The Effects of Design Competence on Firm Performance: Empirical Evidence from the Case of Korea

Yeolyong Sung[1], Young-Jin Ro[2*]

[1] Korea Institute for Industrial Economics & Trade, Sejong, Korea

[2] Department of International Trade, Dong-A University, Busan, Korea

Abstract

Background In modern economy, design is known as one of the most important factors that determine firm's competitiveness. However, there is not much evidence that design could have a positive effect on the firm's sales. In this paper, we investigate the effects of design competence on firm performance, using an econometric method.

Methods We apply econometric methodology to test whether design could affect firm performance. On the basis of survey data collected from 200 firms in Korea, we estimate the effect of quantitative and qualitative design competence on firm performance by using ordinary least squares.

Results We find that both quantitative and qualitative design competence have a positive effect on firm sales, and the size of the effects is influenced by firm characteristics such as the firm's industry type and intellectual property rights. Especially, variables such as design investment, design equipment and facilities, design education and training, and intellectual property rights involving design are the major factors that have a positive effect on firm performance.

Conclusions Since design is found to have a positive effect on firm performance, it would be important for the government to actively seek ways to increase the design competiveness of firms. Based on our empirical results, we suggest three policy implications for the government to promote firm's design competence.

Keywords Design Investment, Firm Performance, Intangible Asset

*Corresponding author: Young-Jin Ro (yjro@dau.ac.kr)

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1. Introduction

In the modern economy, design is known as one of the most important factors for firm competitiveness.[1] As design always creates demand, firms can improve their performances through investment in design. The development of design increases a firm's sales by influencing the appearance of final goods and the corresponding experience value of consumers. In addition, when design is incorporated in the production process, it has a positive impact on competitiveness by enhancing the efficiency of the production process. In spite of the importance of design in doing business, there have not been many studies that analyze the impact of design on firm performance empirically.

Investment in design can be considered as an activity to accumulate intangible assets or knowledge-based capital, because accumulated design competence enhances innovative activities. Firms decide strategically on investment in tangible and intangible assets in order to maximize their profits. The role of intangible assets such as R&D (research and development), patents, design, and brand, has become important, whereas in the past physical capital had dominant effects on profits.

Kemp et al. (2003) applied the Crepon et al.'s (1998) model to their research, who divide the innovation process into four stages: the decision to innovate, the innovative intensity, the innovative output, and the firm performance. At the first stage, a firm decides whether to innovate or not. If the firm decides to innovate, at the second stage, it influences the innovative intensity by increasing the innovative input. At the next stage, the innovative output is determined by the innovative input, and finally, the innovative output influences the firm performance. In short, investment in innovation influences firm performance through the innovation process, as firm investment in design carries the potential to enhance innovation competence through the accumulation of intangible assets.

In this paper, we analyze the effects of design competence on firm performance empirically. We classify design competence into quantitative and qualitative competence and analyze econometrically how each type of competence affects firm performance using survey data of Korean firms. The paper is organized as follows. In Section 2, we review the existing literature about the relationship between design investment in the course of innovation processes and firm performance. In Section 3, we describe the data and the models to be used for the empirical analysis. The results of the analysis are shown in Section 4, and their implications are presented in Section 5.

1) D'Ippolito (2014) discussed and summarized related literatures regarding this issue.

2. Related Literature

Most literature that studies the relationship between design and firm performance suggests that design has a positive effect on firm performance. Gemser and Leenders (2001) show that integrating industrial design in the product development process has a positive impact on firm performance that is measured by profit, turnover, and export sales. They use survey data from two Dutch manufacturing industries: home furniture and precision instruments.

Hertenstein et al. (2001) analyze the relationship between design and financial performance, using variables such as return on assets and net cash flows to sales. They conclude that firm performance is influenced by the quality of design program, the quality of design developed, and the importance placed on the design program (for example, large investment in design).

Cereda et al. (2005) investigate the link between design and innovation in UK firms, using the UK CIS (Community Innovation Survey) data. They estimate a knowledge production function, which involves design expenditure as a factor of knowledge production. The change in knowledge, in turn, affects output or productivity via an output production function. Through this mechanism, they show that design expenditure has a positive and statistically significant effect on productivity growth.

Chiva and Alegre (2009) analyze the impact of design investment and design management on firm performance. Their study is based on a data set of 182 firms in Spain and Italy's ceramic tile industry. They show that design management enhances firm performance, and also design investment is positively related to design management. From these findings, they argue design management is a significant factor in determining the effects of design investment on firm performance.

In case of Korea, there have been only a few studies on the relationship between design and firm performance. Kim and Jung (2009) examine the new environment of design management and suggest its critical success factors by analyzing seventeen successful cases of SMEs (small and medium-sized enterprises). In their work, they use financial performance (sales and return of investment), brand value, processes and networking for innovative design, and market competitiveness as dependent variables that are affected by design management. They find out four common factors leading to successful design management: development of a design-based hit product, good design (design award performance), successful outsourcing, and design leadership.

Kim (2010) sheds light on a new role and the value of design management by presenting critical factors that make a positive contribution to business performance. In the past, firms considered structural factors such as team management, control, and system as critical for successful design management. However, under the new paradigm, firms consider factors oriented towards design development, such as team development, education and training, atmosphere creation, and clear goals.

Kim (2011) analyzes the relationship between design and firm performance, using survey data collected from 173 designers who are employed by firms. In his study, the variables on firm performance include sales, operating profit, corporate image, and market share. He shows that firm performances are positively related to both the internal and external evaluation of design performance.

3. Model and Data

3. 1. Model

The purpose of this paper is to analyze the effects of a firm's design competence on its performance. For this purpose, we classify design competence into quantitative and qualitative measures, and estimate the effect of both quantitative and qualitative competence of design on firm sales. For the measure of quantitative and qualitative competitiveness for design, we use firm's investment on design, and qualitative measure collected from survey in each. Also, we use firm's sales to proxy the firm's performance.

Assuming a linear relationship between design investment that proxies the quantitative competence of design and firm's sales, we provide the following basic regression models:

[The basic model: Quantitative competence]

$$\ln(Sales_i) = \alpha + \beta_1 \ln(DI_i) + \varepsilon_i \quad (1)$$

$$\ln(Sales_i) = \alpha + \beta_1 \ln(DI_i) + D + \varepsilon_i \quad (2)$$

ln(Sales) and ln(DI) are the logarithms of firm sales and design investment, respectively. The error term is denoted by ε and the subscript i represents an individual firm. The basic model is expressed by equation (1), where we assume that there is a linear relationship between design investment and firm sales. To estimate the coefficient of design investment (β_1), we apply OLS (ordinary least squares) estimation method. In equation (2), we add a dummy variable (D) as an additional explanatory variable in order to see whether design investment has a different effect on firm performance by firm characteristics.

Since firm's sales would be affected by the size of firm, the size effect of firm should be considered. In order to control firm size more efficiently, we provide the extended model, equations (3) and (4), in which the number of employees is added as an explanatory variable.

[The extended model: Quantitative competence]

$$\ln(Sales_i) = \alpha + \beta_1 \ln(EMP_i) + \beta_2 \ln(DI_i) + \varepsilon_i \quad (3)$$

$$\ln(Sales_i) = \alpha + \beta_1 \ln(EMP_i) + \beta_2 \ln(DI_i) + D + \varepsilon_i \quad (4)$$

$\ln(EMP_i)$ is the logarithm of the number of employees at firm i. In this extended model, we adjust the effect of firm size by adding the employment variable, and try to estimate the effects of design investment on firm sales by equation (3). Also, by estimating equation (4), we can figure out how the effects vary by different firm characteristics.

We also analyze the effects of qualitative design competence on firm performance in a similar way as follows, which are shown from equation (5) to (8).

[The basic model: Qualitative competence]

$$\ln(Sales_i) = \alpha + \beta_1 (DQ_i) + \varepsilon_i \quad (5)$$

$$\ln(Sales_i) = \alpha + \beta_1 (DQ_i) + D + \varepsilon_i \quad (6)$$

[The extended model: Qualitative competence]

$$\ln(\text{Sales}_i) = \alpha + \beta_1 \ln(\text{EMP}_i) + \beta_2(\text{DQ}_i) + \varepsilon_i \quad (7)$$

$$\ln(\text{Sales}_i) = \alpha + \beta_1 \ln(\text{EMP}_i) + \beta_2(\text{DQ}_i) + \text{D} + \varepsilon_i \quad (8)$$

Firm i's qualitative design competence is denoted as DQ_i. We estimate its effects on firm sales by the simple regression of equation (5). In equation (7) and (8), the employment variable is added to control the firm size, as an extended model. Equations (6) and (8) are the models for the estimation of whether the firm characteristics dummies affect the relationship between qualitative design competence and firm performance.

3. 2. Data

For the data in our analysis, we use survey data collected from 200 Korean firms. We surveyed 502 firms, of which we disregarded 302 firms for two reasons. First, 298 firms are excluded from the sample because they do not disclose the information of either their sales or design investment. Secondly, four firms are excluded from the remaining sample because they are considered as an outliers in either sales, design investment, or employment. Figure 1 shows the box plots of the remaining 204 firms in terms of sales, design investment, and employment. [2]

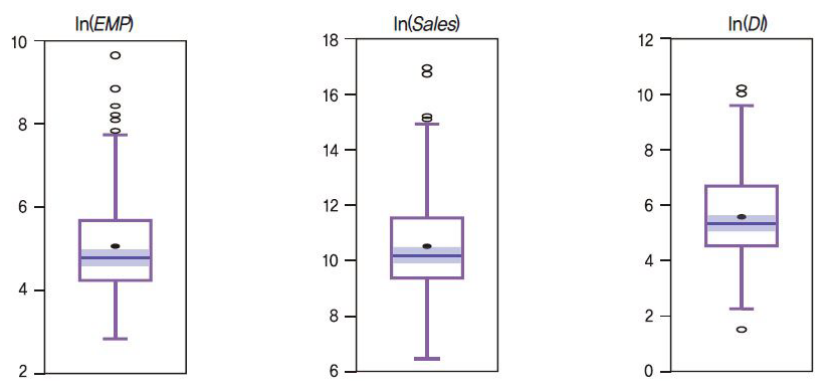

Figure 1 The box plots of the 204 firms

For the analysis, we use firm sales and design investment that represent firm performance and quantitative design competence, respectively. The employment variable is added as an additional explanatory variable to control firm size in the extended model. Table 1 shows the descriptive statistics of the 200 samples in sales, design investment, and employment. On average, the amount of sales is 169.99 billion KRW, the amount of design investment is 1.36 billion KRW, and the number of employees is 291.

Table 1 Statistics of the 200 firms

	Sales (million KRW)	Design investment (million KRW)	Employment
Mean	169,986.1	1,357.8	291
Median	27,400	300	120
Maximum	3,882,400	26,634	4,250
Minimum	690	10	17
Standard deviation	504,646.7	3,252.5	552.9
Skewness	5.4	4.8	4.6
Kurtosis	34.5	30.8	27.2

2) In Figure 1, we excluded firms that reported ln (EMP) 〉 9, ln (Sales) 〉16, or ln (DI) 〈2.

Table 2 shows the distribution of the firms by their main characteristics. 91.5% of the firms in our sample are small and medium sized; 82.5% are unlisted on the stock market; 59.5% are engaged in manufacturing industries; 31.5% operate a foreign organization; 42% outsource designing work; and 47% hold intellectual property rights.

Table 2 Characteristics of the 200 firms

Firm characteristics	Sample statistics
Firm size (FIRM)	Large (17), Small and medium (183)
Listed Company (PT)	Listed (35), Unlisted (165)
Type of industry (IND)	Manufacturing (119), Service (81)
Foreign organization (FO)	Operating (63), Not operating (137)
Design outsourcing (OS)	Outsourcing (84), Not outsourcing (116)
Intellectual property right (IP)	Holding (94), Not holding (106)

Since the effect of design investment on firm performance would be influenced by firm's specific characteristics, we use the firm characteristics listed in Table 2 as dummy variables in the models. In other words, we analyze the effects of quantitative and qualitative design competence on firm performance according to firm size (FIRM), whether they are publicly traded on the stock market (PT), which industry they are in (IND), whether they operate a foreign organization or not (FO), whether they outsource design works or not (OS), and whether they hold intellectual property rights or not (IP). The value of each dummy equals one in the following cases: if a firm is of small and medium size, if it is listed on the stock market, if it is a manufacturer, if it operates a foreign organization, if it outsources design works, and if it holds intellectual property rights.

In order to measure a firm's qualitative design competence, we use eleven variables from our survey data, which can be classified as follows: design personnel (DLN and DLQ), equipment and facilities (EQP), financing (FIN), education and training (EDU), intellectual property rights (IPR), networking (ENT and INT), information (INF), and the perception of design within the firm (CEO and EMD). They are arranged in Table 3. Even though we measure the variables of qualitative competence by a five-point scale in the survey[3], we transferred it to a three-point scale[4] in order to capture the variation of the responses more symmetrically.[5]

3) The responses by a five-point scale consist of "very insufficient (1)", "insufficient (2)", "neither sufficient nor insufficient (3)", "sufficient (4)", and "very sufficient (5)".

4) The responses are transferred by a three-point scale as "insufficient (1)", "neither sufficient nor insufficient (2)", and "sufficient (3)".

5) The results of the analysis are the same for the three-point scale measure and the five-point scale measure.

Table 3 Variables that represent the design competence of a firm

Type	Variable
Quantitative competence	Design investment (DI)
Qualitative competence	Number of workers engaging in design (DLN)
	Quality or ability of designers (DLQ)
	Equipment and facilities for designing such as SW, HW and workspace (EQP)
	Amount of possessed funds and capability of financing (FIN)
	Support for internal/external education and training regarding design (EDU)
	Holding intellectual property rights involving design such as utility/design patents and trademarks (IPR)
	External networks regarding design (ENT)
	Cooperation between departments/divisions within a firm for solutions to design issues (Internal networks,INT)
	Acquisition and utilization of information regarding design (INF)
	CEO's leadership on utilization of design or design management (CEO)
	Employees' perception of design and willingness to apply design (EMD)

4. Empirical Results

4. 1. The impact of quantitative design competence on firm performance

By OLS, we estimate models (1) and (2), which represent a linear relationship between design investment and firm performance, and present the results in Table 4. It is found that all the explanatory variables have a statistically significant effects on firm performance at 1% level (except for IP that is significant at 5% level).

Table 4 Quantitative design competence and firm performance (the basic model)

	Model (1)	Model (2)					
C	8.52*** (0.00)	11.62*** (0.00)	8.37*** (0.00)	8.89*** (0.00)	8.56*** (0.00)	8.67*** (0.00)	8.41*** (0.00)
ln(DI)	0.33*** (0.00)	0.20*** (0.00)	0.29*** (0.00)	0.22*** (0.00)	0.29*** (0.00)	0.37*** (0.00)	0.31*** (0.00)
DUM(FIRM)		−2.59*** (0.00)					
DUM(IND)			0.79*** (0.00)				
DUM(PT)				1.59*** (0.00)			
DUM(FO)					0.68*** (0.00)		
DUM(OS)						−0.84*** (0.00)	
DUM(IP)							0.56** (0.01)
R^2	0.09	0.28	0.14	0.23	0.13	0.16	0.13
Sample size	200	200	200	200	200	200	200

Note: 1) The p-values in parentheses.
2) * significant at 10% level; ** significant at 5% level; *** significant at 1% level.

The results in Table 4 are interpreted as follows. First, design investment has a positive effect on firm sales. Second, the effect of design investment on sales differs by firm size. More specifically, the effect in large firms is greater than that in small and medium firms. Third, the effect of design investment in manufacturing firms is greater than in service firms. Fourth, the effect of design investment in firms listed on the stock market is greater than in unlisted firms. Fifth, the effect of design investment in firms that operate a foreign organization is greater than in firms that do not. Sixth, the effect of design investment in firms outsourcing design is less than in firms depending only on in-house design. Finally, the effect of design investment in firms that hold intellectual property rights is greater than in firms that do not.

Table 5 presents the estimation results of models (3) and (4), which control the firm size effect by including the employment variable. Even if the firm size is controlled, the effect of design investment on firm performance is still statistically significant and positive.[6]

However, if they are estimated together with each of the six dummy variables of firm characteristics, only the estimates of IND and IP are statistically significant. In other words, if the firm size is controlled, the effect of design investment on performance in firms that engage in manufacturing or hold intellectual property rights is greater than in firms that do not.

6) The multicollinearity between design investment and employment is negligible because the variance inflation factor is about 1.01.

Table 5 Quantitative design competence and firm performance (the extended model)

	Model (3)	Model (4)					
C	3.72*** (0.00)	3.72*** (0.00)	3.71*** (0.00)	3.92*** (0.00)	3.79*** (0.00)	3.81*** (0.00)	3.73*** (0.00)
ln(EMP)	1.26*** (0.00)	1.26*** (0.00)	1.24*** (0.00)	1.22*** (0.00)	1.25*** (0.00)	1.24*** (0.00)	1.25*** (0.00)
ln(DI)	0.08* (0.06)	0.08* (0.06)	0.06 (0.18)	0.07 (0.10)	0.08* (0.09)	0.09** (0.04)	0.08* (0.09)
DUM(FIRM)		−0.002 (0.99)					
DUM(IND)			0.46*** (0.00)				
DUM(PT)				0.25 (0.19)			
DUM(FO)					0.18 (0.20)		
DUM(OS)						−0.13 (0.35)	
DUM(IP)							0.25* (0.06)
R^2	0.69	0.69	0.70	0.69	0.69	0.69	0.69
Sample size	200	200	200	200	200	200	200

Note: 1) The p-values in parentheses.
2) * significant at 10% level; ** significant at 5% level; *** significant at 1% level.

4. 2. The impact of qualitative design competence on firm performance

Table 6 shows the relationship between firm performance and the eleven factors that represent qualitative design competence. Out of the eleven factors, three have statistically significant effects on firm performance: equipment and facilities for designing (EQP), support for internal or external education and training regarding design (EDU), and holding intellectual property rights involving design (IPR). They are positively related to firm performance.

In order to control firm size, we add the employment variable in the extended model, and the estimation results are presented in Table 7. Although the results are similar to those of the basic model in a sense that EQP, EDU, and IPR have statistically significant and positive effects on firm sales, they are more valid with higher R^2 by adding the employment variable. In addition, acquisition and utilization of information regarding design (INF) is also shown to be statistically significant.

Table 6 Qualitative design competence and firm performance (the basic model)

	Model (5)										
C	10.37*** (0.00)	10.96*** (0.00)	9.38*** (0.00)	10.21*** (0.00)	9.56*** (0.00)	9.74*** (0.00)	10.51*** (0.00)	10.91*** (0.00)	10.24*** (0.00)	10.00*** (0.00)	10.77*** (0.00)
DLN	0.11 (0.56)										
DLQ		−0.12 (0.62)									
EQP			0.60*** (0.00)								
FIN				0.15 (0.38)							
EDU					0.54*** (0.00)						
IPR						0.41** (0.01)					
ENT							−0.01 (0.96)				
INT								−0.20 (0.24)			
INF									0.13 (0.45)		
CEO										0.22 (0.20)	
EMD											−0.13 (0.41)
R^2	0.01	0.01	0.07	0.01	0.05	0.03	0.00	0.01	0.00	0.01	0.00
Sample size	186	156	185	200	200	200	200	200	200	200	200

Note: 1) The p−values in parentheses.
2) * significant at 10% level; ** significant at 5% level; ***significant at 1% level.

Table 7 Qualitative design competence and firm performance (the extended model)

	Model (7)										
C	3.79*** (0.00)	4.49*** (0.00)	3.68*** (0.00)	3.92*** (0.00)	3.69*** (0.00)	3.71*** (0.00)	3.94*** (0.00)	3.67*** (0.00)	3.62*** (0.00)	3.82*** (0.00)	3.71*** (0.00)
ln(EMP)	1.32*** (0.00)	1.26*** (0.00)	1.29*** (0.00)	1.30*** (0.00)	1.27*** (0.00)	1.28*** (0.00)	1.30*** (0.00)	1.31*** (0.00)	1.30*** (0.00)	1.29*** (0.00)	1.31*** (0.00)
DLN	0.09 (0.37)										
DLQ		−0.08 (0.55)									
EQP			0.21** (0.03)								
FIN				0.07 (0.50)							
EDU					0.27** (0.01)						
IPR						0.21** (0.02)					
ENT							0.05 (0.61)				
INT								0.14 (0.15)			
INF									0.20** (0.04)		

CEO										0.11 (0.27)	
EMD											0.13 (0.15)
R^2	0.69	0.70	0.70	0.68	0.69	0.69	0.68	0.68	0.69	0.68	0.68
Sample size	186	156	185	200	200	200	200	200	200	200	200

Note: 1) The p-values in parentheses.
2) * significant at 10% level; ** significant at 5% level; *** significant at 1% level.

As shown in the above analysis, the factors of qualitative design competence that affect firm performance are design education and training (EDU), design equipment and facilities (EQP), and intellectual property rights (IPR). For this reason, we estimate the equation (6) and (8) using design education and training variable (EDU) and other firm characteristics as explanatory variables. The results are shown in Table 8 and 9. In this table, we only present the effect of design education and training (EDU) on firm performance[7] because the result is robust when we use equipment and facilities for designing (EQP) as an explanatory variable. Also, we exclude intellectual property right (IPR) in the analysis because it is already included in the models as one of the dummy variables (IP).

Table 8 Design education/training and firm performance (the basic model)

	Model (5)	Model (6)					
C	9.56*** (0.00)	12.21*** (0.00)	9.16*** (0.00)	9.55*** (0.00)	9.32*** (0.00)	9.89*** (0.00)	9.18*** (0.00)
EDU	0.54*** (0.00)	0.52*** (0.00)	0.48*** (0.00)	0.37** (0.02)	0.52*** (0.00)	0.51*** (0.00)	0.57*** (0.00)
DUM(FIRM)		−2.86*** (0.00)					
DUM(IND)			0.84*** (0.00)				
DUM(PT)				1.72*** (0.00)			
DUM(FO)					0.85*** (0.00)		
DUM(OS)						−0.65*** (0.00)	
DUM(IP)							0.71*** (0.00)
R^2	0.05	0.29	0.11	0.21	0.10	0.09	0.10
Sample size	200	200	200	200	200	200	200

Note: 1) The p-values in parentheses.
2) * significant at 10% level; ** significant at 5% level; *** significant at 1% level.

7) In this case, the regression model is that $\ln(Sales_i) = \alpha + \beta_1 (EDU_i) + D + \varepsilon_i$ for (6) and $\ln(Sales_i) = \alpha + \beta_1 \ln(EMP_i) + \beta_2 (EDU_i) + D + \varepsilon_i$ for (8).

Table 9 Design education/training and firm performance (the extended model)

	Model (7)	Model (8)					
C	3.69*** (0.00)	3.91*** (0.00)	3.87*** (0.00)	3.62*** (0.00)	3.74*** (0.00)	3.75*** (0.00)	3.65*** (0.00)
ln(EMP)	1.27*** (0.00)	1.25*** (0.00)	1.23*** (0.00)	1.24*** (0.00)	1.25*** (0.00)	1.27*** (0.00)	1.25*** (0.00)
EDU	0.27** (0.01)	0.27** (0.01)	0.25** (0.01)	0.24** (0.01)	0.27** (0.01)	0.27** (0.01)	0.28** (0.01)
DUM(FIRM)		−0.13 (0.65)					
DUM(IND)			0.46*** (0.00)				
DUM(PT)				0.25 (0.20)			
DUM(FO)					0.22 (0.13)		
DUM(OS)						−0.06 (0.67)	
DUM(IP)							0.30** (0.02)
R^2	0.69	0.69	0.71	0.69	0.69	0.69	0.70
Sample size	200	200	200	200	200	200	200

Note: 1) The p-values in parentheses.
2) * significant at 10% level; ** significant at 5% level; *** significant at 1% level.

When we estimated the effect of design education and training, the proxy of qualitative design competence, on firm sales, it provides a similar result to the case when we used design investment as an explanatory variable. First, the design education and training has a statistically significant and positive effect on firm sale whether we control firm size or not. When we consider firm size by adding the employment variable in the model, only the industry dummy and the intellectual property right dummy have a statistically significant and positive coefficient. This implies that the effect of qualitative design competence on performance is greater in firms that are engaged in manufacturing industry and firms that hold intellectual property rights, than in firms that are engaged in services and firms that do not hold intellectual property rights, respectively.

5. Conclusion

In this article, we investigated the effects of design competence on firm performance. Using the survey data collected from 200 firms in Korea, the results of the regression show that the factors having a positive effect on firm performance are design investment, design equipment and facilities, design education and training, and intellectual property rights involving design. The effects of those factors are greater in manufacturing firms than in service firms, and in firms that hold intellectual property rights than in firms that do not.

The empirical results of this study have two policy implications regarding promotion of firm's design competence.

First, in the short term, the government should seek a policy to support firms' investment in design and try to eliminate bottlenecks associated with design investment.
Second, in the long term, we should pay attention to the enhancement of firms' qualitative design competence. The government should support firms in improving design equipment and facilities, and taking advantage of the opportunities of design education and training in and out. Lastly, the government should improve the infrastructure so that firms can hold and utilize intellectual property rights more effectively.

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