovation for Korean manufacturing firms is positive, since process innovation does not have any significant effect but product innovation has positive and significant effect on employment. More concretely, the pure employment growth rate increases 0.95%p, when sales growth rate of new products increases 1%p. It indicates that Korean manufacturing firms produce new products more efficiently than old products using less employment for the production of new products.[17]

Table 6
Employment effect of different types of innovation: Korean firms vs. European firms.

	Dependent variable: Pure employment growth rate				
	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

Legend: $+p < 0.1$; $*p < 0.05$; $**p < 0.01$.
Notes (1): Industry dummies are included.
Notes (2): Korea is based on KIS2002, which was conducted in 1999–2001. Other European countries (France, Germany, Spain, UK) are based on CIS3, which was conducted in 1998–2000.

Compared with some European countries, Korean manufacturing firms use less employment for the production of new products. However, process innovation has less of a negative influence on jobs, which indicates that Korean manufacturing firms may have a greater compensation effect than that in some European countries. An interesting result is that only process innovation has different employment effects across the countries, even though product innovation has rather consistently had a positive effect on employment. We expect that these differences are coming from the different market structure, and test how the market structures affect the employment effect of each type of innovation differently.

To show a different employment effect of innovation by market structure, this paper separates the industries into monopolistic and non-monopolistic industries, and compares the regression results between the two groups. We calculate an industry-level CR3 and define the monopolistic industry as being > 0.75, and a non-monopolistic industry as < 0.75. Table 7 shows the employment effect of innovation by different market structures using Korean manufacturing firm data.

As shown in Table 7, process innovation (d) in a monopolistic market has a greater negative effect than in a non-monopolistic market. More specifically, process innovation has no significant effect on employment in a non-monopolistic market, but is significant in a monopolistic market (−0.02 → −0.20*). By contrast, product innovation in a monopolistic market has a greater positive effect than in a non-monopolistic market (0.95** → 0.98**), but this difference is not that large.

In the second method, we adopt a proxy variable for market structures, the industry-level CR3 (m), and do the additional regressions: the industry-level CR3 is the share of the top 3 firm sales within an industry. Then, we make the interaction terms between this proxy variable for market structure (m) and each type of innovation variables (d, g_2) and estimate the additional employment effect of each type of

[17] We assume constant returns to scale (CRS) for the production of old products that calculate the pure employment growth rate as employment growth rate minus the real sales growth rate of old products. Thus, the production of old products has one to one relationship with employment, which means that employment growth rate increases 1%p, when the real sales growth rate of old products increases 1%p.

Table 7
Employment effect of innovation; 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 (*g*2)	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	10,984	385	10,984	385
r2_a	0.34	0.38	0.31	0.37
rmse	0.46	0.43	0.47	0.43

Legend: $+p < 0.1$; $*p < 0.05$; $**p < 0.01$.
Notes (1): Industry dummies are included.

Table 8
Employment effect of innovation in different market structures.

	Dependent variable: pure employment growth rate	
	OLS	2SLS
Process innovation (*d*)	0.04	0.07
	(0.86)	(1.35)
Product innovation (*g*2)	0.71**	0.97**
	(19.82)	(14.16)
Process and product innovation (*d**)	0.10**	0.00
	(8.64)	(−0.01)
Monopolistic Industry (*m*)	0.03	0.04
	(0.71)	(0.78)
MI*process innovation (*m*d*)	−0.18	−0.22+
	(−1.64)	(−1.94)
MI*product innovation (*m*g*2)	0.01	−0.04
	(0.09)	(−0.26)
_cons	−0.06*	−0.11**
	(−2.50)	(−3.81)
N	11,369	11,369
r2_a	0.34	0.34
rmse	0.46	0.46

Legend: $+p < 0.1$; $*p < 0.05$; $**p < 0.01$.
Notes (1): Industry and year dummies are included.
Notes (2): Monopolistic industry (*m*) is measured by CR3, the sales share of Top 3 firms in an industry.

innovation under different market structures. We test these differences are statistically significant or not.

Table 8 summarizes the estimation results for this. We both provide OLS and 2SLS estimation results, but 2SLS estimation results are used for the analysis.[18] The overall results show us that process innovation does not have any significant effect on employment, whereas product innovation has positive and significant effect on employment, which is the consistent estimation result above. Furthermore, process innovation in a more monopolistic market has a greater negative effect on employment, which is significant, whereas product innovation does not have any additional effect. This is what we expected above and now we can conclude that process innovation in a more monopolistic market has a greater negative effect than that in a less monopolistic market, while product innovation does not have.

Table 9
Firm-level employment effect of innovation by different size firms.

	Dependent variable: pure employment growth rate	
	OLS	2SLS
Process innovation (*d*)	−0.03	−0.02
	(−1.62)	(−1.05)
Product innovation (*g*2)	0.71**	0.96**
	(40.09)	(29.34)
Process and product innovation (*d**)	0.10**	0.00
	(8.57)	(−0.05)
Monopolistic Firms (*m*2)	−0.24	−0.09
	(−1.23)	(−0.28)
MF*process innovation (*m*2**d*)	−0.02	−0.24
	(−0.04)	(−0.39)
MF*product innovation (*m*2**g*2)	0.50+	0.2
	(1.95)	(0.37)
_cons	−0.05*	−0.09**
	(−2.30)	(−4.05)
N	11,356	11,356
r2_a	0.34	0.34
rmse	0.46	0.46

Legend: $+p < 0.1$;$*p < 0.05$;$**p < 0.01$.
Notes (1): Industry dummies are included.
Notes (2): Monopoly firms (*m*2) is measured by market share of a firm = sales of firm/sales by an industry.

However, one may argue that this employment effect of process innovation in a more monopolistic market is induced by market structure of the sectors where firms are located, but not by monopoly power of firms themselves. Hence, it is important to consider whether this monopolistic market effect is based on the sector-level effect or not. If this effect is not coming from the monopolistic market, but rather from power of monopolistic firms, then this effect may be the result of a scale economy and not from the market competition. To confirm the role of market structure in different employment effect of process innovations, we generate monopolistic firm (MF) variables and conduct the similar econometric approach as our previous analysis. The market share of a firm (m_2) is used as a proxy for monopolistic firms and estimates the employment effect of innovations by different firm size using interaction terms between this proxy variable for MF and each type of innovation variables (d, g_2).

Table 9 shows the estimation results using monopolistic firm (MF) variable instead of monopolistic industry (MI) variable. The overall results justify that a more negative employment effect of process innovation in more a monopolistic market is not based on the individual firm-level effect, such as a scale economy, but is based on the industry-level effect, such as product market competition. This can be inferred because the interaction terms between the monopolistic firm variable (m_2) and either type of innovation variables (d, g_2) do not provide any significant effect on employment; neither the process nor product innovations of monopolistic firms cause any significant effect on employment.

Finally, Table 10 summarizes the regression results above. It compares the regression results between the monopolistic industry and firms to confirm the additional employment effect of process innovation is based on the industry-wide effect. Overall results suggest that the larger negative effect of process innovation in a more monopolistic

[18] OLS and 2SLS estimation results show similar, but somewhat different in many ways. However, we make the conclusion based on the 2SLS estimation results, since OLS estimation does not take into account the endogeneity issue of the model that can induce the biased estimation results.

Table 10
Employment effect of innovation in different market structure.

	Monopolistic industry		Monopolistic firm
Process innovation (proc)	0.07	Process innovation (proc)	−0.02
Product innovation (prod)	0.97**	Product innovation (prod)	0.96**
Monopolistic Industries (MI)	0.04	Monopolistic firms (MF)	−0.09
Interaction terms between proc*MI	−0.22+	Interaction terms between proc*MF	−0.24
Interaction terms between prod*MI	−0.04	Interaction terms between prod*MF	0.20
The pure employment effect of process innovation in a monopolistic industry	−0.22+	The pure employment effect of product innovation in a monopolistic firms	0.00
The pure employment effect of product innovation in a monopolistic industry	0.97**	The pure employment effect of product innovation in a monopolistic firms	0.96**

Legend: $+p < 0.1$;$*p < 0.05$;$**p < 0.01$.
Note (1): Monopolistic industry is measured by industry-level CR3.
Monopolistic firm is measured by market share of a firm in an industry.

market is not associated with the scale economy of monopolistic firms, but with the degree of sector level market competition. More specifically, the pure employment effect of process innovation in a monopolistic industry is calculated as the sum of the employment effect of process innovation and an additional monopolistic industry effect. Therefore, the coefficient −0.22 since process innovation does not have a significant effect on employment (0.07 but not significant), but does have a significant effect on employment in a monopolistic industry (−0.22 and significant). However, the pure employment effect of process innovation in monopolistic firms is 0, since neither process innovation (−0.02 but not significant), nor that monopolistic firms (−0.24 but not significant) have significant effects on employment. By contrast, product innovation does not have different employment effect in both monopolistic industry (−0.04 and not significant) and firms (0.20 and not significant), and has the same effect on employment (0.97 and 0.96 each).

5. Conclusions

To estimate and evaluate the employment effect of process and product innovation in different market structures, this paper uses data from 1999 to 2009 on 11,369 Korean manufacturing firms. The main findings are as follows.

First, we find that the overall employment effect of innovation for Korean manufacturing firms is positive, since process innovation does not have any significant effect, but product innovation has a positive effect on employment. Second, we find that process innovation in a more monopolistic market has a greater negative effect, while product innovation in a more monopolistic market does not have a greater positive effect on employment. Third, this greater negative effect of process innovation on employment is not based on the individual firm-level effect, such as a scale economy, but is based on the industry-level effect, such as product market competition.

The empirical findings in this paper may have policy implications. Among other things, the government may try to promote a more competitive market structure in Korean industries, given that the results suggest a likely positive job-creating effect of process innovation under competitive market structures. Possible measures include greater market liberalization, stricter anti-trust regulations, and increased efforts to reduce barriers to entry. Besides, the potential of the open innovation paradigm can also be noted in this regard because it may have competition-enhancing effects to the extent that destructive innovations associated with open innovation may anticipate the emergence of new industries by breaking the boundaries of existing firms and sectors.[19]

This research has some limitations that provide opportunities for future research projects. First, market structure and degree of competition can be better reflected if they consider both domestic and global market conditions, which require greater data gathering work. Second, other sources of technological changes and innovations, such as technologies changes through intensive capital or labor, or those with skilled-bias characteristics are not considered. Third, the proxy for employment growth used in this research, namely the growth rate of the number of employees, do not consider the factor of the increase or decrease in working hours.

Despite these limitations, this paper is one of the first researches that verify how market structure affects the employment effect of different types of innovation. Overall, we show that innovations have different effects on employment across different market structures, which implies that a competitive market is important for increasing employment through innovation.

[19] As is well known, the paradigm of open innovation has emerged strongly, which enhances the speed and scope of innovations by utilizing external and internal resources of firms (Yun et al., 2016; Yun 2015).

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