Yet to Adopt Intelligent Robots for Product Innovation? −A Survey of South Korean Manufacturers−

Moon Jong Choi, Sang Hyun Lim, Yang Sok Kim, Choong Kwon Lee

Abstract

Intelligent robots are being introduced and utilized to create new values in diverse fields such as medical care, national defense, education, and manufacturing. However, while the technical aspects of intelligent robots are spreading, the business side is lacking in recognition. The purpose of this study is to identify the factors affecting product innovation through the introduction of intelligent robots in enterprises. Among the six variables secured from the technology, organization, and environment framework, only perceived direct usefulness and competitive pressure have significant effects on product innovation. The results imply that the effects of introducing robots are still in their early stage from a business perspective.

Keywords : Product Innovation | Intelligent Robot | Risk Sensitivity | Usefulness | Competitor Pressure

I. INTRODUCTION

Many manufacturers have introduced machines or robots that are capable of replacing human labor, but with much higher productivity. Companies with such hardware have produced many products needed for human life and contributed greatly to the development of society. Although robots can produce the same product in large quantities through repetitive tasks, once installed, changing robots to adapt to environmental changes or to produce new products has been a daunting task. Intelligent robots have emerged to overcome these shortcomings of traditional machine robots.

The intelligent robot refers to a robot that collects data such as shape, attribute, and position of an object existing in the external environment, recognizes the situation, and operates autonomously by self−determination. Cleaning robots that can recognize walls and obstacles and move while avoiding them are already being used for family life. Robots that can change language or facial expressions have also been used for educating children. Especially, disaster response robots, like the ones that were put into action at the accident of the Fukushima nuclear plant in Japan, are expected to help people handle extreme situations.

In the manufacturing sector, intelligent robots perform various functions such as welding, assembling, painting, and conveying in the automobile production process, and are replacing tasks that are difficult for human to perform because they require high power or precision. Since the enactment of the 'Development and Promotion of Intelligent Robots Act' in Korea in 2008, the convergence of intelligent robots has been widely occurring in a variety of fields. However, while the technical aspects of intelligent robots are spreading, the business side is lacking in recognition.

Choi and his colleagues [1] studied the effects of the introduction of intelligent robots on process innovation based on the Technology−Organization−Environment (TOE) framework presented by Tornatzky and Fleischer [2]. Among the six variables used as independent variables in the study of Choi et al. [1], direct

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usefulness, indirect usefulness, and innovation and risk sensitivity corresponding to technical characteristics had a positive effect on process innovation. However, among the two environmental variables, only industrial pressure had a positive effect, while the effect of government pressure was not significant. The study by Choi et al. [1] based on the TOE framework revealed that intelligent robots have an overall positive effect on process innovation.

This study extends the research of Choi, et al. [1] to investigate the factors affecting product innovation by introducing intelligent robots in enterprises. Considering that many technologically superior hardware fail in the market due to the lack of business value, it is important to look at intelligent robots from a business perspective as a research topic.

II. RESEARCH MODEL AND HYPOTHESIS

The TOE framework provides a useful model that can provide explanatory power to the factors influencing the introduction and diffusion of technology innovation. It has proved its effectiveness through numerous empirical studies related to various information technologies such as EDI, e-business, ERP and RFID. [3-8].

Based on the TOE framework, the research model is presented as shown in Fig. 1. First, there are technical, organizational, and environmental characteristics from the TOE framework cited in the previous study, and each characteristic contains two potential factors. Perceived direct usefulness and perceived indirect usefulness were used as technical characteristics, and innovation and risk sensitivity were used for organizational characteristics, as in the study by Choi et al. [1]. However, in terms of environmental characteristics, we used collaborator pressure and competitor pressure by adjusting the questionnaire items, rather than the industrial pressure and government pressure used in Choi, et al. [1]. Thus, we hypothesize that these six factors will have a positive impact on product innovation, in addition to process innovation. Figure 1 illustrates the six hypotheses using a regression model.

Hypothesis 1. Perceived direct usefulness will have a positive impact on a firm's product innovation.

Hypothesis 2. Perceived indirect usefulness will have a positive impact on a firm's product innovation.

Hypothesis 3. Innovation will have a positive effect on a firm's product innovation.

Hypothesis 4. Risk sensitivity will have a positive effect on a firm's product innovation.

Hypothesis 5. Perceived cooperator pressure will have a positive impact on a firm's product innovation.

Hypothesis 6. Perceived competitor pressure will have a positive impact on a firm's product innovation.

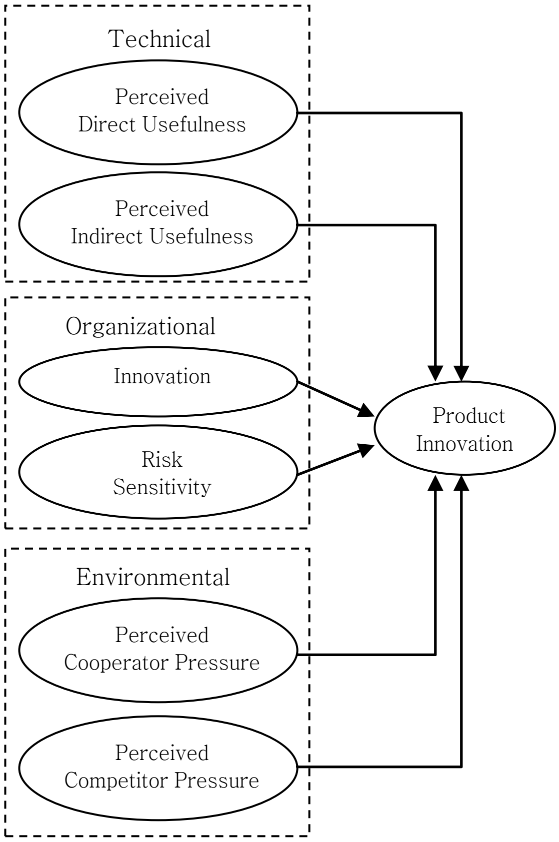

Fig. 1. Research Model

III. RESEARCH METHOD

We conducted survey questionnaires by selecting Korean manufacturers adopting intelligent robots. Of the 89 questionnaires collected, 76 were used as a sample of the study. The demographics of the respondents were 61 males(80.3%) and 15 females(19.7%). There was a mix of various ages but respondents in their 30s(43.4%) had the highest proportion followed by 40s(23.7%), 20s(19.7%), and 50 or more (13.2%). Of the 76 respondents, 47(61.8%) were college graduates, 19(25.0%) high school graduates, 10(13.2%) graduate level degree holders. In addition, more than 70% of the respondents answered that they have robot related education and training programs. As for the main products, the industrial distribution of survey respondents was the highest in metal/machinery(28.9%), followed by electronics and electricity(25.0%), energy(17.1%), automotive(10.5%), shipping/aerospace(9.2%), and others(9.2%).

Before the hypothesis testing of the research model, it is necessary to verify whether the reliability and validity of the observational variables corresponding to the components (potential variables) are satisfied. Therefore, this study analyzed each item using Smart PLS.

Table 1. Intensive validity and reliability verification

Construct	Item	Loadings	CR	AVE	Cronbach's α
Perceived direct usefulness	PDU_1 PDU_3 PDU_4 PDU_5	0.858 0.857 0.819 0.835	0.907	0.710	0.864
perceived indirect usefulness	PIU_6 PIU_8 PIU_9 PIU_10	0.761 0.847 0.854 0.773	0.884	0.656	0.828
innovation	INNO_1 INNO_2 INNO_5 INNO_7	0.821 0.866 0.676 0.794	0.870	0.628	0.801
risk sensitivity	RS_9 RS_11 RS_12	0.812 0.841 0.796	0.858	0.668	0.753
perceived cooperator pressure	COOP_2 COOP_3 COOP_4	0.804 0.872 0.833	0.875	0.700	0.789
perceived competitor pressure	COMP_5 COMP_6 COMP_7	0.711 0.906 0.788	0.846	0.649	0.729
product innovation	PI_1 PI_2 PI_4 PI_5	0.716 0.806 0.812 0.785	0.862	0.609	0.786

As shown in Table 1, all of the observational variables of each element showed to have no problem in construct validity and reliability. Next, we need to know the AVE(Average Variance Extracted) square root value to verify the discriminant validity. To obtain discriminant validity, the square root of AVE should be larger than the correlation coefficient between different factors. In Table 2, the value of the square root of AVE on the diagonal line is larger than the correlation coefficient between the other factors. Therefore, it can be argued that all observational variables have validity.

Cronbach's α coefficient was used to test reliability. If the coefficient is 0.7 or more, the dataset is regarded as reliable. The validity was verified by dividing it into construct validity and discriminant validity. Construct validity means that a high correlation exists between the measurements obtained by the different measurement methods developed to measure the same concept. Discriminant validity is when the correlation between the values obtained when measuring different concepts is low. For construct validation, the factor loading and CR (Composite Reliability) should be 0.6 or more, and AVE should be 0.5 or more.

Table 2. Validation of discriminant validity

	COMP	COOP	PDU	PIU	INNO	RS	PI
COMP	0.804						
COOP	0.628	0.888					
PDU	0.443	0.212	0.843				
PIU	0.449	0.326	0.640	0.810			
INNO	0.493	0.375	0.525	0.426	0.792		
RS	0.561	0.540	0.333	0.461	0.720	0.817	
PI	0.690	0.445	0.603	0.539	0.582	0.552	0.780

NOTE: PI(product innovation); INNO(innovation) COMP(perceived competitor pressure); COOP(perceived cooperator pressure); PDU(perceived direct usefulness); PIU(perceived indirect usefulness); RS(risk sensibility)

IV. RESULTS

The causality test for each factor proposed in the research model was also conducted using the PLS software. The perceived direct usefulness from the technical characteristics in hypothesis 1 was supported at a significance level of 0.05 with a path coefficient of 0.265 and a t-value of 2.128. The perceived indirect usefulness is hypothesis 2 was rejected with a path coefficient of 0.082 t-value 0.719. Entrepreneurial innovation and risk sensitivity had path coefficients of 0.133 and 0.097 respectively, and their t-values were 0.977 0.643. Hypothesis 3 and Hypothesis 4 were also rejected from low path coefficients and t-values. Hypothesis 5, perceived collaborator pressure from the environmental characteristics was rejected with a path coefficient of 0.002 and t-value 0.018. Finally, hypothesis 6 was adopted at significance level 0.01, path coefficient 0.417, and t-value 3.568. Table 3 below summarizes the results of the hypothesis testing.

Table 3. Results

Hypo.	Path	Std. Coefficient	T-Value	Result
H1	PDU →PI	0.265	2.128	Accept
H2	PIU →PI	0.082	0.719	Reject
H3	INNO →PI	0.133	0.977	Reject
H4	RS →PI	0.097	0.643	Reject
H5	COOP →PI	0.002	0.018	Reject
H6	COMP →PI	0.417	3.568	Accept

V. CONCLUSIONS

This study proposed that the introduction of intelligent robots would be influential in the innovation of the firm. This study attempted to extend existing research to find out if factors of technological, organizational, and environmental characteristics affect not only process innovation but also product innovation. However, this turned out not to be the case. Among the six hypotheses, four independent factors, other than perceived direct usefulness and perceived competitor pressure, did not affect product innovation.

As a result, it seems that the six variables from the three characteristics that arise through the introduction of intelligent robots cannot influence both process innovation and product innovation. In the study of Choi et al. [1], it was found that many factors affect process innovation through the introduction of intelligent robots. The results of this study, however, shows that product innovation might not be an optimal reason for Korean manufacturers to adopt intelligent robots. As many devices become intelligent in a smart environment[9, 10], the intelligent robot industry will grow into a key backbone industry in the future and will spread quickly throughout society as a whole. Considering this point, we expect that future research on the introduction of intelligent robots will lead, not only to process innovations in the company, but also to the innovation of the product.

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