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HOW KNOWLEDGE INTEGRATION MECHANISMS AFFECT PRODUCT INNOVATION IN THE NPD PROCESS?

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ABSTRACT

Purpose*: This study tries to examine how a company utilizes knowledge integration mechanisms (KIMs) to achieve the success of product innovation in a new product development (NPD) process.*

Research questions*: (1) How KIMs affect new product performance in the NPD process? (2) Is the effect of KIMs on performance different for developing products with different level of product advantage?*

Design*: This study forms a mediation model to examine that knowledge integration capability (KIC) mediates the effect of KIMs on new product performance, and then forms a moderated mediation model to examine the moderating effect of product advantage on this mediating relationship.*

Methodology*: The hierarchical regression is used to examine 128 Taiwan's manufacturing firms. This study follows Baron and Kenny's (1986) procedure to examine the mediation effect, and follows Muller, Judd, and Yzerbyt's (2005) steps to examine the moderated mediation effect.*

Findings*: KIC positively and completely mediates the effect of KIMs on new product performance. The mediating effect of KIC is strong when the level of product advantage is low.*

Research limitations*: This study only examines the relationship with a cross-sectional data. The generalizability of the findings is limited. This study merely examines product advantage as a moderator in the relationship.*

Research implications*: The use of KIMs is not a sufficient condition for product innovation but the integration capability is the key driver of product innovation. For developing product with*

less product advantage, the mediating effect of knowledge integration capability is stronger.
***Practical implications**: Although KIC converts the effect of KIMs on new product performance, but its effect varies as a function of product advantage. The view implies that by failing to consider the KIC's moderated-mediating role, managers may have reached an overly optimistic view on the effect of KIMs on product innovation.*

Keywords: knowledge integration mechanisms, knowledge integration capability, product advantage, new product performance

INTRODUCTION

Based on the knowledge-based theory, knowledge integration was viewed as the critical factor affecting firms' competitive advantage (Grant, 1996). To create competitive advantage, a firm must create new knowledge by exploring and exploit the acquired knowledge (Marsh and Stock, 2006; Teece, Pisano, and Shuen, 1997). Previous research suggests that the use of *knowledge integration mechanisms* (KIMs), which refer to the formal processes and structures that ensure the access and integration of knowledge among different functional units within a firm, is a critical factor that enables managers to internalize and reorganize what it has learned and decide how to use it in firm's new product development (NPD) process (Hamel and Prahalad, 1994; Zahra, Ireland, and Hitt, 2000). Even several studies have pursued extensively an understanding of the link between the use of KIMs and new product performance, how the effect of using KIMs on new product performance remains unclear. The interest in the assumed relationship between the use of KIMs and new product performance has shown apparent strategic importance in marketing literature. Moreover, previous study suggests that product innovation success appears to depend on the management's capability to effectively integrate all resources and utilize them to achieve success (Wells, 2008). Therefore, this study proposes that knowledge integration capability (KIC) is the key which leads the effect of KIMs to new product performance.

On the other hand, previous studies show that product advantage, which is considered a product's uniqueness and superiority relative to other products in the market (Atuahene-Gima, 1995; Langerak, Hultink, and Robben, 2004; Song and Parry, 1997), positively associates with product performance (Calantone, Chan, and Cui, 2006; Henard and Szymanski, 2001; Langerak et al., 2004). Some studies also indicate that product advantage is related to product newness (Kleinschmidt and Cooper, 1991), and product newness always represents a high uncertainty to firms. Other research suggests that the NPD process and its outcomes depend on the level of perceived uncertainty of the firm's decision makers regarding the external environment (Capon, Farley, Lehmann, and Hulbert, 1992; Zirger and Maidique, 1990). This study therefore tries to link the relationship to examine the moderating effect of product advantage in the KIMs-KIC-new product performance relationship.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

Knowledge integration mechanisms

Some knowledge is tacit, making it difficult to use unless the knowledge integrates into the firm's operation (Grant, 1996). The task of knowledge integration is often accomplished by the use of structures and processes. Using the formal processes and structures ensures the access and integration of knowledge among different functional units within the firm (De Luca and Atuahene-Gima, 2007). Past literature suggests that the use of KIMs enables a firm to internalize and reorganize what it has learned and to decide on how to use the new knowledge (De Luca and Atuahene-Gima, 2007; Hamel and Prahalad, 1994). In order to utilize embedded knowledge that resides within individuals or social groups (Badaracco, 1991), firms need to integrate knowledge into the NPD process. During the integration process, managers must decide what knowledge should be accessed, evaluate the importance, and explore the way to reconfigure knowledge (Zahra et al., 2000). Firms that neglect knowledge integration processes may fail to achieve product innovation (De Luca and Atuahene-Gima, 2007).

Knowledge integration capability

Grant (1996) proposed that integration capability is a key to organizational survival in dynamic environments. Knowledge integration capability refers as a firm's ability to perform repeatedly a product task efficiently, extensively, and flexibly. Grant (1996) identified three characteristics of knowledge integration capability: efficiency of integration, scope of integration, and flexibility of integration. The efficiency of integration refers to the extent to which the capability accesses and utilizes the specialist knowledge held by individual organizational members. The scope of integration refers to the breadth of specialized knowledge the organizational capability draws upon. The flexibility of integration refers to the extent to which a capability can access additional knowledge and reconfigure existing knowledge.

The Mediating role of knowledge integration capability

Previous study identified the positive effect of KIMs on new product performance. However, how does KIMs affect new product performance remains unclear? The resource-based view literature emphasizes that the development of a capability for generating knowledge from external resource is based on internal processes and routines that are organizationally embedded in managerial interpretations (Sharma, 2000). The process of collecting and transferring knowledge among individuals characterizes with ambiguity, and then increasing the likelihood that firms will develop suitable KIMs (Birkinshaw, Nobel, and Ridderstråle, 2002; Germain and Dröge, 1997).

Previous research indicated that integration of primary activities usually results in greater efficiency (Barki and Pinsonneault, 2005) because integration saves time, reduces errors, facilitates the coordination of activities, and reduces total inventory cost (Malone et al., 1999). In addition, integration improves cross-functional communication and synergy, which led to a higher innovation rate and greater new product success (Cooper and Kleinschmidt, 1986). By

building on its existing knowledge, firms can build a broader understanding of market and technological requirements (Marsh and Stock, 2006). As relative capabilities change, firm boundaries are adjusted accordingly (Langlois, 1992). In NPD process, the increase in a firm's knowledge integration scope enhances the positive impact on its new product performance. For example, Hoegl, Ernst, and Proserpio (2007) indicated that as team member dispersion increases, the team work positively and significantly affects team performance. However, a flexible integration, either through continually integrating new tacit knowledge or through constantly reconfiguring existing knowledge, is likely to impose substantial costs in terms of reducing the efficiency of knowledge integration (Grant, 1996). This study argues that as the use of KIMs may increase the integration efficiency, scope, and flexibility of a firm's capability, thus increasing the success of new product performance. This study proposes:

H1: Knowledge integration capability positively mediates the relationship between knowledge integration mechanisms and new product performance.

Product advantage

In the NPD literature, product advantage is considered a product's uniqueness and superiority relative to other products in the market on dimensions such as quality, benefit, and function (Atuahene-Gima, 1995; Calantone et al., 2006; Langerak et al., 2004; Song and Parry, 1997). Highly innovative products are more differentiated from competitors' product in the market and have and greater product advantage (McNally, Cavusgil, and Calantone, 2010). A number of studies have confirmed a positive association between product advantage and performance (Calantone et al., 2006; Gatignon and Xuereb, 1997; Li and Calantone, 1998). A meta-analysis found that product advantage is the most potent driver to new product performance (Henard and Szymanski, 2001).

The Moderating role of product advantage

Product advantage is considered to be related to product newness (Kleinschmidt and Cooper, 1991). Highly innovative products are usually associated with novel attribute, and customers may be perceived more favorable to the new product. Owing to the novel attributes of new products, innovating products may face high uncertainty to firms in the NPD activity. Other research suggests that the NPD process and its outcomes depend on the level of perceived uncertainty of the firm's decision makers (Capon et al., 1992; Zirger and Maidique, 1990). Uncertainty is related to managerial perceptions of business environment that is unpredictable (Dess and Beard, 1984; Milliken, 1987). Highly uncertainty makes sales forecasts and market trends difficult to monitor or predict (Celly and Frazier, 1996). Information processing theory suggests the need of different types of integration mechanisms depends on levels of uncertainty and ambiguous (Sicotte and Langley, 2000). Therefore, businesses operating in an uncertain condition are likely to have a greater need to use KIMs in order to facilitate the flow of information.

The higher the uncertainty that makes internal information transfer more complex, the more need to integrate and centralize in the strategy decision. Therefore, high unpredictable environment

may encourage the firm to engage in dialogue within the firm in order to identify opportunities and facilitate new product development. Managers perceive environment uncertain when they have difficulty to predict the direction and viability of future technologies or to monitor the changing needs of consumers' preferences for product and services (Rueda-Manzanares, Aragón-Correa, and Sharma, 2008). Integration capability helps the firm to develop new knowledge and generate innovations (Sharma and Henriques, 2005). According to the resource-based view, firms obtain competitive advantage not only through the generation of unique, heterogeneous, tangible or intangible assets but also via their ability to integrate and develop these assets as capabilities to achieve new product success (Amit and Schoemaker, 1993; Barney, 1991). Therefore, this study proposes:

H2: The higher the advantage of a new product, the more positive the mediating effect of knowledge integration capability on the knowledge integration mechanisms-new product performance relationship.

RESEARCH METHODS

Measures

Most scales for the constructs included in this study are available in the extant literature: existing measures are used or adapted to suit the purposes of this study. However, scale for knowledge integration capability does not exist from previous study. This study develop knowledge integration capability scale based on Grant's (1996) conceptual definition. These items are pre-tested through interviews with both academic researcher and managers. At each stage, participants are required to comment on the ease with which they understand the items. Where items are confusing, they reword or eliminate in keeping with questionnaire development guideline (Churchill, 1979). After incorporating suggested changes, pilot test is conducted. Each measure is addressed as follows.

New product performance is measured using a five-item scale that is adapts and refines scale from De Luca and Atuahene-Gima (2007), Langerak, Hultink and Robben (2004). This study uses the scale to assess the extent to which the firm has achieved the product development objectives on market share, sales, profitability, sales growth, time-to-market, time to break-even, and within budget. *Knowledge integration mechanisms* are measured by a seven-item scale that is adapted from De Luca and Atuahene-Gima (2007). This study uses the scale to assess the extent to which a firm uses a set of formal processes to capture and integrate knowledge. This study develops *knowledge integration capability* scale based on Grant's (1996) conceptual definition. This study defines knowledge integration capability as the extent to which a firm's ability to perform repeatedly a product task efficiently, extensively, and flexibly. The efficiency of integration is defined as the extent to which a firm's ability to access and utilize the specialist knowledge held by individual organizational members. The scope of integration refers as the extent to which a firm's ability to collect different types of specialized knowledge. The flexibility of integration refers as the extent to which a firm's ability to extending existing knowledge to encompass additional type of knowledge and reconfiguring existing knowledge into new type of knowledge. Product advantage is measure using a seven-item scale adapted from Song and Parry

(1997), Langerak, Hultink, and Robben (2004), and Atuahene-Gima (1995). This scale assesses the extent to which a new product is highly innovative, is superior to competing product, and offers unique benefits for customers.

In addition to the above constructs, this study includes five control variables to reduce the possibility of alternative explanations, and to lend weight to the analyses in the next section. Firm size represents the degree to which a firm has plentiful resources (Bonner and Walker, 2004). Firms may be more able to innovate when they have greater resources (Autio, Sapienza, and Almeida, 2000). This study, as with previous studies (e.g., Atuahene-Gima, 2005; Tsai and Wang, 2008), employs the number of employees as a proxy for firm size. This study also controls the firm age variable because younger firms tend to be more flexible, while older firms may develop a more rigid bureaucratic structure and encounter a competency trap (Gopalakrishnan and Bierly, 2006; Tushman and Anderson, 1986). Besides, this study also controls three types of e*nvironmental context* adopted from Jaworski and Kohli (1993) which is composed of technological turbulence, market turbulence and competitive intensity. The technological turbulence is measured by a five-item scale that assesses the extent to which a firm perceived that a technology in an industry was in a state of flux. The market turbulence is measured by a seven-item scale that assesses the rate of change in the composition of customers and their preferences. Competitive intensity is measured by a six-item scale that assesses the behavior, resources, and their ability of competitors to differentiate product in the market. All variables are rated with Likert scales ranging from 1 (disagree extremely) to 7 (agree extremely).

Sample and data collection

The sample is drawn from Taiwan's manufacturing firms. Survey respondents were personnel from R&D, marketing, or manufacturing functional units that have been responsible for at least one NPD project launched within the three years prior to data collection in Taiwan. Collecting data at the project level was consistent with earlier research efforts (Souder et al., 1998). Accordingly, all measures were specified on the project level. Initially, each subject was contacted by telephone to verify qualification of having launching new product less than three year from the date and then to solicit cooperation in the study. Managers were promised, as an incentive, a summary of the research findings. A package was then mailed out consisting of a personalized letter on university headed paper, a copy of the questionnaire survey and a stamped return envelope. A reminder letter send out two weeks later and another letter and package to those who still had not responded three weeks later.

Survey respondents were personnel from R&D, marketing, or manufacturing functional units that have been responsible for at least one NPD project launched within the three years prior to data collection in Taiwan. The respondent was asked to complete the survey with respect to the product development process in which he or she had been involved. Before answering the questionnaire, we asked respondents to identify one new product launched by their firm within last three years among all product lines. This new product then served as a referent for all questions pertaining to the firm's product development process. Respondents then answer each question item according to their experience and judgment on whether they agree or disagree with the statements in the question items.

Reliability, Validity, and Descriptive Statistics

Reliability was initially evaluated using Cronbach's alpha and item-to-total correlations. This study uses confirmatory-factor analysis (CFA) to verify the reliability and validity of the scales. Except for technological turbulence construct, all the multi-item measures demonstrate adequate internal consistency, with all producing alphas of 0.70 or more threshold for acceptable reliability. These results indicate that the measures are internally consistent (Nunnally, 1978). The composite reliability (CR) of each scale was calculated using the procedures suggested by Fornell and Larcker (1981). The CR values for the constructs ranged from .61 to .94, exceeding the acceptable level of .60 suggested by Bagozzi and Yi (1988). As a further check, the major constructs of the values for average variance extracted (AVE) exceeded the threshold level of .50 suggested by Bagozzi, Yi, and Phillips (1991). The significance of each standardized coefficient loading indicates convergent validity (Bagozzi et al., 1991). The CFA results show that each of the measures loaded significantly on its intended construct, indicating convergent validity in each scale. The square roots of the AVE for each construct are significantly greater than the off-diagonal elements (Hulland, 1999), meeting Fornell and Larcker's (1981) criterion for discriminant validity. The model shows that a comparative fit index (CFI) of 0.94, incremental fit (IFI) of 0.94, non-normed fit (NNFI) of 0.93, and the root mean square error of approximation (RMSEA) of 0.078, suggesting an acceptable degree of model fit. Table 1 shows the means, standard deviation, correlation, and square roots of average variances extracted in this study.

RESULTS

This study evaluates the proposed models using the Baron and Kenny's (1986) procedure to examine the mediation and using Muller, Judd, and Yzerbyt (2005) approach to examine the moderated mediation. Since the product term is usually highly correlated with its individual variable, the model estimations follow the straightforward procedure suggested by Friedrich (1982) to reduce or eliminate multicollinearity bias. Table 1 shows the result of mediation and Table 2 summarize the statistical results of moderated mediation.

TABLE 1 Mean, standard deviation, correlation, and square roots of average variances extracted

Variable	1	2	3	4	5	6	7	8	9
(1) New product performance	**.85**								
(2) KIMs	.39	**.81**							
(3) KIC	.42	.69	**.77**						
(4) Product advantage	.25	.41	.44	**.75**					
(5) Market turbulence	.42	.30	.41	.49	**.63**				
(6) Competitive intensity	.23	.14	.17	-.00	.44	**.65**			
(7) Technological	.30	.39	.25	.46	.52	.40	**.54**		
(8) Company Age	-.02	.01	.08	.06	.12	-.10	.00	N.A.	
(9) Company Size	.13	.04	-.03	-.28	-.11	-.08	-.09	.34	N.A.
Number of items	5	7	11	7	6	5	4	1	1
Mean	4.51	5.16	4.99	5.04	5.12	5.16	5.31	5.23	4.60
SD	1.20	1.13	1.03	1.09	.85	1.09	.87	2.07	1.73

Note: * The notations are interpreted as below, and used in the rest of this study: KIMs: knowledge integration mechanisms. KIC: knowledge integration capability. N.A. = not applicable.

** Square roots of average variances extracted are bold on the diagonal. The figures on the triangle elements are correlations among the composite measures (unweighted mean of the items for each construct).

In Table 1, the result in model 2 show that the coefficient estimate of KIMs is significant, indicating that KIMs has a positive effect on KIC. Furthermore, the results in Model 3 show that the effect of KIC on new product performance is significant and that the coefficient estimate of KIMs on new product performance is significantly reduced from Model 1. This results support H1, suggesting that KIC totally mediates the positive effect of KIMs on new product performance.

TABLE 2 Results of regression analysis for mediation

	Criterion: KIC		Criterion: NPP			
	Model 2		Model 1		Model 3	
Independent Variables	**b**	***t***	**b**	***t***	**b**	***t***
Firm age	.03	*(.86)*	-.06	*(-1.54)*	-.07	*(-1.73)*
Firm size	-.03	*(-.79)*	.12	*(2.51)*	.13	*(2.67)* **
Market turbulence	.33	*(3.54)* ***	.42	*(3.69)*	.35	*(2.96)* **
Competitive Intensity	.02	*(.29)*	.03	*(.34)*	.02	*(.29)*
Technology turbulence	-.19	*(-2.13)* *	.02	*(.14)*	.06	*(.51)*
KIMs	.67	*(9.79)* ***	.27	*(3.23)* ***	.13	*(1.16)*
KIC					.21	*(1.93)* *
F value	23.43 ***		8.45 ***		7.94 ***	
R^2	.54		.30		.32	
Adjusted R^2	.52		.26		.28	
ΔR^2	.37		.06		.02	
F change	95.78 ***		10.43 **		3.73	

*p < .05; **p < .01; ***p < .001 (one-tailed test for hypotheses, and two-tailed test for control variables).

Notes: N = 128. b = standardized path coefficients. *t* = t value. NPP = new product performance. KIMs = knowledge integration mechanisms. KIC = knowledge integration capability.

In Table 2, the results from Model 1 indicate an overall effect of KIMs on new product performance (β_{16} = .26, p < .01), but that of the product term of KIMs and product advantage does not achieve a statistical significance (β_{18} = .01, p > .05). This satisfies the necessary condition required for a moderated mediation examination. Next, Model 2 presents a significant coefficient estimate of KIMs (β_{26} = .62, p < .01), Model 3 indicates that the coefficient estimate of the KIC × product advantage interaction is significant (β_{26} = -.21, p < .05). Taking these statistical results together, the results support H2, suggesting that KIC have a mediating effect on the link between KIM and new product performance and that this mediating effect is affected by product advantage. Previous research suggests that merely inspecting the signs and magnitudes of regression coefficients is usually insufficient for a moderation (contingency) hypothesis (Schoonhoven, 1981). Hence, this study further performed post hoc analysis to examine the nature of this interaction using the Aiken and West (1991) procedure. Results of post hoc analysis reveal that the mediating effect of KIMs is stronger when product advantage is low (β= .27, *p* < .01). In contrast, when product advantage is high, the mediating effect of KIMs remains the

same (β= -.01, p > .05).

DISCUSSION

Summary

This paper seeks to advance the marketing and innovation management literature by untangling the relationships among KIMs, KIC, product advantage, and new product performance. The results show that KIC completely mediates the relationship between KIMs and new product performance, and this mediating effect is strong when the level of product advantage is low.

Contributions to Scholarship

This research contributes to extant literature in the following ways. First, previous study suggested that new product performance is enhanced by KIMs (De Luca and Atuahene-Gima, 2007; Ruekert and Walker, 1987); this study deepens the current literature by providing a completely mediating factor of knowledge integration capability which leads the effect of KIMs to reach new product success. In other words, the success of knowledge integration can be attributed to the increase in integration capability. Second, this study further demonstrates that such an effect varies with the level of product advantage. The findings of this study show that KIC play an important role for utilizing KIMs in the NPD process to achieve new product performance, and further show that when product advantage is low, a product's uniqueness and superiority relative to other products in the market is not particularly obvious; firms utilizing integration mechanisms in the NPD process possess high integration capability of innovating product, thus producing higher innovation performance. On the contrary, when product advantage is high, the mediating effect of knowledge integration capability remains the same. These findings imply that for it is especially important to fertilize the integration capability for developing less innovative product.

Applied contributions

The finding of this study demonstrates that it is not integration mechanisms itself but integration capability to achieve new product success in a NPD process. It indicates that the use of KIMs is not a sufficient condition for product innovation but the integration capability is the key driver of product innovation. Managers who encourage the use of KIMs but do not focus on the increase of integration capability will not achieve new product success. In the other way, the finding of this study show the mediating effect of knowledge integration capability is especially useful for products with less superiority to other product in the market in the NPD activity. For those firm developing less innovative products, managers should deliberate the use of KIMs to make progress on integration capability to achieve new product success.

Limitations and future research directions

This study attempts to discover some fundamental ideas among knowledge integration mechanisms, knowledge integration capability, product advantage, and new product performance.

However, any conclusions drawn from this study should be viewed in the context of its limitations, and should also be extended in future studies. The results of this study have three main limitations that also offer opportunities for further research. First, this study examines the relationships with a cross-sectional data. The results of this study may not accurately portray firms' long-term product performance. Future study may use a longitudinal research design and assess actual performance with the data from company records. Second, the generalizability of these findings is limited because these findings are based on a sample of Taiwanese manufacturing firms. Future study should be validated in detail in other contexts. Third, this study merely examines product advantage as a moderator in the stated relationship; however, there are other possible moderators affecting the relationship.

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TABLE 3 Results of regression analysis for moderated mediation

	Criterion: KIMs		Criterion: NPP			
	Model 2		Model 1		Model 3	
Independent Variables	**b**	***t***	**b**	***t***	**b**	***t***
Firm age	.03	*(.79)*	-.07	*(-1.57)*	-.06	*(-1.44)*
Firm size	-.00	*(-.06)*	.13	*(2.49)* *	.13	*(2.53)* *
Market turbulence	.25	*(2.56)* *	.40	*(3.20)* ***	.33	*(2.67)* **
Competitive Intensity	.07	*(1.05)*	.04	*(.47)*	.02	*(.25)*
Technology turbulence	-.25	*(-2.66)* **	.00	*(-.00)*	.07	*(.59)*
KIMs	.62	*(8.79)* ***	.26	*(2.93)* **	.12	*(1.11)*
Product advantage	.18	*(2.04)* *	.05	*(.43)*	.03	*(.26)*
KIMs x Product advantage	-.04	*(.64)*	.01	*(.18)*	.15	*(1.47)*
KIC					.20	*(1.81)* *
KIC x Product advantage					-.21	*(-1.89)* *
F value	18.48 ***		6.27 **		5.95 ***	
R^2	.55		.30		.34	
Adjusted R^2	.52		.25		.28	
ΔR^2	.00		.00		.04	
F change	.43		.03		3.59	

*p < .05; **p < .01; ***p < .001 (one-tailed test for hypotheses, and two-tailed test for control variables).

Notes: N = 128. b = standardized path coefficients. *t* = t value. NPP = new product performance. KIMs = knowledge integration mechanisms. KIC = knowledge integration capability.