IT SMEs’ Product Planning Capability and Manufacturing Capability in the Context of Digital Convergence: The Mediating Impacts of the Product Exterior and Interior Design Capabilities

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Abstract IT SMEs' product planning, product design, and manufacturing capabilities are of importance to creating their sustainable competitive advantages in the context of digital convergence. However, there have been few empirical studies investigating the relationships among them, which has made this research attempt to model the relationships and empirically test them. Especially, this study divided IT SMEs' product design capability into the product exterior and interior design capabilities and focused on the mediating effects of the product exterior and interior design capabilities between the product planning and manufacturing capabilities. By analyzing the 310 samples of Korean IT SMEs with the ordinary least squares regression analysis, this study has empirically revealed that IT SMEs' product exterior and interior design capability jointly and fully mediate the positive relationship between their product planning and manufacturing capabilities.

Key Words: Digital Convergence, IT SMEs, Product Planning Capability, Product Design Capability, Manufacturing Capability

요약 디지털 융합 환경에서 제품기획능력, 제품디자인능력 및 제조능력은 IT 중소기업의 지속적인 경쟁우위를 창출하는 데 매우 중요하다. 그러나, 이러한 주요 능력들간의 관계를 규명하는 실증 연구들이 거의 부재하여, 본 연구는 IT 중소기업의 제품기획능력, 제품디자인능력 및 제조능력 사이의 관계를 모형화하고 이에 대한 실증 분석을 실시하였다. 특히, 본 연구는 IT 중소기업의 제품디자인능력은 제품외부 디자인능력과 제품내부 디자인능력으로 구분하고 이러한 두 가지 형태의 디자인능력이 IT 중소기업의 제품기획능력과 제조능력 사이에 미치는 매개효과에 초점을 맞추었다. 본 연구는 310개의 한국 IT 중소기업을 대상으로 실시한 최소자승회귀분석 결과를 통해 IT 중소기업의 제품외부 디자인능력과 내부 디자인 능력은 제품기획능력과 제조능력 사이에 존재하는 양(+)의 관계를 함께 완전 매개한다는 것을 실증적으로 보여준다.

주제어: 디지털 융합, IT 중소기업, 제품기획능력, 제품디자인능력, 제조능력

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1. Introduction

In the context of digital convergence today, firms' product exterior and interior design capabilities play a critical role in manufacturing good products satisfying customers' needs [1, 2, 3]. For example, it is natural for customers to be attracted by a laptop computer with nice external appearances and high processing speed resulting from the laptop computer manufacturing firm's excellent product exterior and interior design capabilities. Therefore, a firm's product exterior and interior design capabilities are of importance to its success and growth [2, 3, 4]. However, the existence of these capabilities is not a sufficient condition for making good products attracting and satisfying customers. When a firm's product exterior and interior capabilities are well aligned with its product planning and manufacturing capabilities, it can make successful products [5]. Therefore, a firm's product planning, product exterior and interior design, and manufacturing capabilities are very crucial for their success[2, 3, 4, 5]. These capabilities are also very important to increasing the success of the Korean small and medium-sized enterprises (SMEs) running their business in information technology (IT) sector. But, there have seldom been empirical studies on the relationships in spite of the various recent studies on Korean SMEs such as [11, 12, 13, 14, 15, 16, 17, 18, 19], which has made this study attempt to build the three hypotheses in research model in [Fig. 1] to illuminate the relationships based on the following reasons and related prior studies.

2. Theory and Research Model

Dynamic capabilities theory emphasizes the point that firms’ dynamic capabilities play a critical role in creating their sustainable competitive advantages in the fast-changing business context such as the market in which Korean IT SMEs are running their business [6, 7, 8, 9, 10]. Dynamic capabilities refers to firms’ capacity to align, build up, and adapt their resources and competences to the fast-changing business context [9, 10]. Rather than purchased, dynamic capabilities are developed and built up over time as firms’ resources and capabilities are well integrated, established, and reconfigured to the fast-changing business context [8, 9, 10]. Therefore, in order for Korean IT SMEs to successfully integrate their resources and capabilities for their dynamic capabilities, it is necessary to understand well the relationships among firms’ important capabilities such as product planning, design, and manufacturing capabilities. But, there have seldom been empirical studies on the relationships in spite of the various recent studies on Korean SMEs such as [11, 12, 13, 14, 15, 16, 17, 18, 19], which has made this study attempt to build the three hypotheses in research model in [Fig. 1] to illuminate the relationships based on the following reasons and related prior studies.

![Fig. 1] Research model

Firms’ product planning is an important pre-step to product design and manufacturing [20]. It is hard for the SMEs without adequate product planning capability to develop and produce successful products in market [21]. One of the essential roles of the product planning
is to sense customers’ needs, develop product–related ideas to satisfy them, identify feasible features of products, and screen them [5, 21]. Firms’ manufacturing capability realizes the feasible product–related plans by actually making their products based on the feasible product–related plans resulting from their product planning capability [5, 20]. Therefore, firms’ product planning capability provides a cornerstone for their manufacturing capability [5, 20, 21]. Furthermore, according to Swink and Hegarty [22], manufacturing capability is composed of seven core capabilities: improvement, innovation, integration, control, acuity, agility, and responsiveness capabilities. Feedback is one of the essential factors to determining the control capability, playing an important role in comparing processed products with desired products [22]. In the product planning, customers’ desires for products are identified and reflected into feasible product concepts [5, 20, 21]. Therefore, good product planning capability can make a positive contribution to making the feedback work well by setting the right standard for the desired products with accurately sensing customers’ needs, which generates the following hypothesis 1 for the base model in this research in [Fig. 1].

H1: IT SMEs’ product planning capability is positively related to their manufacturing capability.

The product design can be classified into the outside and inside design of a product [1, 23]. Concerning the outside design of a product (i.e., product exterior design), in order for a firm to make their products have successful outward appearances, it is essential for the firm to sense customers’ cultural, aesthetic and symbolic needs and reflect them into their product exterior design [2, 4, 23]. The product planning capability plays a critical role in sensing the customers’ needs [2, 21], which can make a positive relationship between the product planning capability and the product exterior design capability. Furthermore, the product exterior design capability can have a significant relationship with the manufacturing capability because a firm’s product exterior design is generally related to its manufacturing capability [3]. However excellent the external appearance of a product planned by a firm may be, the product can not be actually made if its exterior design is beyond the firm’s manufacturing capability [3]. In other words, the consistency between the product exterior design and manufacturing capabilities is important to actually making products attracting customers [3]. Therefore, considering the positive relationships not only between the product planning and product exterior design capabilities but also between the product exterior design and manufacturing capabilities, this research builds the following hypothesis 2 for the mediating model I in the research model.

H2: IT SMEs’ product exterior design capability mediates the positive relationship between their product planning and manufacturing capabilities.

In planning a product, it is essential for a firm to identify customers’ needs for the functions of the product in terms of the technical excellence supported by the knowledge from various fields in science and engineering [1, 20, 21]. A firm’s good capability of accurately identifying the functional features which customers long for provides useful information that is a good input for the successful product interior design [2, 20, 21, 24], which can make a positive relationship between the product planning and product interior design capabilities. Moreover, the effective product interior design for the good item arrangement within a product helps firms reduce its cost accompanied by its manufacturing and increase the manufacturability of the products [1, 2], which can build a positive
relationship between the product interior design and manufacturing capabilities. Accordingly, based on the positive relationships between the product interior design and manufacturing capabilities as well as between the product planning and product interior design capabilities, this study generates the following hypothesis 3 in the mediating model II for this research.

H3: IT SMEs’ product interior design capability mediates the positive relationship between their product planning and manufacturing capabilities.

3. Research Methodology

This study tested the research model composed of the base model, the mediating model I and II by analyzing the relationships among the product planning, product exterior and interior design, and manufacturing capabilities of the 310 IT Korean SMEs in the 2013 SMEs’ Technology Statistics which the Korea Federation of Small and Medium Business (KBIZ) and the Small & Medium Business Administration had performed in 2013. As of the 30th in June in 2013, the levels of the Korean IT SMEs’ capabilities of technology-related product planning, product exterior design, product interior design, and manufacturing were respectively measured with a 100% point scale, compared to the best level in the world which took the value of 100%.

In order to empirically test the significances of the base model (H1), the mediating model I (H2), and II (H3), this research carried out the ordinary least squares regression analysis and the Sobel test [26] by using the IBM SPSS Statistics version 22.

Table 1 reports the features of the analyzed 310 samples in terms of the means, standard deviations, maximum and minimum values of the variables in the research model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Planning Capability</td>
<td>70.780</td>
<td>20.535</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Product Exterior Design Capability</td>
<td>64.500</td>
<td>25.839</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Product Interior Design Capability</td>
<td>72.306</td>
<td>21.714</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Manufacturing Capability</td>
<td>60.425</td>
<td>33.968</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

4. Empirical Test Results

The empirical test results have supported all of the three hypotheses in accordance with the research model.

First, related to the hypothesis 1 in the base model, there exists a positive relationship between Korean IT SMEs’ product planning capability and their manufacturing capability (regression coefficient = 0.425, t-value = 4.667).

Second, concerning the hypothesis 2 in the mediating model I, Korean IT SMEs’ product exterior design capability partially mediates the positive relationship between their product planning capability and manufacturing capability as illustrated in [Fig. 2]. The product planning capability is positively related to the product exterior design capability (regression
coefficient = 0.713, $t$-value = 12.075). The product exterior design capability is positively associated with the manufacturing capability (regression coefficient = 0.204, $t$-value = 2.338). There exists a positive relationship between the product planning capability and the manufacturing capability (regression coefficient = 0.280, $t$-value = 2.548). The $z$-value resulting from the Sobel test [26] for the mediating model I is 2.301, empirically confirming the significance of the mediating model I.

![Diagram](image)

**[Fig. 3] The mediating model II test results**

Third, with regard to the hypothesis 3 in the mediating model II, Korean IT SMEs’ product interior design capability fully mediates the positive relationship between their product planning capability and manufacturing capability as illustrated in [Fig. 3]. The positive and significant relationship between the product planning and manufacturing capabilities in the base model (regression coefficient = 0.425, $t$-value = 4.667) has become insignificant (regression coefficient = 0.096, $t$-value = 0.934) when the mediating impact of the product interior design capability is considered in the mediating model II, which empirically confirms the full mediating effect of the product interior design capability according to Baron and Kenny (1986) [25]. The $z$-value resulting from the Sobel test [26] for the mediating model II is 5.178, and it also confirms the mediating impact of the product interior design capability in the mediating model II.

![Diagram](image)

**[Fig. 4] The multiple mediating effects test results**

Fourth, related to the hypothesis 2 and 3 in the research model, this study has examined the multiple mediating effects of the product external and internal design capabilities by extending Baron and Kenny (1986) [25]’s single mediating effect test to the multiple mediating effects test in the research model. [Fig. 4] shows the multiple mediating effects test results. The positive relationship between the product planning and manufacturing capabilities (regression coefficient = 0.425, $t$-value = 4.667) has become insignificant ($t$-value = 0.089) when the multiple mediating effects of the product external and internal design capabilities are reflected at the same time as seen in [Fig. 4], which confirms that the product external and internal design capabilities jointly and fully mediate the relationship between the product planning capability and manufacturing capabilities.

5. Conclusion

5.1 Summary of the new findings

This research attempted to construct the relationships
among Korean IT SMEs’ important capabilities such as product planning, product exterior and interior design, and manufacturing capabilities and empirically test the relationships by using the 310 Korean IT SMEs data in the firm-level.

The empirical test results have revealed four interesting and meaningful findings which can enrich the knowledge about the relationships among the product planning, product exterior and interior design, and manufacturing capabilities in Korean IT SMEs as follows. First, Korean IT SMEs’ product planning capability has a positive relationship with their manufacturing capability. Second, their product exterior design capability partially mediates the positive relationship. Third, their product interior design capability fully mediates the positive relationship. Fourth, their product exterior and interior design capabilities jointly and fully mediate the positive relationship between Korean IT SMEs’ product planning capability and their manufacturing capability.

5.2 Implications from the new findings

Playing a critical role in making firms’ success [27, 28], the capabilities of firms enable them to create, sustain, and develop their own competitive advantages necessary for their survival and growth in market [29, 30]. Therefore, the research on the capabilities of firms like this study can be of importance, especially to Korean IT SMEs which have thirst for the sustainable competitive advantages in both domestic and international markets. Focusing on Korean IT SMEs’ important capabilities such as product planning, product exterior and interior design, and manufacturing capabilities, this study has revealed that product exterior and interior design capabilities jointly and fully mediate the positive relationship between their product planning and manufacturing capabilities. It has also pointed out that Korean IT SMEs’ product exterior design capability partially mediates the positive relationship but their product interior design capability fully mediates this positive relationship, which previous studies on SMEs’ capabilities have not empirically illuminated enough so far.

5.3 Limitations

This research possess the following several limitations. First, the research model was tested by using only the samples from Korean IT SMEs, which prevents the findings of this study from being generalized in other countries. Second, this study concentrated on the product-related capabilities of IT SMEs. Future studies about the service-related capabilities of IT SMEs such as the service design capability will provide good implications which this study can not present. Third, IT SMEs’ capabilities are so various that modeling the relationships among more various capabilities of IT SMEs will produce more meaningful findings.

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