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Impact of Cross-functional Integration on Npd Efficiency: The Knowledge Acquisition Perspective

[1]Ma Wencong, [1]Zhang Guangyu and [2]Ding Baojun
[1]School of Management, Guangdong University of Technology, Guangzhou, 510520, China
[2]School of Business Administration, South China University of Technology, Guangzhou, 510641, China

Abstract: Enhancing NPD efficiency through cross-functional integrations is the key to new product development management. However, empirical studies in this subject are scarce. This study investigates the effects of five different cross-functional integrations on NPD efficiency from knowledge acquisition perspective. It also explores the impact of knowledge acquisition on NPD efficiency. Finally, we found the relationships between five different cross-functional integrations and NPD efficiency are not same and we clarified the mechanisms that cross-functional integrations have significant effects on NPD efficiency through knowledge acquisition. These results can provide implications for the NPD management practices.

Key words: Cross-functional integration, knowledge acquisition, NPD efficiency

INTRODUCTION

With domestic and international economic environment changes, the industry upgrade has been critical to economic reforming in China. It requests enterprises to be engaged in new product development positively. However, the economic globalization and the information technology development has brought the huge challenge for the new product development, so promoting the new product fast or enhancing efficiency becomes one of the important factors on new product competition. When the competitive environment is getting more complicated, the new product development does not only require the integration of interior function but the integration of exterior resources such as suppliers, the customers, the universities and so on (Wu and Wu, 2008). Although the cross-functional integration has always been the subject of the new product development studies, they mainly focused on the enterprise interior functional integration or from the information perspective in the past. They paid little attention on exterior integration and few of them were from knowledge acquisition perspective (Wu and Wu, 2008). We know that in reality the enterprise has a variety of cross-functional integrations. Then how do these cross-functional integrations promote new product development efficiency? This study argues that cross-functional integration could affect new product development is due to internal and external knowledge obtained by different enterprises. Based on the knowledge acquisition perspective, this study explored the mechanism how cross-functional integration affects the efficiency of new product development. It found the effects of five different cross-functional integrations on new products development knowledge acquisition are not identical. It provides suggestions and implications for enterprises to promote new product development efficiency.

LITERATURE REVIEW AND HYPOTHESIS

Three kinds of knowledge for new product development: New product development is kind of knowledge innovation activities, involving multiple disciplines of knowledge. The success of the new product development depends on the effective knowledge acquisition. Then, what knowledge does it need? Does it need common knowledge, specialized knowledge, process knowledge, marketing knowledge, or customer knowledge? This kind of classification cannot summarize the knowledge needed to develop new product. Drawn on Vincenti's opinions that the engineering design needs the function knowledge and structure knowledge, this study presents three kinds of knowledge required to develop new product after interviews: Function knowledge, structure knowledge and process knowledge (Zhang and Zhang, 2005). Function knowledge is the knowledge about the customer needs. Structure knowledge is the knowledge about the technology structure, explaining how new products are constructed. Moreover, process knowledge is the knowledge about manufacturing, describing how new products are manufactured.

Cross-functional integration and knowledge acquisition: Sherman *et al.* (2000) found that five cross-functional

Corresponding Author: Ma Wencong, School of Management, Guangdong University of Technology, Guangzhou, 510520, China

integrations have significant effects on new product development cycle but it was not from the perspective of knowledge acquisition. This study investigates the impact of five cross-functional integrations on knowledge acquisition as follow:

- **R and D and customer integration:** R and D and customer integration helps obtain customer knowledge (Yli-Renko *et al*., 2001) and it is the customer perception o n product properties (function knowledge) and technical components (structure knowledge). Primary task of NPD is to confirm the properties new product should achieve based on customer needs and it is the knowledge about the product's features. Being involved in new product development, customers can not only express their individual needs about product properties but also provide suggestions on product components. Therefore, this study put forward the research hypothesis:

H1a: R and D and customer integration has a significantly positive effect on function knowledge acquisition.

H1b: R and D and customer integration has a significantly positive effect on structure knowledge acquisition.

- **R and D and supplier integration:** As to R and D and supplier integration, suppliers participate in knowledge acquisition in many different ways as follows (Ye *et al*., 2006). (a) To deepen the supplier's understanding of the ultimate objective of product design so that they can provide suggestions to optimize the product design; (b) To show new technologies and new materials to manufacturers (function and process knowledge); (c) To assist manufacturers to build a technology roadmap and grasp the technical trend; (d) To help manufacturers gain marketing knowledge (knowledge about competitors and customer). The mature technologies developed by supplier help to extend the existing product properties (function knowledge) by enterprises, while the mature technologies provided by suppliers are technical part of the new product properties (structure knowledge) and manufacturing processes of improving the products (process knowledge). Therefore, this study put forward research hypothesis.

H1c: R and D and supplier integration has a significantly positive effect on function knowledge acquisition.

H1d: R and D and supplier integration has a significantly positive effect on structure knowledge acquisition.

H1e: R and D and supplier integration has a significantly positive effect on process knowledge acquisition.

- **University-industry collaboration:** Achieving university-industry collaboration, enterprises aim to absorb external knowledge and apply them to innovation. Colleges and research institutes have senior experts and scholars which used as a "brain trust" for the enterprise to provide professional technical guidance. In that way it will help enterprises solve the problems in the new product development and help them to develop new products market. Monjon and Waelbroeck (2003) found that university acted as provider of new ideas for the enterprise or directly helped enterprises achieve the existing projects. University-industry collaboration plays a very important role in diffusing knowledge to industries and these knowledge is to adapt to the enterprise product development faced with the problem of market knowledge (function knowledge), the product technical problems (structure knowledge), quality problems, process knowledge (process knowledge). Therefore, this study put forward research hypothesis.

H1f: University-industry collaboration has a significantly positive impact on function knowledge acquisition.

H1g: University-industry collaboration has a significantly positive impact on structure knowledge acquisition.

H1h: University-industry collaboration has a significantly positive impact on process knowledge acquisition.

- **R and D and marketing integration:** Marketers learn more about the characteristics of the market than R and D engineers do. R and D and marketing integration helps research staffs obtain market knowledge (Wu and Wu, 2009) which is about customers and competitors. Customer knowledge is the customers' demand on products and it is their perception of the product properties (function knowledge) and composition (structure knowledge). Competitor knowledge is the properties of competitors' new products (function knowledge), the new technical knowledge they adopt (structure knowledge) and the new process (process knowledge). The knowledge will help R and D engineers discover innovative points on product properties and compositions. Therefore, this study puts forward research hypothesis.

H1i: R and D and marketing integration has a significantly positive effect on function knowledge acquisition.

H1j: R and D and marketing integration has a significantly positive effect on structure knowledge acquisition.

H1k: R and D and marketing integration has a significantly positive effect on process knowledge acquisition.

- **R and D and manufacturing integration:** Studies have found that R and D and manufacturing integration can help research staffs understand there will be some manufacturing problems during new products trial-production (process knowledge) (Twigg, 2002). The problems they meet before (structural knowledge and process knowledge) can help them improve the manufacturability of new products and avoid many design changes due to the restrictions of the manufacturing process in the late stage. The Product Design Philosophy of DFM (Design for Manufacturing) puts forward the idea that we should consider process issues when select technology and structure design to avoid failure in product trial-production later. Therefore, this study puts forward research hypothesis.

H1l: R and D and manufacturing integration has a significantly positive effect on structure knowledge acquisition.

H1m: R and D and manufacturing integration has a significantly positive effect on process knowledge acquisition.

Knowledge acquisition and new product development efficiency: New product development is an activity of knowledge innovation, including knowledge acquisition, integration and application (Gold *et al*., 2001). Its success depends on how new products meet customer demand. Function knowledge acquisition is the premise to meet customer demand. At the same time, enterprises have to face competition from rivals. What kind of technologies will competitors adopt? What cost will they meet customer requirements at? Without a clear answer to these questions, the subsequent design changes will be inevitable. This may force enterprises to obtain the structure knowledge and process knowledge. New product development needs to combine a variety of tacit knowledge to reduce the uncertainty and fuzziness which can help improve the efficiency of new product development. Therefore, this study puts forward research hypothesis.

H2a: Function knowledge acquisition has a significantly positive impact on new product development efficiency.

H2b: Structure knowledge acquisition has a significantly positive impact on new product development efficiency.

H2c: Process knowledge acquisition has a significantly positive impact on new product development efficiency. To sum up, the research framework of this study shows in Fig. 1.

RESEARCH DESIGN

Data collection: In order to guarantee the reliability and validity of the questionnaires, we have interviewed five companies, discussed with experts (three rounds) and did pilot test before the formal investigation. We conducted the formal investigation in Guangdong province and we distributed the questionnaire in three ways. First, teachers from our school's research center bring questionnaires with them and ask R and D supervisors to finish them face to face. We invite R and D managers or supervisors in manufacturing industry through some of students and friends to fill in the questionnaires. Third, we deliver questionnaires to R and D supervisors in part-time master class through engineering training center. Two hundred and seventy eight questionnaires were distributed and 172 questionnaires were received, for a response rate of 61.8%. One hundred and fifty eight questionnaires were

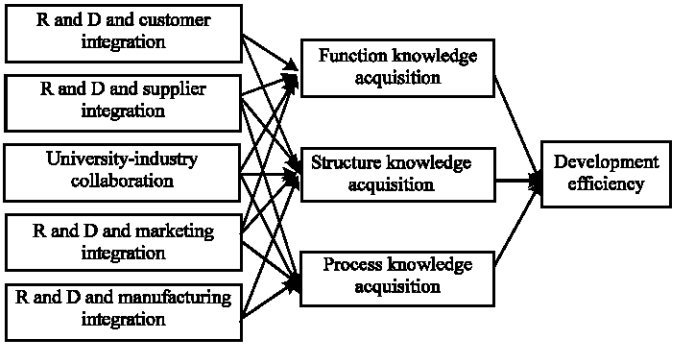

Fig. 1: Research framework of this study

Table 1: Distribution of the sample

Property	F-value	(%)	Industry	F-value	(%)	Age	F-value	(%)	Employees	F-value	(%)
State-owned	6	3.8	Food/drink	20	12.7	>5	23	14.6	<100	30	19.0
Private	79	50.0	Electronic	69	43.7	5-10	40	25.3	100-499	52	32.9
Overseas	27	17.1	Metal	29	18.4	10-15	51	32.3	500-999	16	10.1
Joint venture	12	7.6	Textiles	8	5.0	15-20	14	8.9	1000-4999	44	27.8
Others	34	21.5	Others	32	20.3	>20	30	19.0	above 500	16	10.1

Table 2: Results of model M2

Paths			Coefficient	T-value
R and D customer integration	→	Function knowledge acquisition	0.421	3.368**
R and D marketing integration	→	Function knowledge acquisition	0.481	3.382***
University-industry collaboration	→	Structure knowledge acquisition	0.313	2.96**
R and D manufacturing integration	→	Structure knowledge acquisition	0.382	3.072*
R and D and supplier integration	→	Structure knowledge acquisition	0.255	2.124
University-industry collaboration	→	Process knowledge acquisition	0.292	2.73*
R and D manufacturing integration	→	Process knowledge acquisition	0.439	3.273**
R and D and supplier integration	→	Process knowledge acquisition	0.359	2.7*
Function knowledge acquisition	→	Development efficiency	0.325	2.808*
Structure knowledge acquisition	→	Development efficiency	0.286	2.303**
Process knowledge acquisition	→	Development efficiency	0.624	4.36**

*p<0.05, **p<0.01, ***p<0.001

usable and the effective rate is 56.8%. Respondents generally are R and D director, middle managers or senior managers of the enterprise. We describe the characteristics of respondents in Table 1, including enterprise property, industry, enterprise age and number of employees.

Measurement: We adopted the measurement of cross-functional integration from Sherman's study when considering the independent variables (Sherman *et al*., 2000). And then we made some revisions according to specific activities when carrying out cross-functional integration. As to the measurement of knowledge acquisition, we adopted the questionnaire in Gold's study (Gold *et al*., 2001) and we also revised some items. We selected some items from Tseng's study to measure new product development efficiency (Tseng and Changhwa, 2006). These measurement items were selected after group discussion with experts and R and D directors in industries.

Reliability and validity: All of the items were measured by a 5-point Likert scale, ranging from 1 to 5. First, we performed a series of analyses to test the reliability and validity of the constructs. Then we tested the reliability of each construct by calculating its Cronbach's α. All of them exceeded 0.70. And then we calculated the composite reliabilities by Confirmatory Factor Analysis (CFA) and the results show that all the factor loadings are higher than 0.5 and most of them are higher than 0.7 ($p<0.001$). In addition, all the Average Variance Extracted (AVE) values were higher than 0.5. Therefore, all the constructs have high reliability and convergent validity.

RESULTS

We used AMOS7.0 software to do Structural Equation Model (SEM) analysis to test the research hypotheses in this study. We have 158 Samples which is conform to the minimum requirements (100-200).

First, we did SEM analysis on theoretical model M1. The initial model fitting results show that the Chi-square value is 546.208 (df 334). Moreover, the value of X2/df is 1.689 (less than 2), showing that the fitting of model is good. We presented the goodness of fit indices as follow: RMSEA = 0.094, RMR = 0.06, TLI = 0.913, CFI = 0.913 and GFI = 0.86. Therefore, the model is acceptable in general. Most of C.R. values corresponding with path coefficients in the initial structural equation model were higher than 1.96 ($p<0.05$). But the paths "R and D and customer integration to structure knowledge acquisition", "R and D and marketing integration to structure knowledge acquisition", "university-industry collaboration to function knowledge acquisition" and "R and D and supplier integration to function knowledge acquisition" were not significant. Their C.R. values were less than 1.96 ($p<0.05$). So they fails to meet the requirements (Fig. 2).

After testing the hypothesis model, we found that not all of the paths are significant, so we need to make some revision in the later analysis. We deleted some paths that were not significant in model M1 based on theory and practice, then we got a revised model M2. We tested model M2 by Structural Equation Model (SEM) analysis and the results are shown in Table 2. All the paths in model M2 are significant ($p<0.05$). The goodness of fit indices is acceptable. We used the nested model M2 to compare with model M1. Nested model method helps verify the advantages of each model by comparing

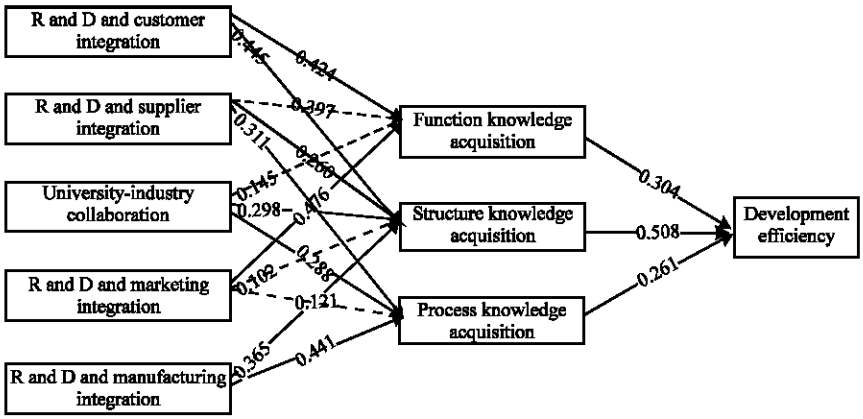

Fig. 2: Result of model M1

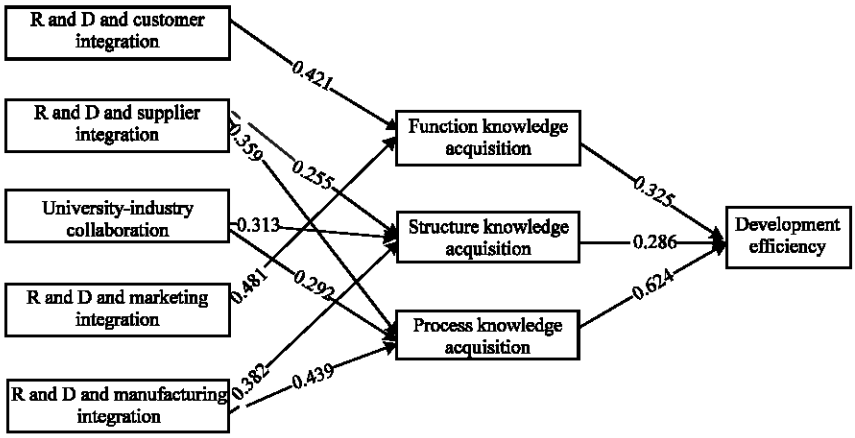

Fig.3: Results of model M2

Table 3:Fitting indices of model M1 and M2

Results	M1	M2
Chi-square value x2	564.208	565.669
Degree of freedom	334.000	339.000
x2/df	1.689	1.674
Goodness of fit index (GFI)	0.860	0.870
Adjusted goodness of fit indices AGFI)	0.810	0.810
Root mean square residual RMR)	0.060	0.070
Comparative fit index CFI)	0.935	0.936
Tucker-Lewis Index TLI)	0.913	0.917
Root mean square error of approximation (RMSEA)	0.094	0.093

Chi-square value of different models. The rule is to compare the two models' Chi-square values, to see if it has a significant difference. If there is a significant difference between them, the more complex model should be chosen (Yli-Renko *et al*., 2001). The fitting Chi-square value of model M2 is 565.669 (df 339), x2/df 1.674<2 (Table 3) which shows that the fitting is good and the C.R. values corresponding with path coefficient in model M2 are all higher than 1.96 (Table 2 and Fig. 3). In conclusion, the fitting of model M2 passed the test. The difference of Chi-square value between model M1 and M2 is not significant, so model M2 is the best model.

DISCUSSION

Based on the previous studies, combined with three kinds of knowledge needed in new product development, this study investigated the effects of five different cross-functional integration on knowledge acquisition in new product development and the effects of knowledge acquisition on the new product development efficiency. The majority of hypotheses are supported, indicating that cross-functional integration has a significant impact on knowledge acquisition and it also has a significant impact on new product development efficiency through knowledge acquisition. We can see from the model M2 that the relationships between five different cross-functional integrations and NPD efficiency are not

same. This study has made further analysis and discussion about the hypotheses not supported. We argue the reason why hypothesis H1b is not supported varied. The possible reason is the sample enterprises didn't get sufficient knowledge from customer when doing new product development project. Most of them mainly focus on product properties and long-term strategic cooperative relationship development. They fail to get the customers involved in new product development project. The enterprises in our country still need to actively explore how to involve customers in new product development, build a strategic partnership with important customers, acquire helpful knowledge form customers and finally enhance the efficiency of new product development. Hypothesis H1c that R and D supplier integration has a significant impact on function knowledge acquisition is not supported. It indicates the level of cooperation between investigated enterprises and suppliers is still instrumental innovation, not strategic cooperative partnership (Faems *et al*., 2005). Perhaps for confidentiality or other reasons, many enterprises still consider suppliers merely as the providers of raw materials, components, failing to establish technology roadmap with suppliers and seek development together. In addition, the possible reason is the enterprises stop the suppliers from participating in the enterprise product strategy long-term plan on account of benefits, only asking them to provide essential services. Hypothesis H1f that university-industry collaboration has a significant impact on function knowledge acquisition is not supported. The reasons may be the university-industry collaborations are mainly market-oriented new product development activities. This kind of collaboration is the enterprise's short-term cooperation behavior and it aims to solve the existing problems of enterprises (Monjon and Waelbroeck, 2003), not regard university-industry collaboration as an important initiative of their strategic development. Hypothesis H1J which is R and D and marketing integration has a significant impact on structure and process knowledge acquisition, is not supported. The reasons come from the marketers themselves. These marketers' judgment to the technologies is limited by the technical knowledge they owned which becomes the main obstacle to their knowledge sharing.

Through the above discussion, we can find that enterprises should pay attention to knowledge acquisition when they engage in new product development and build cross-functional teams. Acquisition and application of knowledge is the intrinsic motivation of cross-functional integration. When engaged in new product development, the knowledge needed to go beyond the knowledge stock of their own business or team members, we had to expand the organization or team external links to obtain external knowledge through cross-functional integration. Since the impact of different cross-functional integration on knowledge acquisition in new product development is not identical, we should pay attention to the matching between cross-functional integration and the knowledge needed in new product development and management. We also need to identify whether external or internal sources are able to provide the knowledge acquired. In order to enhance knowledge acquisition capacity, Chinese enterprises still need to explore how to develop strategic partnership with external organizations (customers, suppliers, universities and research institutes), as well as how to improve the knowledge acquisition capabilities of marketing staffs by enhancing their technical knowledge. Only in this way, Chinese enterprises can promote their innovation capability and finally enhance new product development efficiency.

Limitations and future directions: Cross-functional integration, knowledge acquisition, new product development are three areas covering a very broad content. Due to various objective and subjective reasons, there are still a lot of limitations in this study. First, in terms of samples, due to the difficulty of survey, research scale and resource constraints, coupled with the enthusiasm of Chinese enterprises to participate in academic research is not high, we did not do a larger survey in this study. Second, we did not let scale, industry, enterprise property, number and other control variables included in the research. Although Blindenbach and Ende (2006) point out that it is difficult to find there were significant differences in size, industry and ownership among different companies, in terms of knowledge acquisition, these factors may cause the effects of cross-functional integration on alternative knowledge acquisition vary. Due to the limitation of the number of effective data, this study did not do further analysis to explore these problems. Third, enterprises are limited to the Pearl River delta region. Because of China's vast territory and the regional imbalance on economic development, cross-functional integration in new product development may be varied. These questions still need to be further studied in future.

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