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Understanding the Effect of Non-Technological Innovation on Technological Innovation and Innovation Success[1]

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Abstract

By using empirical data collected from 278 manufacturing firms in Korea, this study investigates the relationship between technological innovations (i.e., product and process innovations) and non-technological innovations (i.e., organizational and marketing innovations) and innovation success. We propose that non-technological innovation is considered an essential precondition of technological innovation, leading to innovation success. We highlight that technological innovation exerts a strong influence on innovation success only when non-technological innovation adequately strains the relationship between them. The findings of this study show that the indirect effect of non-technological innovation on innovation success through technological innovations enables firms to enhance firm performance and that no synergistic effect exists between technological and non-technological innovation on innovation success.

***Keywords**: Technological innovation, non-technological innovation, determi-nant, innovation success*

1. Introduction

Innovation plays a central role in economic growth. Schumpeter [17] argued that economic development is driven by innovation through a dynamic process called "create destruction," in which new technologies replace the old processes. Innovation in firms mainly aims to gain a competitive advantage by reducing costs and improving productivity; thus, it is the core factor for sustaining business value. Firms can enhance their performance through innovation activities to develop new products and new processes [1]. Firms generally have considered their innovation activities as technological innovations [16].

Despite a shift in the value area of firms from the technological to non-technological in a service economy environment, most firms still focus on technological innovations. The innovative approaches apply traditional manufacturing sector logic to understand innovation in firms. However, considering technological innovations alone is not sufficient to understand the innovative activities of firms, innovations include technological activities (e.g., introducing and developing new technologies) as well as non-technological activities (e.g., re-establishing business strategies; changing the organizational method; and external network, marketing, and customer interaction) [1]. For a long time, researchers have been aware of the close relationship between non-technological and technological innovations. To succeed in the market through new ideas and opportunities in a highly competitive environment, many researchers have stressed that organizational and marketing concepts should complement the concept of

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technological innovations, which consist of product and process innovations. For these reasons, the OECD renewed to classify the concept of innovation into four areas, namely, product innovation (PDI), process innovation (PRI), organizational innovation (ORI), and marketing innovation (MKI) [14]. Despite the apparent importance of non-technological innovation for innovation success, few researches have attempted to identify the role of non-technological innovation in facilitating and leveraging technological innovation, which leads to innovation success and superior firm performance.

To address the research gap, this study aims ***to explore the role of non-technological innovation in promoting technological innovation for innovation success***. For this purpose, two technological innovations (*i.e.,* PDI and PRI) and two non-technological innovations (*i.e.,* ORI and MKI) are identified based on the Oslo Manual (Third Edition) by the OECD [14]. By collecting empirical data from 278 manufacturing firms in Korea, we determine the causal relationships among technological innovation, non-technological innovation, and innovation success. The findings provide valuable information to those who seek practical guidance in implementing non-technological innovation activities to accelerate their technological innovation activities.

2. Theoretical Development

Developing a new product and a new process can enhance productivity and allow firms to gain competitive advantage [2]. Technological innovation is closely linked to new product and process innovations, resulting in the creation of a new value of firms and improving existing value to customers. Firms can also increase their benefits by re-establishing business strategies, organizational methods, marketing strategies, and customer interactions. Changes in organizational methods can improve the efficiency and quality of the operation of firms, thereby increasing customer satisfaction and reducing costs [4]. Moreover, marketing strategies can create new customer needs through product differentiation by focusing on a new market. Taking a different position, researchers suggested that strong marketing innovation may lead to imitations and marginally new products [15]. Thus, many researchers in innovation literature have indicated that non-technological innovations are also primary factors that significantly affect innovation success and improve firm performance. For these reasons, the Oslo Manual (Third Edition) by the OECD added the concept of non-technological innovations to complement that of technological innovation. However, few studies have investigated the relationship between technological and non-technological innovations. Thus, the harmony between technological and non-technological innovations, which results in innovation success, are necessary.

Therefore, this study developed four types of innovation based on the innovation framework of the Oslo Manual (Third Edition) in the OECD [14], namely, PDI, PRI, ORI, and MKI. These four types of innovation can encompass a wide range of changes in a firm’s innovative activities. This study determines which relationship between non-technological and technological innovations best explains innovation success.

2.1. Relationships among Technological Innovation, Non-Technology Innovation, and Innovation Success

Technological innovation consists of PDI and PRI. PDI (goods or services) is the market introduction of new or significantly improved goods and services [14]. PDI also provides new value to a particular market in terms of technological specifications, components and materials, incorporated software, user friendliness, and other functional characteristics. A significant improvement to existing products and services decreases costs, extends a market share, and increases firm profits. Hence, firms can satisfy customer needs through PDI. Although PDI takes several risks in developing new products and services, it is positively related to firms' innovation success and ultimately increases firm performance.

PRI always accompanies PDI. It indicates the introduction of new or significantly improved methods such as production processes, supporting activities for production processes, logistics, as well as delivery and distribution methods for goods or services [14], leading to reduced costs and increased product quality and market share. It also indicates the changes in the development and production processes to offer different products and services. Firms with effective development and production processes can offer different products and services to customers. Thus, firms can improve customer satisfaction through PRI, which results in innovation success. Technological innovation also covers significantly improved techniques, equipment, and software in supporting activities such as purchasing, accounting, computing, and maintenance. This support leads to innovation success and superior firm performance. Therefore, technological innovation, including PDI and PRI, positively affects innovation success. Thus, we hypothesize the following:

H1-1: Technological innovation has a positive effect on innovation success.

The Oslo Manual (Third Edition) by the OECD [14] pointed the importance of non-technological innovation for innovation success and attempted to complement the concept of technological innovation with non-technological innovation. It regarded ORI and MKI as non-technological innovations. ORI is defined as the introduction of new organizational methods to an enterprise's business practices (including knowledge management), workplace organization, or external relations not previously used by the enterprise [14]. ORI changes the organizational structure and the learning process and adopts to the process of technology and technological equipment [6]. Firms' organizational structure can affect the efficiency of innovation activities, with some structures being better suited to particular innovation activities than others [4],[6]. A high degree of organizational integration may improve the co-ordination, planning, and implementation of technological innovation activities.

Furthermore, customer demand for new products may depend not only on the quality and characteristics of products and services but also on the customer view and social characteristics of these products and services [11]. Marketing theories focus on implementing marketing practices, such as the marketing mix model [13]. MKI is defined as the implementation of new marketing concepts or strategies that differ significantly from firms' existing marketing methods [14]. MKI focuses on addressing customer needs, opening new markets, or repositioning a firm's products and services on the market, resulting in innovation success and ultimately realizing firm profits. Hence, ORI and MKI represent two of the most important and sustainable sources of competitive advantage for firms [9]. Therefore, non-technological innovation is positively associated with innovation success. Thus, we hypothesize the following:

H1-2: Non-technological innovation has a positive effect on innovation success.

2.2. Relationship between Technological Innovation and Non-Technology Innovation

Many researchers have addressed the close relationship between non-technological and technological innovations [3], [6]. Non-technological innovations can favor the development of technological functions. For example, business practices, such as quality control, can promote an increase in efficiency and consequently improve the outcome of PRI. Marketing orientation and PDI are likely to be highly interrelated [10]. MKI enhances the communication and exchange between all organizational functions related to customers and competitors, giving these functions greater proximity to the latest market trends [8] to generate PDI. Customer orientation and the inter-functional coordination of organizational resources encourage research and development (R&D) to develop more line extensions and new products and services by providing important marketing methods.

According to the resource-based view, non-technological innovation is considered as an initiator for technological innovation because an introduction of non-technological innovation comprises rare, valuable, inimitable, and non-substitutable working practices. Non-technological innovation enables firms to encourage the establishment of appropriate organizational infrastructure to support new product and service designs and their communication efficiently to introduce new and improved products and services to the market. Therefore, non-technological innovation is positively related to technological innovation. Thus, we propose the following:

H2: Non-technological innovation has a positive effect on technological innovation.

Some recent studies emphasize the complementary nature of non-technological and technological innovations, indicating that the two types of innovation more complement than substitute each other. Some researchers in the innovation and IS literature pointed out that the role of non-technological innovation is not an initiator but rather an enabler of technological innovation [4]. Camisón and Villar-López [4] indicated that ORI promotes the development process of PRI. Firms can create a new development or sales department, as well as reorganize workflow and external network to improve the outcome of PRI. Moreover, PDI can also be strengthened through MKI [12]. As new products are introduced through a new marketing method, firms should accept new marketing methods to increase productivity and product quality. For this reason, technological innovation can positively affect innovation success through non-technological innovation. Thus, we propose the following hypothesis:

H3: The effect of technological innovation on innovation success is positively moderated by non-technological innovation.

3. Research Methodology

3.1. Development of Measures

The survey respondents were randomly selected from an entire population of manufacturing firms based on the 2008 Korea Innovation Survey (http://kis.stepi.re.kr). In developing the measurement instruments, four items, including PDI, PRI, ORI, and MKI were measured through yes–no questions, whereas the other item, innovation success, was measured on a five-point Likert scale ranging from "extremely low" to "extremely high." In the case of the yes–no questions, the measurement instrument should be merged to one dummy variable because the nominal scale can be difficult to use in this analysis. Finally, 5 constructs and 15 items were employed as measures in this study (see Appendix).

3.2. Sample and Data Collection

The 2008 Korea Innovation Survey was used for the empirical analysis. The survey only focused on Korean manufacturing firms. Hence, respondents who had implemented at least one innovation in the reference period starting from 2005 to 2007 were asked to respond to the entire questionnaire. A total of 1,432 responses were finally received. The complete case approach applied was the missing data imputation method. Finally, 278 responses were found to be useful for this study, with a usable response rate of 19.4%. Table 1 summarizes the respondent characteristics. The sample was stratified across six sub-sectors in the manufacturing sector. A large number of respondents came from other machinery and equipment (21.2%), electrical equipment (17.6%), motor vehicles (16.6%), medical (16.5%), electronic components (12.9%), and other transport equipment (5.7%). The mean number of employees was 334.1, with a standard deviation (S.D.) of 1190.7. The mean of R&D budget rate was 5.1 (S.D.=8.0), and the mean of total sales was 475.7 million US dollars (S.D.=3108.9).

Table 1. Characteristics of the Sample

(a)Industry (Manufacturing)
(b) Number of employees
(c) R&D budget rate(%)
(d) Total sales ($: US dollar)

Industry type	Frep.(%)
Electronic components	36(12.9%)
Medical	46(16.5%)
Electrical equipment	33(17.6%)
Other machinery and equipment	77(21.2%)
Motor vehicles	32(16.6%)
Other transport equipment	54(5.7%)
Total	**278(100%)**

Year	Frep.(%)
Less than 49	112(40.3%)
50~99	28(10.1%)
100~499	69(24.8%)
500~999	56(20.1%)
1000 and above	13(4.7%)
Total	**278(100%)**

Range	Frep.(%)
Less than 0.9	74(26.6 %)
1.0~4.9	124(44.6 %)
5.0~9.9	42(15.1 %)
10.0~14.9	18(6.5 %)
15.0 and above	20(7.2 %)
Total	**278(100%)**

Range	Frep.(%)
Less than $49.9 mil	75(27.0%)
$50~$99.9 mil.	30(10.8%)
$100~$499.9 mil.	72(25.9%)
$500~$999.9 mil.	25(9.0%)
$100 mil. and above	76(27.3%)
Total	**278(100%)**

4. Analysis and Results

4.1. Analysis Method

In this study, partial least squares (PLS) was chosen to examine the hypotheses because the following reasons. PLS is appropriate when the research model is in the early stage of development and has not been tested extensively [7]. Thus, it can be used to analyze the collected data because this study is an early attempt to identify the relationship between non-technological and technological innovations. The research models in this study have the four formative constructs (*i.e.,* PDI, PRI, ORI and MKI). PLS uses components-based algorithms and can estimate formative constructs. Hence, PLS is the appropriate technique for testing the proposed models using the gathered data. Smart PLS 2.0 version was used to analyze measurement and structural models.

4.2. Measurement Model

Convergent validity was assessed through the composite reliability (CR) and average variance extracted (AVE) taken from the measures. Table 2 shows that the obtained CR values ranged from 0.73 to 0.85, which exceeded the threshold value of 0.7. The AVE ranged from 0.51 to 0.63 [7], which was above the acceptable value of 0.5. A score of 0.5 indicates an acceptable level for AVE by a measure [7]. The results showed that AVE ranged from 0.714 to 0.794, which was above the acceptable value. All measures were significant on their path loading at the level of 0.01. Table 3 shows that the square root of AVE for each construct was greater than the correlations between a construct and all other constructs. These results indicate that the measurement models were strongly supported by the data gathered, thereby requiring further analysis.

Table 2. Results of PLS Measurement Model

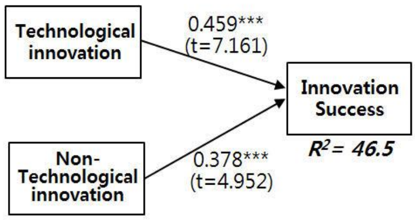
Construct	Item	CR	AVE	Loading	t-value
Tech. innovation(TI)	PDI	0.79	0.60	0.939	2.725
	PRI			0.867	2.944
Non-Tech. innovation(NTI)	ORI	0.85	0.63	0.647	1.989
	MKI			0.920	8.254
Tech. innov. x Non-tech. innov. (TI*NTI)	PDIORI	0.73	0.51	0.709	5.632
	PDIMKI			0.784	3.745
	PRIORI			0.712	4.912
	PRIMKI			0.841	2.755
Innovation success (IS)	INS1	0.82	0.61	0.846	9.437
	INS 2			0.821	8.049
	INS 3			0.661	4.874

Table 3. Correlations Between Constructs

Construct	TI	NTI	TI*NTI	INS
TI	***0.775***	-	-	-
NTI	0.322	***0.794***	-	-
TI*NTI	0.063	0.065	***0.714***	-
IS	0.580	0.527	0.099	***0.781***

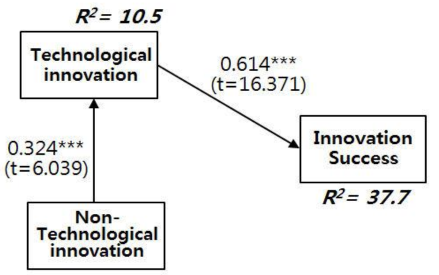
4.3. Structural Model

With adequate measurement models, the proposed hypotheses are tested with PLS. A resampling bootstrap procedure with 500 subsamples was used to determine the significance level of the path coefficients through the PLS technique [5]. Figure 1 shows that the results of three structural models including the path loadings, t-values of the paths, and R-square. As shown in Figure 1, among the four hypotheses, three were significant. Figure 1 (a) shows that technological innovation had a significant and positive effect on innovation success ($\beta = 0.459$; $t = 7.161$; $p < 0.01$). Hence, ***H1-1 is supported***. Non-technological innovation was also found to be related significantly to innovation success ($\beta = 0.378$; $t = 4.952$; $p < 0.01$), although the effect of non-technological innovation was smaller than that of technological innovation. This result ***supports H1-2.*** The value of R^2 for innovation success was 46.5%. As shown in Figure 1 (b), non-technological innovation was positively associated with technological innovation ($\beta = 0.324$; $t = 6.039$; $p < 0.01$). Then, technological innovation had a positive and significant effect on innovation success ($\beta = 0.614$; $t = 16.371$; $p < 0.01$). Non-technological innovation had an indirect effect on innovation success through technological innovation. ***Therefore, H2 is supported.*** In this model, non-technological innovation accounted for 10.5% of the variance in technological innovation, and technological innovation accounted for 37.7% of the variance in innovation success. The results show that technological innovation enhanced innovation success with the precondition of non-technological innovation ($\beta = 0.614$; $t = 16.371$; $p < 0.01$) beyond that improved alone by technological innovation ($\beta = 0.459$; $t = 7.161$; $p < 0.01$). Figure 1 (c) shows that non-technological innovation had no moderating effect on the relationship between technological innovation and innovation success. The results show no synergistic effect between non-technological and technological innovations on innovation success. As a result, ***H3 was not supported.*** Technological innovation accounted for 46.6% in innovation success in this model.



*p<0.10, **p<0.05, ***p<0.01

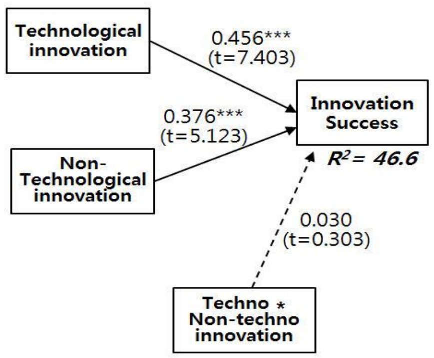
(a).Direct effects of technological and non-technological innovations on innovation success



*p<0.10, **p<0.05, ***p<0.01

(b) A indirect effect of non-technological innovation through technological innovation on innovation success

Figure 1. Results of the hypothesized model (cont.)



*p<0.10, **p<0.05, ***p<0.01

(c) An interactive effect between technological and non-technological innovations on innovation success

Figure 1. Results of the Hypothesized Model

5. Discussion and Implications

The objective of this study was to investigate which relationship between non-technological and technological innovations best explains innovation success. A few points are discussed. First, the results indicate a positive relationship between technological innovation and the innovation success. Technological innovation is believed to be an essential factor to achieve innovation success. Thus, firms should accurately assess the effect of technological innovation on innovation success and firm performance.

Second, although the effect of non-technological innovation on innovation success is smaller than that of technological innovation, the result implies that non-technological innovation is also a critical factor for innovation success. Firms should consider the fact that non-technological innovation may function as significant differentiators of firms such as valuable, inimitable, and non-substitutable working practices compared to competitors, leading to innovation success and finally improving financial benefits. Hence, fostering non-technological innovation is a critical success factor to increase innovation success.

Third, the results of this study indicate the absence of an interactive relationship between technological and non-technological innovations, although non-technological innovation is closely linked to technological innovation activities. However, non-technological innovation has been found to be an essential precondition of technological innovation for superior innovation success. The results show that technological innovation preceded by non-technological innovation enhances innovation success beyond that improved by technological innovation alone. Non-technological innovation is an initiator of technological innovation for a successful innovation. Therefore, firms that strategically and efficiently conduct technological innovation for innovation success should establish non-technological innovation before performing technological innovation.

Finally, this study increases the understanding on the role of non-technological innovation (ORI and MKI) in enhancing the effects of technological innovation (PDI and PRI) on innovation success. In turn, non-technological innovation becomes highly successful through technological innovation, leading to superior firm performance. Therefore, establishing an antecedent model of non-technological innovation would help manufacturing firms seeking to efficiently implement technological innovation activities to succeed in innovation and enhance firm performance.

Future research should determine the relationship between sub-innovations (*i.e.*, product-organization, product-marketing, process-organization, and process-marketing innovations). Moreover, we limited this study to manufacturing firms and hence, future research should extend the scope of service firms to explore the more relevant effects of innovation.

This study is an early attempt to conceptualize and investigate the relationship between non-technological and technological innovations in overall innovation activities by developing and comparing the two different roles of non-technological innovation in technological innovation. The findings of this study facilitate substantial progress in future research toward exploring the role of non-technology in technological innovation. Our findings also reveal that managers should conduct non-technological innovation and encourage technological innovation for successful innovation and superior firm performance. Consequently, this study provides practical steps for managers interested in performing technological innovation activities to achieve innovation success preceded by non-technological innovation.

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Appendix: The Measure of Survey Instruments

Measurement
Technological innovation(TI)
- Product innovation(PDI)
PDI1. Introduction of significantly Improved product
PDI2. Introduction of new product
- Process innovation(PRI)
PRI1. Introduction of new or significantly improved methods of manufacturing or producing good or service
PRI2. Introduction of new or significantly improved logistics, delivery or distribution methods for your inputs, good, or services
PRI3. Introduction of new or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing
Non-technological innovation
- Organization innovation(ORI)
ORI1. Introduction of new business practices for organizing procedures
ORI2. Introduction of new methods of organizing work responsibilities and decision making
ORI3. Introduction of new methods of organizing external relations with other firms or public institutions
- Marketing innovation(MKI)
MKI1. Significant changes to the aesthetic design or packaging of a good or service
MKI2. Introduction of new media or techniques for product promotion
MKI3. Introduction of new methods for product placement or sales channels
MKI4. Introduction of new methods for pricing goods or services
Innovation success(IS)
IS1. Increase in range of goods or service
IS2. Increase in market share
IS3. Increase in customer satisfaction

