Improving NPD Performance with Supplier Involvement: An Endogenous Path

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Abstract: The importance of supplier involvement in New Product Development (NPD) has been emphasized. Suppliers can help makers adopt new technologies and improve the NPD performance in cost, quality, delivery, etc. On the other hand, makers may benefit from an independent relationship with suppliers. These two kinds of view suggest different operational processes for the supplier involvement in NPD. A path model among the supplier partnerships, NPD performance, internal capabilities in R&D, manufacturing, and market was built and examined empirically. The customer partnership was examined as a comparison. A survey was conducted with a questionnaire in 156 manufacturing enterprises. The methods of factor analysis and Structure Equation Modeling were adopted for data analysis. The results showed that, although an intermediary role of internal capabilities including R&D, manufacturing, and marketing, is necessary for the impact of the supplier partnerships on NPD, it is not necessary for the customer relationships. The results were discussed from the view of endogenous growth view, which suggests that without the support of internal capabilities, it would be difficult to improve NPD performance with the supplier partnerships. Some suggestions were provided on how to improve the endogenous growth capability with the help of the supplier involvement.

Key Words: New product development; Internal capability; Supplier partnerships; Endogenous growth; Empirical study

1. Introduction

New Product Development (NPD) can be defined as the process by which an enterprise increases the value of its products by combining its capabilities, resources and knowledge to change its products (He, 2014). It is one of the critical processes by which companies sustain or even increase their competitive advantage (Tessarolo, 2007). With the development of technology and the globalization of the market, NPD has become a hot spot for industry competition (Um, 2013). Numbers of approaches can be found on how to improve NPD performance based on the internal capabilities in R&D, manufacturing, marketing, etc. and the external partnerships with suppliers and customers (Su et al., 2009). For example, the support of manufacturing capabilities can avoid the non-realistic idea; the customer participation is an important motivation for NPD; and the support of suppliers can provide the advanced technologies in NPD (Li et al., 2012; Vanpoucke et al., 2014, 2017). In the above impacting factors, the supplier relationship is playing a more and more important role with the development of international division of labor. More fabrication factories have been moved to the low labor cost areas, due to the advanced countries started to concerned on the high value-added components. Much profit of the finished products has been accounted to the providers of the key components. For example, 70-80% of the total cost of one PC is the component procurement cost (Nikkei Business, Sep 10, 2013).

In previous studies, the necessary of the supplier involvement in NPD has been examined through different view, i.e. signaling theory, agency-related costs, social exchange theory, contingency perspective, organizational dependence view, real option, game theoretical, Resource Based View (RBV), etc. Moreover, the complementary nature between the internal capabilities and the external partnerships in product innovativeness can be explained through different perspectives (Su et al., 2009; Chesbrough, 2003; Zaheer and Bell, 2005; Galoghirou et al., 2004), i.e., the exploitation of existing capabilities and the exploration of new possibilities captures in firm behaviors (March, 1991), the strategic theory of the firm on coordinating complementary assets and activities (Stieglitz and Heine, 2007), the combinative capability perspective (Kogut and Zander, 1992), and the architectural competence perspective (Henderson and Cockburn, 1994), etc. However, few studies examined the role of internal capabilities in the supplier involvement in NPD from the perspective of endogenous growth. On the basis of previous studies about suppliers involvement in NPD, this paper also considered the internal factors that affecting NPD. Through a questionnaire survey of 156 manufacturing enterprises, combined with factor analysis and Structure Equation Modeling, the specific variables were stud-
ied, and the research results are applicable.

The following sections are organized as follows. Section 2 reviewed the previous studies about NPD, and the hypotheses were proposed on their relationships with internal capabilities, supplier partnerships and customer relationships. Section 3 introduced the research methods and data analysis. Section 4 discussed the data analysis results and made a conclusion.

2. Literature review and hypotheses

2.1 NPD and influence factors

The role of supplier involvement in NPD may be impacted by different factors, i.e., technology items (technology information sharing degree, level of technical difficulty, knowledge of suppliers), NPD stages (earlier stages in NPD projects or other stages), market turbulence degree, product characteristics (complexity, criticality, and innovativeness), buyers’ and suppliers’ behavior (trust, satisfaction, and commitment, equilibrium behaviors, absorptive capacity), etc. Among these factors, the role of the internal capabilities has not been fully examined. A direct effect of the supplier involvement on NPD can be found (Koufteros et al., 2005; Petersen et al., 2005; Flynn et al., 2010; Ragatz, 2002; Primo, 2002); and an indirect effect of supplier involvement on NPD through the internal capabilities may also be suggested. Among three typical kinds of internal capabilities, R&D has similar contents as NPD, but there are differences between them. NPD is a concrete manifestation of a company’s core capabilities, such as a corporate goal pursued by multiple departments, i.e., manufacturing, marketing, rather than a function of the knowledge in R&D departments. Few studies have been found on the relationships between NPD and other internal capabilities in manufacturing and marketing. In this study, the relationships among all kinds of internal capabilities, the supplier involvement, and NPD performance were examined. As a comparison, both the supplier relationship and the customer relationship, which can be called as the external partnerships, were examined to improve the NPD performance as suggested by some studies (Lutjen et al., 2017; Xu et al., 2016; Li et al., 2019).

NPD can be affected by many factors. As summarized in Table 2, over 11 factors have been found, i.e., corporate strategy (F1), organizational structure (F2), R&D capability (F3), manufacturing capability (F4), marketing capability (F5), corporate culture (F6), human resource management (F7), upstream suppliers (F8), downstream customers (F9), horizontal competitors (F10), universities and research institutes (F11), etc. According to their locations in or out bound of firms, there factors may be divided into two types, i.e., 1) the internal capabilities in strategy and organization (F1, F2), R&D capability (F3), manufacturing capability (F4), marketing capability (F5), corporate culture (F6), etc.; 2) the external partnerships with suppliers (F8), customers (F9), technology cooperators (F11), competitors (F10), etc. As shown in Table 2, three factors in the internal capabilities, i.e., F3, F4, F5, and two factors in the external partnerships, i.e., F8, F9 have been mostly suggested in the literature. These five factors are introduced as follows.

1) R&D capabilities

The R&D capabilities are necessary in generating new scientific discoveries or technological breakthroughs and designing new products. The R&D capabilities may be reflected through high patient quantities, more R&D employees with high qualifications, better infrastructure in labs, etc. The R&D capabilities can provide technologies and guarantees for the realization of NPD. R&D capability can help enterprises to better absorb prior capability knowledge and technologies to carry out new products (Eisenhardt and Martin, 2000; Cohen and Levinthal, 1990).

2) Manufacturing capabilities

Manufacturing capabilities can be defined “as the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments” (Teece, 2014; Leuschner et al., 2013; Liu et al., 2017). Manufacturing capabilities need integrating a large number of specific skills relating to component manufacturing, production scheduling, assembly processes, quality control procedures, and inventory control mechanism (Grant, 1995). It can be measured by to which extent an organization can achieve specific production goals (Hallgren and Ollaghe, 2006), or by dynamic operations (Chavez et al., 2017). Therefore, a high level of manufacturing capability is the basis of providing various products by manufacturing enterprises.

3) Marketing capabilities

Marketing capabilities are the complex bundles of knowledge, skills, and routines that enable companies to make use of marketing-related resources to carry out marketing tasks and adaptation to marketplace changes (Day, 1994). Marketing capabilities can be measured by the indicators, such as development profitability of new products, the commercial value of new products, etc. (Weerawardena, 2003). Similar as R&D capabilities, the marketing capabilities are the core value creation capabilities (O’Cass and Ngo, 2012). Marketing capabilities are vital pre-variable for enterprises to carry out innovations (Chang et al., 2016). It can help enterprises to find and take advantages of market opportunities (Atuahene-Gima and Evangelista, 2000). Through grasping market opportunities, it is more conducive for enterprises to focus on developing new products with good market prospects.

Based on literature review and case studies, the internal capability (IC) includes three indicators, i.e. R&D capability (RD), Manufacturing Capability (MF), Marketing Capability (MK). Each indicator was surveyed with 4 questions as shown in the appendix.

4) Supplier partnership

Supplier partnerships are important for the product innovativeness (Li et al., 2012; Tseng, 2014; Whipple et al., 2015). Usually, one firm cannot finish all operations by itself, and have to purchase some components and get supports from the suppliers to integrate the components. Some companies have a department called “R&D procurement” for the integration of suppliers and R&D, i.e., Toshiba. The reason why suppliers’ involvement in NPD is necessary is that it can bring many unexpected ben-
benefits to enterprises (Johnsen et al., 2006; Jassawalla and Sushittal, 2010). The partnerships with suppliers may provide a reasonable foundation for the product innovativeness in manufacturers in the component procurement and guarantee, component technology update, etc. (Vargo and Lusch, 2004). It is the avenue through which makers and suppliers can seek competitive advantage in the marketplace and tapping into each other’s resources as a result of the formation of alliances (Li and Kuo, 2016; Lao et al., 2010). For example, the high-quality partners have more advanced technologies and production capabilities to support the product innovativeness in manufacturers (Baum et al., 2000; Terwiesch and Cachon, 2012).

5) Customer partnership

Customer partnership management refers to the maintenance and development of long-term customer relationships by adopting customer information systems and understanding customer needs (Campbell, 2003). Customers can strengthen their relationships with manufacturers by taking part in NPD. For example, the customers can work as the inspiration providers in the earlier stages of NPD, and as the market promoters in the later stage to help launch new products (Bettencourt and Dorr, 1997; Ritter and Walter, 2003). There are certain risks to promote new products into market (Carbonell et al., 2010). Having a good customer relationships and involving customers in NPD can help to avoid the potential risks to some extent.

Based on literature review and case studies, the External Partnership (EP) was measured with two indicators, i.e., Supplier Partnership (SP) and Customer Partnership (CP). Each indicator was surveyed with 4 questions as shown in the appendix. For example, the qualitative indicators were generated for measuring the NPD capabilities based on literature review (Yan et al., 2012; Sheng et al., 2013; Cohen et al., 1996; Cooper et al., 1994): 1) the speed of NPD comparing with the NPD project schedule (NPD1); 2) the performance of NPD on bringing profit from market (NPD2); 3) the new product value for customers with solving the customer’s problems with high quality (NPD3). In details, these indicators can be surveyed with some questions as shown in appendix.

| Factors                | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 |
|-----------------------|----|----|----|----|----|----|----|----|----|-----|-----|
| Davis, 1983           |    |    |    |    | Y  | Y  |    | Y  | Y  |     |     |
| Karimi et al., 1996   | Y  | Y  | Y  | Y  |    |    |    |    |    |     |     |
| Pierrce, 1998         |    |    | Y  | Y  |    |    |    |    |    |     |     |
| Danneels, 2002        | Y  | Y  | Y  | Y  |    |    |    |    |    |     |     |
| Ritter and Walter, 2003| Y  | Y  | Y  | Y  |    |    |    |    |    |     |     |
| Homburg et al., 2003  | Y  | Y  | Y  | Y  |    |    |    |    |    |     |     |
| Johnsen et al., 2006  | Y  | Y  |    |    |    |    |    |    |    |     |     |
| Su et al., 2009       | Y  | Y  | Y  | Y  | Y  | Y  | Y  | Y  | Y  |     |     |
| Tseng, 2014           | Y  | Y  | Y  | Y  |    |    |    |    |    |     |     |
| Whipple et al., 2015  | Y  | Y  | Y  | Y  |    |    |    |    |    |     |     |
| Li et al., 2019       | Y  | Y  | Y  | Y  |    |    |    |    |    |     |     |

2.3 Interactive relationships between supplier involvement and internal capabilities

There is an interactive relationship between the internal capabilities and the supplier involvement. With the stronger internal capability, an enterprise can have higher level of attracting suppliers and customers (Burger and Cann, 1995; Frambach et al., 1997; Walter and Hans, 2000). The external partnerships with suppliers and customers are important for improving the internal capabilities on R& D, manufacturing, and marketing (He et al., 2010; Schoenherr et al., 2012). The importance of the supplier partnerships in manufacturing and the importance of the customer partnership in marketing have been widely realized by most enterprise (Zimmermann and Foerstl, 2014; Su et al., 2009). The suppliers’ support is also necessary in R& D capability improvement. The suppliers can provide not only the materials and equipment (Vanpoucke et al., 2014; 2017), but also the previous knowledge and technocracy to create new products (Flor et al., 2018; An et al., 2014). As a comparison to the supplier
involvement in NPD, the customer partnership in NPD was adopted in this study. Customers are the motivation and the idea source of R&D capabilities. The personalized demands of customers are the original motivation of mass customization. With more customer participation, the performance improvement of NPD has become an inevitable choice for enterprises to implement the “customer-centered” strategy. According to Knowledge Based View (KBV), the significance of the customer participation in NPD lies in the integration of customer knowledge and enterprise knowledge to further improve the performance of NPD. The degree of integration determines the performance of NPD (Zhang and Cao, 2018).

The importance of supplier involvement in NPD can be explained with several different views. From the view of knowledge management, the increased knowledge of a supplier is more likely to result in greater information sharing and involvement of the supplier in the product development process (Petersen et al., 2005). From the view of contingent theory and the organizational dependence, the supplier involvement in NPD is not always successful (Yan and Nair, 2016). The level of supplier involvement on the NPD project can be seen as contingent on the level of technical difficulty of the NPD project (Mprimo and Damundson, 2002). The supplier involvement has an inverted U-shaped relationship with product innovativeness (Cheng and Krumwiede, 2018). From the view of agent-cost, the requirement to transfer information from its point of origin, such as suppliers, to a specified problem-solving site, such as makers, will significantly affect the locus of problem-solving activity when that information was shifted costly (Hippl, 1998). In addition, some other relative point of views can also be found to support the topic, i.e., the endogenous growth view, signaling theory, real option, game theory, etc. However, the influential mechanism of supplier integration in NPD is still basically a “black box”, and more researches are needed to identify and examine how supplier integration affects NPD performance (He, et al., 2014). The reason why endogenous growth was emphasised in this study is due to its close relationships with the innovation spillovers in supply chain and the operational process in strategic planning.

Organizations can no longer solely rely on their own resources to innovate. Therefore, they need to look for strategic interactions outside their organizational boundaries (Sjoerdisma and van Weele, 2015). During the innovation spillover in supply chain, a firm can learn from the internal capabilities may have closer relationships with the external partnerships, i.e., the partnerships with customers (CP) and the partnerships with suppliers (SP).

### 2.4 Paths models for improving NPD performance

There are two path models among NPD, internal capabilities, and external partnerships, i.e. a parallel model and a sequential model. The internal capabilities include three types of capabilities, i.e., R&D capabilities (RD), manufacturing capabilities (MF), and marketing capabilities (MK). The external partnerships include two types of partnerships, i.e., the partnerships with customers (CP) and the partnerships with suppliers (SP).

1) A parallel path model on improving NPD

A parallel relationship suggests that both of the internal capabilities and the external partnerships can affect the NPD directly and can work concurrently to improve NPD. Lots of studies suggest that both internal capabilities and openness towards external knowledge sharing can drive the innovation performance (Galoghirou et al., 2004; Zaheer and Bell, 2005; Lee et al., 2001). Therefore, a hypothesis can be proposed as follows:

**Hypothesis 1:** Both the internal capabilities and the supplier partnerships have direct impact on NPD and can work concurrently.

2) A sequential path model on improving NPD

A sequential relationship suggests that the external partnerships may not affect the NPD directly and the internal capabilities may play a mediate role between them. For example, Su et al. (2009) suggest that the internal capabilities can serve as a foundation for identifying and exploring external opportunities from partnerships. In addition, the internal capabilities may have closer relationships with NPD than the external partnerships. A hypothesis can be proposed as follows:

**Hypothesis 2:** The supplier partnerships have not direct impact on NPD, and the internal capabilities mediate the relationships between them.

In order to test the hypotheses on NPD, a path model was founded as the following figure. There are three paths
in the model, i.e., a path between external partnerships and NPD, a path between internal capabilities and NPD, and a path between internal capabilities and external partnerships.

3. Methodology and data analysis

3.1 Sampling and data collection

A survey was conducted with a questionnaire. The Likert scale was adopted for the answer choices to each question. During the period from March to September 2018, the questionnaire was initially launched and collected mainly in several provinces in China, i.e., Sichuan, Chongqing, Shanxi, Shandong, Guangdong, Shanghai, Jiangsu, etc. The main reason for selecting these provinces is that these regions have relatively high industrialization level and more application of service-oriented manufacturing. Multiple approaches were adopted for the survey, i.e., enterprise interview, mail distribution, and E-mail distribution. 300 enterprises joined the survey. A total of 232 questionnaires were fulfilled. After eliminating the invalid questionnaires with missed answers, 156 valid questionnaires were obtained for the following analysis. The average value of the item in all samples.

The survey encompassed a wide range of industries. There is little difference in the distribution of industries. The description of the firms in samples can be found in Table 2. 39% firms have employee number over than 1000; and 39% firms have employee quantity between 100 and 1000. The persons fulfilling the questionnaires include senior managers (20%), middle managers (70%), and grass-roots managers (10%). All responders have the working experience over than 3 years. It is possible to regard them with adequate knowledge concerning the product innovations of their organizations.

3.2 Measurement validation

The indicators of NPD, R& D capability (RD), Manufacturing Capability (MF), Marketing Capability (MK), Supplier Partnership (SP) and Customer Partnership (CP) are generated based on literature review. There are three steps in data analysis. At first, Exploratory Factor Analysis (EFA) was adopted to analyze the measurement scales on each variable. Then, Confirmatory Factor Analysis (CFA) was adopted for analysis the measurement scales for all variables. At last, Structure Equation Modelling (SEM) was adopted for testing the proposed frameworks. Principal component analysis method was selected in factor analysis. KMO (Kaiser-Meyer-Olkin) was used for examining the sampling adequacy. SPSS 25.0 was used for data analysis.

The KMO value is examined for the factor analysis. If an item has the loading value less than 0.5, it can be eliminated. The comprehensive reliability (CR) and Cronbach’s alpha value of all measurement variables need exceed the 0.7 thresholds. It indicates that the reliability of the scale was sufficient, and the scale could fully represent its respective constructs (Bagozzi and Yi, 1989). The factor loading of all items need to be higher than 0.5, indicating that the questions under each item can convey the same information. Evaluate the validity of the convergence by checking the AVE value. AVE values need exceed 0.5, indicating that the scale captures a large amount of variance (Hair et al., 2010).

1) Test of measure scales of NPD

The results of factor analysis on the measurement scales of NPD were shown in Table 3. It can be found that KMO (0.896) supporting factor analysis, and three factors shared by the 12 measurement questions can be summarized as NPD1, NPD2, and NPD3.

Table 3 Measurement scales of NPD. (Factors loading above 0.50; KMO=0.896)

2) Confirmatory factor analysis (CFA)

The indicators of all variables were examined with confirmatory factor analysis. The results can be shown in Table 4. The results show that 6 variables can be generated from the factor analysis, i.e., on NPD, RD, MF, MK, SP, and CP.

Average variance extracted (AVE) = \( \sum (\text{standardized loading})^2 / (\sum (\text{standardized loading})^2 + \sum \epsilon) \). Composite Reliability (CR) = \( (\sum \text{standardized loading})^2 / (\sum \text{standardized loading})^2 + \sum \epsilon \).

The correlation relationships among six variables were shown in Table 5. The results show that there are strong positive correlation relationships between every two variables.

3) Reliability and validity

This study adopted the clone Bach reliability coefficient (Cronbach’s alpha) and reliability (CR) of the portfolio value to detect the internal consistency of the measure scales for each variable, including NPD, RD, MF, MK, SP, and CP. The NPD Cronbach’s alpha value is 0.861, other constructs Cronbach’s alpha value is above 0.85. All of the CR value is greater than 0.8. The data shows a good internal reliability and internal consistency for each variable. In addition, each item meets the standard of AVE more than 0.50. This indicates that the convergent validity of the scale can be accepted. Finally, the AVE square root of each construct in the model should be greater than the absolute value of the correlation coefficient of its row and column to test the validity. The results are can be satisfied as shown in Table 9. The results indicate that the scale has a good discriminant validity.

3.3 Data analysis results

In order to examine the relationships among NPD, internal capabilities, and external partnerships, two structural equation models were developed with AMOS 22.0 based on the proposed hypotheses. The model can be evaluated with the following indicators: 1) the degree of freedom (DF) represents the difference between independent statistics and parameters of the fitting model. 2) the likelihood ratio test (LRT) statistics are minimized, usually interpreted as ?2 variable. The probability level of ?2 test should be higher than the 5% level. Model fitting index is a statistical index to investigate the degree of fitting of theoretical structure model to data: 3) goodness of fit index (GFI), 4) adjusted goodness of fit index (ACFI) and 5) comparative fit index (CFI). Reorder the degree of fitting between the observed value and the expected value.
The fitting of GFI, AGFI, and CFI values between 0.80 and 0.89 is better while values above 0.90 represent a very good fit. 6) root mean square error of approximate (RMSEA) is a measure of the overall deviation adjusted for DF to test the model. The value of RMSEA is 0.08 or less, indicating a reasonable error of approximation. On the basis of the above models, NPD’s relationships with three types of internal capabilities were studied, as well as its relations with two types of external partnerships. Totally, 6 models were built with referring to the former model. 6 models have good performance in the evaluation indicators, i.e., GFI, AGFI, CFI, and RMSEA. The path coefficients and the significant level in each model were shown in Table 6.

The results of six models on NPD show that: 1) The supplier partnerships have no direct influences on NPD; 2) Customer partnerships have direct influences on NPD; 3) Three types of internal capabilities have direct influences on NPD. Therefore, Hypothesis 1 cannot be supported, and hypothesis 2 can be supported.

4. Discussion

The data analysis results showed that the supplier partnerships can impact the NPD performance, but cannot
Table 4 Confirmatory factor analysis (Factors loadings above 0.50; KMO=0.881)

| Variable | Measurement scales | Factor loading | Cronbach’s α | AVE | CR |
|----------|--------------------|----------------|--------------|-----|----|
| NPD      |                    |                |              |     |    |
| NPD1     |                    | 0.579          | 0.861        | 0.514 | 0.756 |
| NPD2     |                    | 0.829          |              |     |    |
| NPD3     |                    | 0.721          |              |     |    |
| RD       |                    |                | 0.921        | 0.634 | 0.874 |
| RD1      |                    | 0.787          |              |     |    |
| RD2      |                    | 0.785          |              |     |    |
| RD3      |                    | 0.792          |              |     |    |
| RD4      |                    | 0.741          |              |     |    |
| MF       |                    |                | 0.893        | 0.532 | 0.816 |
| MF1      |                    | 0.564          |              |     |    |
| MF2      |                    | 0.862          |              |     |    |
| MF3      |                    | 0.765          |              |     |    |
| MF4      |                    | 0.787          |              |     |    |
| MK       |                    |                | 0.88         | 0.482 | 0.788 |
| MK1      |                    | 0.636          |              |     |    |
| MK2      |                    | 0.712          |              |     |    |
| MK3      |                    | 0.688          |              |     |    |
| MK4      |                    | 0.713          |              |     |    |
| SP       |                    |                | 0.934        | 0.714 | 0.908 |
| SP1      |                    | 0.897          |              |     |    |
| SP2      |                    | 0.898          |              |     |    |
| SP3      |                    | 0.833          |              |     |    |
| SP4      |                    | 0.782          |              |     |    |
| CP       |                    |                | 0.935        | 0.638 | 0.875 |
| CP1      |                    | 0.774          |              |     |    |
| CP2      |                    | 0.806          |              |     |    |
| CP3      |                    | 0.811          |              |     |    |
| CP4      |                    | 0.797          |              |     |    |

Table 5 Correlation of various influencing factors and NPD.

| Variable | 1 NPD  | 3 RD   | 4 MF   | 5 MK   | 6 SP   | 7 CP   |
|----------|-------|-------|-------|-------|-------|-------|
| 1 NPD    | 1.00  |       |       |       |       |       |
| 3 R& D capability | 0.570** | 1.00  |       |       |       |       |
| 4 Manufacturing capability | 0.484** | 0.600** | 1.00  |       |       |       |
| 5 Marketing capability | 0.544** | 0.682** | 0.639** | 1.00  |       |       |
| 6 Supplier partnership | 0.231** | 0.304** | 0.348** | 0.309** | 1.00  |       |
| 7 Customer partnership | 0.455** | 0.422** | 0.426** | 0.426** | 0.613** | 1.00  |
| Mean     | 3.54  | 3.82  | 3.42  | 3.71  | 4.03  | 4.14  |
| SD       | 0.582 | 0.753 | 0.918 | 0.789 | 0.785 | 0.653 |

Table 6 The combination of capabilities and partnerships

| Model (SP) | Path | Coefficient | Model (CP) | Path | Coefficient |
|------------|------|-------------|------------|------|-------------|
| RD,SP,NPD  | RD → NPD | 0.45*** (t=7.117) | RD,CP, PD  | CP → RD | 0.49*** (t=5.789) |
|            | SP → RD  | 0.29*** (t=3.969) |            | CP → NPD | 0.37*** (t=4.918) |
|            | SP → NPD | 0.07 (t=1.277)   |            | CP → NPD | 0.38*** (t=4.332) |
| MF,SP,NPD  | MF → NPD | 0.28*** (t=5.261) | MF,CP,NPD   | CP → MF | 0.55*** (t=5.347) |
|            | SP → MF  | 0.41*** (t=4.617) |            | CP → NPD | 0.32*** (t=4.462) |
|            | SP → NPD | 0.08 (t=1.287)   |            | CP → NPD | 0.32*** (t=4.462) |
| MK,SP,NPD  | MK → NPD | 0.43*** (t=6.54)  | MK,CP, PD   | CP → MK | 0.52*** (t=5.869) |
|            | SP → MK  | 0.31*** (t=4.048) |            | CP → NPD | 0.28*** (t=3.956) |
|            | SP → NPD | 0.07 (t=1.256)   |            | CP → NPD | 0.28*** (t=3.956) |

***, p < 0.001

directly improve it. The impacts can be mediated by the internal capabilities, and each of three kinds of internal capabilities can avoid the mediation role. The R& D capability may have a higher efficiency in the mediation affection than the manufacturing capability and the market capability. As a comparison, the customer relationship can directly promote the NPD performance, and can also promote it through the mediation of three kinds of internal capabilities.

Different from the customer relationships, the supplier partnerships cannot influence NPD performance directly. This result may be partly different from the suggestions on the importance of the supplier involvement in NPD (Johnsen et al., 2006; Jassawalla and Sashittal, 2010; Li et al., 2012; Tseng, 2014; Whipple et al., 2015). One reason may be that few existing studies have considered both the internal capabilities and the external capabilities together. The supplier partnerships have a significant positive relationship with NPD (t=0.231, p<0.05) as shown in Table 6. However, when working with the internal capabilities, the influence of the supplier partnerships could be not significant. On the other hand, the importance of makers in supply chain should be further emphasized. Without manufacturing function, the innovation in suppliers may not be transformed to customers. For example, because of the shortage in manufacturing function, lots
of original innovations in components in U.S. cannot be commercialized (Bonvillian et al., 2019). The results can also partly explain why the developed countries have been calling back factories from oversea.

5. Conclusion

The results supported the interactive relationships between the internal capabilities and the supplier involvement when improving the NPD performance (Teece et al., 1997; Um et al., 2017; Karniouchina et al., 2010). In addition, the mediation role of the internal capabilities suggests that makers should not depend on the suppliers’ innovation during improving its NPD performance. Maker need try to improve the internal capability through different interactive approaches with outside partners including suppliers, i.e., collaboration, knowledge transfers, or mentoring (Serpa and Krishnan, 2018). From the view of the endogenous growth capability, the endogeneity is the decisive factor to promote technological progress and economic growth. Two prerequisites are needed in the endogenous growth model, i.e., the heterogeneity of knowledge and the absorptive capacity of knowledge (Pan and Shi, 2001). This idea suggest that in order to improve NPD performance, it is necessary to improve the internal capabilities so as to make use of the support from suppliers.

The relationships among NPD, internal capabilities, and supplier partnerships in manufacturing enterprises were examined. Theoretically, different form the previous researches on suppliers’ participation in NPD, the relationships among these sides are relaborated from the new research perspective – endogenous growth theory perspective. In order to prove this point of view, 156 questionnaire surveys were conducted among manufacturing enterprises. The results of data analysis show that the internal capabilities have direct effect on NPD, and the supplier partnerships need relay on the mediate function of internal capabilities to impact the NPD performance. However, the present study does not consider that the type of supplier or other external factors will have different effects on this conclusion, i.e., the innovative suppliers or the functional suppliers; the national suppliers or the oversea suppliers. In future studies, the types of suppliers may be examined as a control variable in the SEM model.

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Appendix

A. Questionnaire

1. The following is a review of your NPD. Please indicate how much you agree with them
   (1- totally disapprove; 2- disapprove; 3 - general; 4 - in favor of; 5- totally agree).

| A. Speed of NPD (NPD1) |
|------------------------|
| NPD1: Our company is developing new products far ahead of the project schedule | 1 2 3 4 5 |
| NPD2: Our company is developing new products much faster than the industry average | 1 2 3 4 5 |
| NPD3: Our company is developing new products much faster than expected | 1 2 3 4 5 |
| NPD4: Our company develops new products much faster than our regular products | 1 2 3 4 5 |

| B. Performance of NPD (NPD2) |
|-----------------------------|
| NPD21: On the whole, our company’s NPD is successful | 1 2 3 4 5 |
| NPD22: The new product has effectively increased our company’s market power | 1 2 3 4 5 |
| NPD23: The new product brought the company considerable profits | 1 2 3 4 5 |
| NPD24: On the whole, our customers are satisfied with the new products | 1 2 3 4 5 |

| C. Customer value of NPD (NPD3) |
|--------------------------------|
| NPD31: Our company’s newly developed products are of higher quality | 1 2 3 4 5 |
| NPD32: Our company’s newly developed products solved the customer’s problem | 1 2 3 4 5 |
| NPD33: Our company’s newly developed products have saved customers a lot of costs | 1 2 3 4 5 |
| NPD34: Our company’s newly developed products help simplify the customer’s use process | 1 2 3 4 5 |

2. The following is a review of the internal capabilities of your company. Please indicate how much you approve of them.
   (1- totally disapprove; 2- disapprove;3 - general; 4 - in favor of; 5- totally agree)

| D. R& D capability (RD) |
|-------------------------|
| RD1: We have a better level of products/services development than our competitors | 1 2 3 4 5 |
| RD2: We have a better ability to continuously develop new products/services capability than our competitors | 1 2 3 4 5 |
| RD3: We have the ability to commercialize new products/services faster than our competitors | 1 2 3 4 5 |
| RD4: We offer more unique products/services features than our competitors | 1 2 3 4 5 |

| E. Manufacturing capability (MF) |
|---------------------------------|
| MF1: We are more flexible in responding to capability changes than our competitors | 1 2 3 4 5 |
| MF2: We have lower mass production costs than our competitors | 1 2 3 4 5 |
| MF3: We have a more efficient production system than our competitors | 1 2 3 4 5 |
| MF4: We have lower operating costs than our competitors | 1 2 3 4 5 |

| F. Marketing capability (MK) |
|-------------------------------|
| MK1: We have a more efficient distribution channel than our competitors | 1 2 3 4 5 |
| MK2: We have better marketing capability than our competitors | 1 2 3 4 5 |
| MK3: We have a better reputation for customer service and product support than our competitors | 1 2 3 4 5 |
| MK4: We care more about our customers than our competitors | 1 2 3 4 5 |

3. Below is a review of the partnerships with suppliers and customers, please indicate how much you approve of them.
   (1- totally disapprove; 2- disapprove; 3 - general; 4 - in favor of; 5- totally agree)

| A. Supplier partnership (SP) |
|------------------------------|
| SP1: Our company has the ability to establish long-term relationship with suppliers in the supply chain | 1 2 3 4 5 |
| SP2: In the supply chain, our company has the ability to maintain close relationship with some suppliers | 1 2 3 4 5 |
| SP3: Our company focuses on suppliers to improve the quality of supply chain | 1 2 3 4 5 |
| SP4: In the supply chain, our company forms partnerships with suppliers through information sharing | 1 2 3 4 5 |

| B. Customer partnership (CP) |
|------------------------------|
| CP1: In the supply chain, our company takes customer satisfaction as the center to carry out related activities | 1 2 3 4 5 |
| CP2: In the supply chain, our company communicates a positive message to customers | 1 2 3 4 5 |
| CP3: Our company can effectively manage customer relations, in the service before and after sales to make customers a good impression | 1 2 3 4 5 |
| CP4: Our company is able to establish good customer relations, so as to improve customer brand loyalty | 1 2 3 4 5 |