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The Role of Absorptive Capacity between External Knowledge Search and Firm's Product Innovation Performance

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Abstract:
External knowledge search is crucial for firm's product innovation performance (PIP). However, it is still not clear, what dimensions of firms' external knowledge search strategy are crucial in determining their product innovation success, and how firms are exploiting the external knowledge from their external knowledge search activities. This study examines the effect of two different external knowledge search strategies-collaboration breadth and collaboration depth on PIP by proposing multidimensional absorptive capacity as the mediating variable in between these relationship. Empirical result in a sample of 137 Malaysian manufacturing firms found that absorptive capacity is partially mediated between collaboration depth and PIP. The findings provide insight that absorptive capacity could explain interfirm differences in benefiting from external knowledge search. This study advances extant literature by explaining the way of a firm in attaining superior PIP from external search strategies and absorptive capacity and provide insights for managers in developing suitable strategies to gain and sustain competitive advantages. As firms improve in its PIP, it could move up the value chain of a country, and encourage better economic development of the nation.

Keywords: Managers, manufacturing sector, external knowledge search, absorptive capacity,product innovation performance

1. Introduction

Malaysia facing challenges to achieve sustainable high growth economy based on labour-intensive manufacturing activities. Globalisation and disruptive impacts from fast technology development eroded comparative advantages in these activities. As the trend continues, to sustain competitive advantages, manufacturing sector should focus on the knowledge production factor rather than emphasising on capital and labour as key factors of development. The ability to innovate in creating new products is the key for sustainable competitive advantages for firms.

Product innovation requires the combination of a broad set of heterogeneous competencies and knowledge because the development of new product involves multidisciplinary of knowledge (Ardito & Petruzzelli, 2017). A firm may not master all types of knowledge due to firm's nature of bounded rationality and limited internal information processing (Simon, 1991). As a result, firm's open access to external sources exposed greater opportunities for firms to access the various knowledge sources that they are unable to master (Chesbrough, 2003; West & Bogers, 2014). The access to external knowledge enhanced new knowledge creation by leveraging, integrating, and recombining the useful external knowledge into new product development process (Salge, Farchi, Barrett, & Dopson, 2013).

Based on the Chesbrough's work on "open innovation" model, firms should actively search the knowledge from environment for innovation opportunities (Chesbrough, 2003). External search of firms is regarded as firms' strategies to purposefully search external knowledge that allowed them to create new combinations of technologies and knowledge (Wu, Wang, & Li, 2015). There are substantial body of literature examining the effect of external knowledge search strategies on product innovation performance (Laursen & Salter, 2006; Sofka & Grimpe, 2010; Wu, Wang, & Li, 2015; Ardito & Petruzzelli, 2017; Radicic & Pugh, 2017), and yet the studies presented mixed results by suggesting positive or curvilinear or negative effect of external knowledge search on product innovation performance. These heterogeneous findings suggested the need to find an explanation of the differences of firms in benefiting from external knowledge search.

Benefiting from external knowledge search is crucial to product innovation performance. Knowledge-based view posits that strategic knowledge includes both "knowing what" and "knowing how" is the most important resources that helps firm to create competitive advantage (Kotabe, Jang, & Murray, 2011). Knowledge acquired externally is just a tool of knowledge, and knowing will not develop when the knowledge is not used in practice (Marabelli & Newell, 2014). The ability to use the knowledge is depends on the firm's ability to identify appropriate information from broad external knowledge and then assimilate, transform and exploit the relevant knowledge into innovation process (Ahn, Ju, Moon, Minshall, Probert, Sohn, & Mortara, 2016). Absorptive capacity is a key to transform external knowledge into useful knowledge that could apply in new product development process.

Based on the original conceptualization by Cohen and Levinthal (1990), various conceptualization of absorptive capacity has emerged due to its wide definitions with very few exceptions (Massini, Lewin, & Greve, 2003). The extant literature that focus on indirect proxy, such as internal research and development expenditure and pattern counts, received criticism due to first, limited to industries where formal R&D are common and have great intellectual protection, and second, overlooks the internal dimension of absorptive capacity that enable firms to initiate changes from within (Lewin, Massini, & Peeters, 2011). Despite of these limitations, current study will address the validity challenges of absorptive capacity by proposing multidimensional absorptive capacity based on a set of underlying internal capabilities that could provide a more proactive view of absorptive capacity that encompassed firm's ability to translate external knowledge into competitive advantages in product innovation. In so doing, we may add a contribution to the literature by unpacking firm's internal processes to leverage external knowledge, as well as, explaining interfirm differences in benefiting from external search.

2. Literature Review

Knowledge-based view underscore that the tacit, context-specific and perishable knowledge is the source of competitive advantage that could determine performance differences between the firms (Grant, 1996; Lichtenthaler, 2016). Absorptive capacity is a firm specific knowledge for a firm which is built over time based on organizational routines (Lewin, Massini, & Peeters, 2011), and therefore it is crucial in explaining why some firms are better than others in capturing and creating value from externally in-sourcing knowledge. In this regard, when firm engage in external search, it tends to expand their internal knowledge base and they are able to increase their absorptive capacity significantly (Vanhaverbeke, Cloodt, & Vrande, 2007), hence lead to better product innovation performance. The following sections elaborate further between the linkages of external knowledge search, absorptive capacity and product innovation performance (PIP).

2.1. External Knowledge Search and PIP

Product innovation requires a broad knowledge base because the development of new product involves multi-discipline of knowledge (Annique et al., 2010). In this respect, firm's open access to external sources exposes greater opportunities for firms to access to knowledge that is needed in product innovation process (Chesbrough, 2003; West & Bogers, 2014). Collaboration with external partners enables thefirm to fill up the knowledge gap and enable them successfully commercialising new knowledge to the market (Chesbrough, 2003; Nieto & Santamaria, 2007).

Collaboration breadth is one of the open searchstrategies that enables firm sources important knowledge for their product innovation. Collaboration breadth refers to the extent of the firm has a relationship with different types of external partners (Laursen & Salter, 2006). Typically, collaboration with diverse partners enablesfirm to access to different types of knowledge that are important for innovation to take place (Nieto & Santamaria, 2007). The findings of empirical research in investigating linkages between collaboration breadth and product innovation are mixed. There are some prior research indicated direct positive linkages of collaboration breadth with PIP (Ebersberger & Herstad, 2011; Katila & Ahuja, 2002; Love, Roper & Vahter, 2014; Nieto & Santamaria, 2007), some indicated inverted U relationship with PIP (Chen et al., 2011; Kang & Kang, 2009), and others indicated insignificant relationship with PIP (Ferreras-Mendez et al., 2015).

Collaboration with various external partners contributes to firms' PIP. Prior studies indicated that collaboration with external partners exerted positive impact on PIP related to the rate of new product introduction (Laursen & Salter, 2006; Kang & Kang, 2009), novelty of new products (Nieto & Santamaria, 2007; Ebersberger & Herstad, 2011; Bengtsson, Lakemond, Lazzarotti, Manzini, Pellegrini & Tell, 2015; Monteiro et al., 2016), financial performance from new products sales, compatibility of new products (Ferreras-Mendez et al., 2015), speed of new product introduction and relative better market value and quality (Brettel & Cleven, 2011). Hence, in this research, researcher considers the effect of external collaboration breadth on PIP through the following hypothesis:

→ H1: Collaboration breadth is positively related to PIP.

On the other hand, collaboration depth refers to the extent to which firm draws intensively from different collaborating partners (Laursen & Salter, 2006). In this regard, deeper relationship between the collaborating partners enable firm to understand more of the knowledge has been acquired (Hsieh & Tidd, 2012), facilitate the transfer of knowledge, and greater access to tacit knowledge, such as partner's experience and skill. There is some prior research found positive linkages between collaboration depth and PIP (Chen et al., 2011; Katila & Ahuja, 2002), while other found inverted U relationship between collaboration depth and PIP (Ferreras-Mendez et al., 2015).

Typically, collaboration depth allows the firm to maintain a stronger relationship with external partners and resulted in adeeper level of trust and communication among partners (Laursen & Salter, 2006; Terjesen & Patel, 2015). Consequently, this will lead to a greater understanding of firm with external sources. In this regard, it allows firms to develop common knowledge with external sources, which support the new product development process in the firms, hence, lead to greater PIP (Zhang et al., 2015). Several prior researchers indicate that collaboration depth has positive impact on the rate of the introduction of new products, sales and speed of new products (Chen et al., 2015), novelty and sales of new products (Monteiro, Mol & Birkinshaw, 2016), and efficiency of new products (Bengtsson et al., 2015). Therefore, hypothesis is developed as following:

→ H2: Collaboration depth is positively related to PIP.

2.2. External Knowledge Search and Firm's Absorptive Capacity

Studies of external search always link with absorptive capacity in explaining the impact on firm's innovation performance. Indeed, the relationship between absorptive capacity and external knowledge search is twofold. Typically, a firm that engages in external knowledge search contributes in developing firm's absorptive capacity, while, the firm also need the absorptive capacity in absorbing external knowledge or information from its external knowledge search strategy (Clausen, 2013).

Absorptive capacity is a broad concept, which allows for different operationalise meanings (Murovec & Prodan, 2009). For the current study, researcher operationalised absorptive capacity as a set of dynamic capabilities that acquire, assimilate, transform, and exploit external knowledge sources for firm's innovation process. Unlike other research that operationalised absorptive capacity as firm's internal R&D (Bougrain & Haudeville, 2002), defining absorptive capacity in multidimensional context enable researcher to collect more information on firm's internal mechanism in absorbing external knowledge sources (Lewin et al., 2011), and therefore suitable apply for broad context include the non-research intensive firms (Oliver, Garrigos, & Gil-Pechuan, 2011).

Collaboration with diverse partners enablesfirm to access to different types of knowledge sources. In this respect, Fosfuri and Tribo (2008) argued that greater interaction with different types of external partners lead to the greater absorptive capacity of the firm. Likewise, Enkel and Heil (2014) found that interaction with a diverse partner has widened firm's awareness of new knowledge value. In the same manner, Morovec and Prodan (2009) supported that the broader collaborative network contributes to firm's absorptive capacity. In essence, this research considers the effect of collaboration breadth on absorptive capacity through the following hypothesis:

→ H3: Collaboration breadth is positively related to firm's absorptive capacity.

On the other hand, a firm that develops adeep connection with external partners tends to increase the potential information and tacit knowledge transfer from its focal firms (Vinding, 2006). Likewise, Rowley, Behrens, and Krackhardt (2000) contended that strong relationship between the collaborating partners produce thick information exchange that allows firms to gain better assimilate, transform and exploit the knowledge. Intensively, Murphy et al. (2012) argued that deep connection with external partners bridge the knowledge gaps between the firms. Indeed, this can make firm better in identifying the valuable external knowledge, enhancing firm's understanding of the knowledge, and improving firm's transformation and exploitation on the valuable external knowledge sources. In this respect, Ferreras-Mendez et al. (2015) found a positive relationship between collaboration depth and firm's absorptive capacity. In essence, this research considers the effect of collaboration depth on absorptive capacity through the following hypothesis:

→ H4: Collaboration depth is positively related to firm's absorptive capacity.

2.3. Firm's Absorptive Capacity and PIP

Following the proposed model by several prominent past researchers, absorptive capacity is linked to innovation performance (Cohen & Levinthal, 1990; Lichtenthaler, 2009; Van Den Bosch et al., 1999; Zahra & George, 2002). In this regard, absorptive capacity has an equally important role for PIP because absorptive capacity allows firms to utilise new knowledge to increase its PIP (Stock et al., 2001), as well as to help guiding the uncertain search for innovations (Fabrizio, 2009).

There is a great deal of research have done on investigating the relationship between absorptive capacity and PIP, however, prior researchers are not consensus in conceptualising the concept of absorptive capacity. In this respect, past research conceptualised absorptive capacity in two respective means, which are, absorptive capacity as external knowledge search and absorptive capacity as firm's ability in acquire, assimilate, transform, and exploit the external knowledge.

For the first conceptualised mean of absorptive capacity, the researcher argued that it is possible to jeopardise the original means of absorptive capacity. In this regard, absorptive capacity is indeed comprised of complex meaning and it is reflecting firm's ability in absorbing external knowledge for firm's innovation process rather than firm's external search strategies whereby search for external knowledge does no necessary internalised the knowledge or exploit the knowledge in new product development (Cohen & Levinthal, 1990; Zahra & George, 2002).

For the second conceptualised mean of absorptive capacity, there are two types of operationalised measurements. First is proxies' type of measurements and thesecond is the direct measurements. Proxies' type of measurements may have potential to underestimate the absorptive capacity in the firm (Schmidt, 2010). Direct measurements overcome the limitation of proxies because it allows researchers to capture richer structure nature of absorptive capacity.

In general, majority findings from prior research found a positive and significant relationship between absorptive capacity and PIP. However, the application of the concept of absorptive capacity varies across the literature. Indeed, the differences of the operationalised concept of absorptive capacity could lead to a different understanding of the mechanism of firm's access to surrounding technology opportunity and the mechanism of firms in extracting the valuable external knowledge as well as using it in the innovation process.

In this research, researcher attempt to open the black box (inside the firm) regarding firm's internal mechanism in utilising external knowledge sources, thus, defined absorptive capacity as firm's ability to acquire, assimilate, transform and exploit external knowledge sources for product innovation. Moreover, researcher proposed to use direct measures in capturing firm's absorptive capacity. Since, majority findings indicated the positive linkage between absorptive capacity and PIP, researcher considers the effect of absorptive capacity on PIP through the following hypothesis:

→   H5: Absorptive capacity is positively related to PIP.

2.4. Firm's Absorptive Capacity as Mediator between External Knowledge Search and PIP
The presence of valuable external sources of knowledge does not imply that firm are automatically or directly utilise the external knowledge sources in its innovation process. Principally, KBV suggested that knowledge assets can be traded, but it does not indicate that firms canrecognise the potential value of the external knowledge as well as utilise it into the production factor (Aranda & Molina-Fernandez, 2002; Grant, 1996b). KBV suggested that firm is a knowledge processing entity (Almedia, Song, & Grant, 2002). This establishes a link with the absorptive capacity concept, whereby, absorptive capacity processed the acquired external knowledge sources and applied this knowledgeto the commercial end (Cohen & Levinthal, 1990; Zahra & George, 2002). In this respect, absorptive capacity is the key to explain how the firms process the externally acquired knowledge as to enable it to be applying to commercialisation process. In essence, absorptive capacity plays an intermediate role in explaining by what means of the external knowledge search that drives the innovation benefit. For instance, Kostopoulos et al. (2011) argued that absorptive capacity may contribute to firm's innovation performance in two folds, which is first, undertaking the role as a tool for processing new external knowledge that can contribute to innovation performance, and second, as a pathway to transfer the knowledge for cross-organisation activities. Likewise, Moilanen et al. (2014) also argued that without absorptive capacity, external knowledge has no value for the firm's innovation performance.
To date, there is only limited empirical research that has investigated the mediating role of absorptive capacity between the external knowledge search and PIP. Although Kostopoulos et al. (2011) and Moilanen et al. (2014) have conducted the empirical research in investigating the mediating role of absorptive capacity, however, they tends to used proxies rather than direct measure in capture firm's absorptive capacity, and this might encounter potential in underestimating the absorptive capacity of the firms (Schmidt, 2010). In this regard, both of the studies proposed the future research should use qualities measures for capturing different dimensions of absorptive capacity in studying the role of absorptive capacity plays between external knowledge search and PIP.
In this research, due to the limitation of using proxies to measure the absorptive capacity, researcher proposed direct measures that include four dimensions of absorptive capacity in studying the role of absorptive capacity plays between external knowledge search and PIP. There are two types of external knowledge search involved in this research for investigation, this includes, collaboration breadth, collaboration depth. Researcher attempts to investigate how a firm can benefit (regarding product innovation) from engaging in these four types of external knowledge search through absorptive capacity. Based on the discussion in previous sections, it has indicated that the positive link between these four types of external knowledge search and absorptive capacity, and the positive link between absorptive capacity and PIP. Thus, this leads to the development of following hypotheses:

→   H6: Absorptive capacity is a mediator between collaboration breadth and PIP,
→   H7: Absorptive capacity is a mediator between collaboration depth and PIP.

3. Research Model

Figure 1 describes the mediating role of absorptive capacity between external knowledge search and PIP relationship.
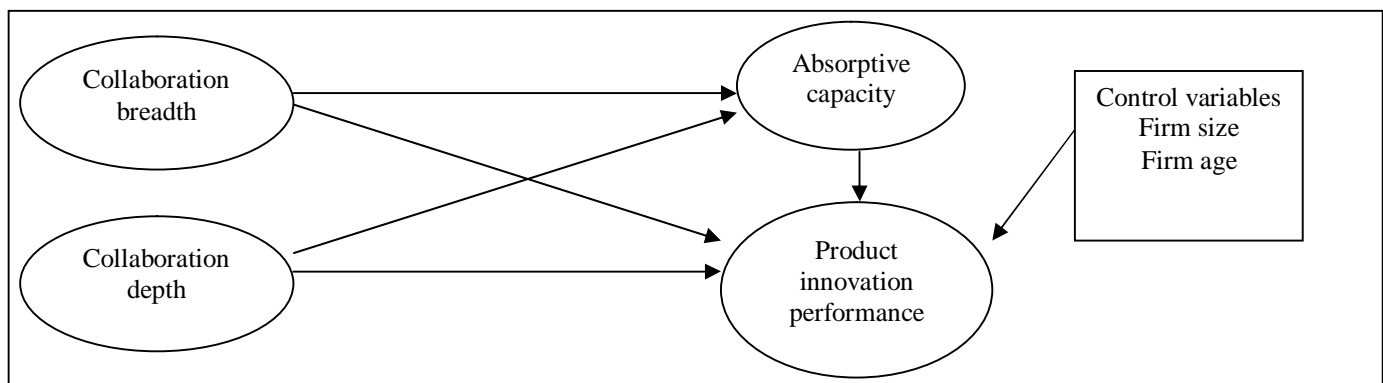

Figure 1: Research model for the proposed hypotheses

4. Methodology

4.1. Sample and Data Collection
The current study employed sample survey research method. The unit of analysis for this study is emphasised on Malaysian manufacturing firms whereby the "process of converting raw materials into products" (Kalpakjian & Schmid, 2006, p. 1) is being observed as it involved in product innovation activities. The firms selected for this study were chosen based on the Federation of Malaysian Manufacturers Directory 2015 because the Directory provides a comprehensive information of Malaysia Manufacturers' (typically cover all manufacturing industries in Malaysia). Based on the list, there are total 700 manufacturing firms selected as the sample of this study which covered the textile industry, food industry, electrical and electronic component industry, chemicals and

chemical products industry, metallic product industry, furniture industry, rubber and plastic products.

The respondents of the questionnaires were the managers who had conducted product innovation projects or involved in product innovation process or the person who were highly knowledgeable regarding the firm's product innovation, this includes, Product or R&D Managers Managing Director, R&D Manager, New Product Development Manager, Product and Design Manager Chief Executive Officer, Marketing Manager, Manufacturing Manager, etc. To improve the survey response rate, researcher has called or emailed the firms in the sample list to explained the objectives of the study and invite them to participate in the survey. At the same time, via call or email, researcher confirmed the names and job title of the respondents and this allows the questionnaire sent using registered postal service to the named respondents instead of the department name to reduce the chances of bureaucracy in mail handling.

Out of total 700 questionnaires sent, there are 148 return questionnaires. There is a total of 11 unusable responses with seven questionnaires were returned blank, or answered with less than half of the total questions, and four questionnaires stated that they have less than three years' experience in the firm that they have worked. This left with 137 usable responses giving the final percentage of 19.6% response rate over n=700. Based on the return questionnaires, Appendix A shows the demographic profile of respondents.

4.2. Definitions and Measurements of the Constructs

The questionnaire comprised four parts. First part consisted of respondent's background; second part was the measurements of product innovation performance; third part was the measurements of external knowledge search strategies; fourth part was the measurements of absorptive capacity. The definitions and measurements of the study were further elaborate as follows.

Variable	Components	Measurements
Product innovation performance	Financial performance (adapted from Tsai, Hsu & Fang, 2012)	Sales, profit, market growth and sales growth of innovate product in the market
	Product development speed and cost performance (adapted from Tsai, et. al., 2012)	Costs and time to develop innovate product to the market.
	Product performance (adapted from Lin, Tu, Chen & Huang, 2013; Hannachi, 2015)	Product performance regarding its' market and quality performance
	Product innovativeness (adapted from Gracial & Calantone, 2002)	Innovativeness of the product at firm level, industry level
Absorptive capacity	Acquisition capability (adapted from Gebauer, Worch & Truffer , 2012)	Five items designed to capture the acquisition capability in a firm, this includes employees' motivation to use external knowledge and to put their effort to acquire the external knowledge, as well as, their ability to identify, select and retain, and classify the acquired knowledge
	Assimilation capability (adapted from Camison & Fores, 2010; Flatten, Engelen, Zahra & Brettel, 2011; Gebauer, et.al., 2012)	Seven items designed to measure assimilation capability in order to capture firm's capability in resolving the inconsistency between newly acquired knowledge and firm's existing knowledge bases through creating a collective understanding throughout firm's members on the newly acquired knowledge as to enable the integration of newly acquired knowledge with firm's existing knowledge base.
	Transformation capability (adapted from Lichtenthaler, 2009; Camison & Fores, 2010; Gebauer et al. 2012	There are six items designed to measure transformation capability as to capture firm's ability to maintain and reactivate the knowledge, interpreting and combining the knowledge, and integrates the new knowledge with the existing knowledge base
	Exploitation capability (adapted from Flatten; Gebauer et al. 2012)	Three items designed to measure exploitation capability as to capture capability of the firm to use and implement the acquired knowledge into commercial applications. acquired knowledge into the commercial end. Indeed, this item is essential because it can intuitively determine the extent of employees' effort delicate to convert acquired knowledge into commercial applications
Collaboration breadth (From Laursen & Salter, 2006)	Collaboration breadth of the firm is measured by summing up the eight dummies. When the firm has no collaboration link with the stated partners, the firm gets a score of zero, while the firm gets a value of eight when the firm has collaborated with all stated external partners.	
Collaboration depth	Collaboration depth is measured with the average of the eight scores represented the depth of collaboration link with the external partners. For the firm that gets an average score of zero, this indicates that the firm has no deep relationship with collaborated partners while the firmthat obtained a value of eight indicates that the firm has a deep relationship with collaborated partner.	
Control variables	Firm size- The firm size is measured by using logarithm on the number of employees of a firm	
	Firm age- Firm age was measure by the number of years since foundation in logs	

Table 1

5. Data Analysis and Research Findings

This study employed Smart PLS 3 to verify the research model and hypotheses. There are four antecedents of the research model, namely collaboration breadth, collaboration depth, external information search breadth, external information search depth, and the consequent is PIP, while, absorptive capacity is the mediator for this study. The analysis consists of two parts, namely structural model-inner model and measurement model-outer model.

5.1. Evaluation of Measurement Variables

Since the measurement model in this study is reflective in nature, it should assess using internal consistency reliability, convergent validity (factor loading, Cronbach's Alpha, composite reliability, average variance extracted) and discriminant validity (Fornell-Larcker criterion). As depicted in Appendix B, all the outer loadings of the constructs are significant at the level of .001, and the value is above the suggested threshold value of .708. This indicated that the items used to represent the latent variable had satisfactory internal consistency reliability. Moreover, the value of composite reliability for each latent variable range from .874 to .971, and Cronbach's Alpha exceed 0.70 also indicates that the variables have satisfactory internal consistency reliability. Other than the assessment of the outer loading, average variance extracted value is the common method used to assess the convergent validity by measure the degree to which a latent variable explains the variance of the indicators (Zait & Bertea, 2011). The AVE display values ranging from .695 to .892, which exceeded the recommended threshold value .500. This indicates that the measurement model of this study demonstrated adequate convergent validity (refer Appendix B).

To assess discriminant validity, Fornell-Larcker criterion and cross-loading criterion were used to assess the discriminant validity. The Appendix C shows the value of square roots of AVE (diagonal values) exceeded the intercorrelation value (off-diagonal values) between the variables, while, Appendix D shows that in all cases, an indicator' s loadings on its own constructs are higher than all of its cross-loadings with other constructs. These results indicate there is discriminant validity between all constructs.

5.2. Evaluation of Structural Model

After the measurement model has been confirmed as reliable and valid, the next step is to assess the structural model results. Before interpretation the structural model results, the first step was to assess the collinearity among the variables. Refer to Appendix E, VIF values for all exogenous variables shows within the range 1.246 to 1.373, which is below 5.0, and this indicates that the structural model is not affected by collinearity problem.

Subsequently, the examination of the coefficient of determination (R^2) of endogenous variables shows that the collaboration breadth, collaboration depth, information breadth and information depth (with two controls firm size and firm age) can explain 20.3% (R^2= .203) of the variance in absorptive capacity. The collaboration breadth, collaboration depth, information breadth, information depth and absorptive capacity (with two controls firm size and firm age) explain 51.3% (R^2= .513) variance on PIP, which can be considered as moderate follows by Chin (1998). This result suggests the predictive power R^2 of PIP has adequate predictive power of innovation since the R^2 value is higher than 0.1, whereby, explain at least 10% of the construct variability derives from the model (Falk & Miller, 1992).

The effect size f^2 isa "measure used to assess the relative predictive relevance of a predictor construct on endogenous constructs" (Hair et al., 2014, p. 201). Indeed, the measure of effect size serves as a practical guide forinterpreting the magnitude of a particular relationship, and the effect size f^2 is to explain themagnitude of a predictor construct on endogenous constructs (Preacher & Kelley, 2011). The effect size f^2 can be calculated directly from Smart PLS Version 3, and the results are shown below in Appendix F. According to Cohen's (1988) rule of thumb, absorptive capacity has a medium effect on PIP amounting to 28.1%. On the other hand, collaboration depth has a small effect on absorptive capacity amounting 9.3%. These results suggest that the exogenous variables in the hypothesised model have predictive relevance of endogenous variables.

In addition to evaluation of the magnitude of the coefficient of determination (R^2), the predictive relevance of the structural model can be assessed by calculating the Stone-Geisser's Q^2 value (Stone, 1974; Geisser, 1975). The Q^2 value can be obtained by "using the blindfolding procedure for a ceratin omission distance D.=." (Hair et al., 2014, p. 178). In this study, omission distance used is seven, followed the default setting in Smart PLS 3. In accord with the rule of thumb suggested by them, Q^2 value for absorptive capacity and PIP (greater than zero) indicates that the exogenous variables have predictive relevance on absorptive capacity and PIP (refer Appendix G). In other words, these results suggest that the structural model in this study has predictive relevance.

5.3. Test of Mediation Effect

This study used the bootstrapping method to test the mediation effect. Following Preacher and Hayes (2004, 2008), the bootstrap of sampling distribution for indirect effect is suitable to apply for simple and multiple mediator models. Indeed, bootstrapping makes no assumptions on sampling distribution, which indicates that this method is non-parametric based. Therefore, it can be concluded that this approach is perfectly suitedto PLS-SEM method. Accordingly, this study applies bootstrapping procedure with 500 subsamples and no sign change, with the confidence interval Method-Bias-Corrected 95% bootstrap confidence interval for testing the indirect effect for Model 2. The confidence interval method-Bias-Corrected is selected because this method provides more accurate Type I error rates and have greater power for detecting indirect effect compare to other stated methods (Preacher & Hayes, 2008).

The structural model result presented that direct effect between collaboration depth shows significant relationship with PIP (β= .362, p<0.001), while, collaboration breadth shows insignificant relationship with PIP (refer to Appendix H). This support hypothesis H2, while, rejected hypothesis H1. On the other hand, path analysis indicates that collaboration depth has positive and significant relationship with absorptive capacity with the path coefficient of (β= .304, p< .001), and collaboration breadth shows significant

relationship with absorptive capacity with the path coefficient (β= .223, p< .001). These support both hypothesis H3 and H4. Absorptive capacity has positive and significant relationship with PIP (β= .415, p< .001), and this support hypothesis H5.

Following Preacher and Hayes (2004, 2008), mediation analysis involved the assessment to indirect effect. Study shows that collaboration depth has significant indirect relationship with PIP (β= .126, t= 3.324, p< .01) (refer Appendix H). This suggests mediation effect of absorptive capacity exist in relationship between collaboration depth and PIP. As to examine the effect size of mediation effect, we follow Hair et al. (2014) suggestion by calculating the size of indirect effect relative to the total effect-variance accounted for (VAF) in the model. The VAF value for collaboration depth-absorptive capacity-firm's PIP is .488, which indicates only 25.8% of collaboration depth effect on firm's PIP is explained via the absorptive capacity. Indeed, this result suggests that the exits of partial mediation effect (20% <VAF < 80%) of the role of absorptive capacity in the relationship between collaboration breadth and PIP, hence, provide partial support for hypothesis H7.

6. Discussions

The findings of external knowledge search on absorptive capacity indicate that collaboration depth has positively contributed on all four dimensions of absorptive capacity. This result suggested that firms engage in collaboration and draws intensively from different collaborating partners contributing to the increase of firms' absorptive capacity. Absorptive capacity is firms' ability to realised the value from acquired external knowledge (Gebauer et al., 2012), integrate external knowledge to current knowledge bases (Flatten et al., 2011), storing and reactivate the external knowledge when needed (Lichtenthaler, 2009), and apply it in new product development (Flatten et al., 2011). Collaboration depth allows firms to deepen the knowledge of external partners, and this enables the firm to become more easily to understand the pieces of knowledge and information provided by its partners (Cruz-Gonzalez et al., 2015). As a result, this increases the firms' realised value from acquired external knowledge and consequently having the competitive advantage in improving the integration and application of this knowledge in commercial ends.

Moreover, collaboration depth with external partners create a deep connection, and this enhances communication (Patel & Van der Have, 2010) and allows firms to sustain a pattern of interaction with external agents over times (Ferreras-Mendez et.al., 2015). Firms interact with external agents to build up a shared understanding and common ways of working [assimilation] and this allow the transfer of fine-grained knowledge (Carnabuci & Operti, 2013) that will facilitate the transfer and combination of the knowledge [transformation] with the already existing knowledge base (Chen et al., 2011). Recombination of the existing knowledge and firm's knowledge base, lead to better exploitation of knowledge in new product development process (Knudsen, 2007).

Deep connection with external agents overtimes increases trust between firms and external agents (Ferreras-Mendez et al., 2015) by unlocking sticky knowledge, such as skills and processing ability. Moreover, this enhances the transfer of knowledge of external agents to the firms and support acquisition, assimilation, transformation and exploitation of knowledge to create innovation (Datta, 2011). Instead of that, deep connection allows firms to identify and evaluate the arbitrage opportunities, such as differences between firms' existing knowledge and newly acquire sticky knowledge, and hence, leads to alteration of firms' absorptive capacity level in capture these opportunities for future developments (Hughes & Wareham, 2010).

The current study indicated that firms engage in external knowledge search contribute indirectly to PIP. Typically, the result indicated that external knowledge search has a direct relationship with absorptive capacity, but no PIP. There are two reasons to justify the current findings. First, based on the knowledge-based view (KBV), knowledge is characterised as partial public goods. In this notion, knowledge can be transmitting between one with another party, or with multiple parties, but with time and investments and resources devoted to it (Galende, 2006). In fact, knowledge is not a "scale free reproduction property", because the replication of knowledge concerning processes, organisational arrangements that required significant efforts, costs, and degrees of uncertainty about the ultimate success (Dosi & Nelson, 2009). This provides a fundamental explain in why firms engage in external knowledge search practices (collaboration breadth and depth, information search breadth and depth) does not directly lead to improvement of the PIP.

Secondly, acquired knowledge from external search practices offers greater opportunities for firms to gain greater external knowledge and information (Foss, Lyngsie & Zahra, 2013). However, this knowledge and information does not directly generate valuable outcome if firms does not realise its value (filtering and selecting the suitable knowledge), assimilate it (transmit and share information as pre-requisite to integrate the knowledge in firms' existing knowledge base), transform (integrates the new knowledge with the existing knowledge base) and exploit the knowledge for commercialisation. In order to bring a new product to markets, it entails a complex process because the well-codified ex-ante knowledge does not sufficiently establish the detailed properties in the ways of the product production process or artefact to carry out in bringing a new product to the market (Pavitt, 1984).

Absorptive capacity helps to translate the external knowledge and information into a meaningful way for firms, eventually, apply it in new product development process. Typically, there are two reasons for the necessity to translate the external knowledge, before firms can use them in their new product development process (Dosi & Nelson, 2009). First, the efforts at inventing and solving technological problems may be reaching beyond the range of options that are perfectly understood. Ultimately, knowledge acquired from external sources need to be learned, through disseminating and integrating process. Secondly, firms in an industry tend to differ from one another in their product development routines. Hence, the external knowledge needs to integrate into firms' existing knowledge base, and this would result in a new routine for product development process that creates a new product to the market.

7. Conclusions and Implications

The outcome of this empirical research provides fruitful extensions of refining the concept of absorptive capacity in innovation studies. As various empirical research viewed absorptive capacity as facilitator in increase advantages in firm's external search activities (Ebersberger & Herstad, 2011; Escribano et al., 2009; Laursen & Salter, 2006), few have link the external knowledge search

as antecedent for absorptive capacity and the outcome of absorptive capacity (Kostopoulos et al., 2011). In this regard, as proposed by Volberda, Foss & Lyles (2010), integration of external search with firm internal ability in absorbing the external knowledge are necessary to explain whether the firm can tap into external knowledge sources. Indeed, firm engages in external search may contribute to enhance firm's absorptive capacity cumulatively over time by accumulating a relevant knowledge base that can be further used to generate new products.

The findings of this study provide empirical support for absorptive capacity model established in past research (Torodova & Durisin, 2007; Zahra & George, 2002), which indicates that absorptive capacity could explain a substantial part of cross-firm heterogeneity in profiting from external knowledge search (Kostopoulos et al., 2011). In this regard, firms engage in external search activity is not directly derived to the outcome, but, it tends to contribute in developing absorptive capacity over time. Eventually, with greater firm's absorptive capacity, the more likely is the firm will be proactive in exploiting opportunities present in the environment, thus contributes to better outcomes.

On the other hand, the findings of this study provide insights for managers to improve PIP. Typically, the results indicate that collaboration depth contribute in explaining variance in firm's PIP through absorptive capacity. This suggests that the collaboration depth contribute in enhance firm's internal learning base (absorptive capacity) that later could translate into better PIP. Thus, it gives implication for managers and suggests that building and maintaining different search practices contributes to firm's interactive learning from external agents and learning from the external environment.

Moreover, absorptive capacity is the key to facilitating a greater learning of firm because the high level of absorptive capacity helps to understand the nature of new knowledge and become a decisive competitive factor (Anatoliivna, 2013). Developing and maintaining AC is critical for firms' long-term success and survival because it reinforces complements and changes the focus of their knowledge base (Zahra & George, 2002). High absorptive capacity is associated with the better chances to produce success product innovation and showing better performance, and also overcoming the "Not-Invented-Here" syndrome. Indeed, investing in external knowledge search is only a first step for firms for product innovation. Managers should also devote more effort to develop their absorptive capacity as to capture the valuable knowledge from external search and translate this knowledge into tangible and intangible outcome for firms in return. In this regard, absorptive capacity is a source of competitive advantages for the firm, which is valuable, rare, inimitable and non-transferable during their process of catching up with their counterparts.

This study offers some policy implications. First, this study suggests that investment in external knowledge search and develop absorptive capacity is the key that contributes to firms' success product innovation. Absorptive capacity enlarges knowledge base of the firm through cumulatively integration of reconfigure external knowledge and internal knowledge that resulted in them deploying knowledge to create technology and new products (Gebauer et al., 2012). As Malaysia wish to move to high value added manufacturing, it is important for policymakers to acknowledge the role of absorptive capacity in catching up the opportunities for product innovation and improve the greater success of product innovation. As this research found that external knowledge search enhances firm's absorptive capacity, it gives implication for policymakers to promote a better business environment that could facilitate greater firms' external knowledge search.

Intensively, firm building and maintaining different search practices are essential for firms to foster its absorptive capacity and trigger success product innovation. Typically, it is suggested that formulating policies that aim at generating industrial cluster or geographically agglomerated industries encourage firms to maintain a better relationship with its external agents (enable the firm to acquire quality information) could foster greater firm's learning. Moreover, policies also need to target at supporting intermediate institutions (universities, public research centers, local and professional associations), encourage participation in exhibitions and trade fairs, as well as, promoting greater speed of internet accessibility because information from these external sources also play an important role in foster greater learning of local manufacturing firms.

Second, this study suggests four dimensions capabilities base model of absorptive capacity in explaining the way of firm extract valuable knowledge from external knowledge search practices. This suggested that development of absorptive capacity is not a straightforward process as prior research suggested, merely through conducting R&D activities (Murovec & Prodan, 2009), hiring qualified employees (defined as greater education qualification) and training (Mancusi, 2008), but it is embedded in organisational routines, which means that employees should be able to learn and turn the new knowledge into organisational knowledge.This indicates that it is an organisational learning process, through facilitating motivation of employees to acquire and filter the knowledge (acquisition capability), trigger mutual/ collective understanding in firm (assimilation capability), store and maintain, transform and reconfigure the knowledge (transformation capability) and exploit the knowledge in their commercialise end (exploitation).

Consequently, a policy that design to improve absorptive capacity needs to focus on motivating firm's capability to acquire the knowledge, facilitate knowledge sharing in the organisation, trigger cognitive thinking to transform and reconfigure the knowledge, as well as motivate them to apply the new knowledge in commercialisation end. Typically, a policy that designed to provide an incentive for the firm is essential to trigger firm's motivation to innovate that will lead to the improvement of the firm's absorptive capacity. Indirectly, this will benefit the firm in terms of their future product innovation. Moreover, since absorptive capacity is collectively based on a firm, therefore human capital is still the key to sustain the absorptive capacity of a firm. Thus, a policy that designed to provide a quality education system that matching with industrialised requirement tends to improve firm absorptive capacity.

8. Limitations and Directions for Future Research

The present study has some inherent limitations that may also suggest future research lines. First, the model introduced in the study does not allow for the analysis of external search strategies within each search channel, and the way of it that contributes to improving firm's PIP through absorptive capacity. Future research may assess this aspect by developing several fine-grained items for each of the

external search channels.

Secondly, the current study found that external knowledge search (collaboration depth, information search breadth and depth) explain only 28.4% variance on firm's absorptive capacity, and therefore, suggested the further explore for possible antecedent for firm's absorptive capacity needed to improve the explanation power on firm's PIP. According to Volberda et al. (2010), intra-organizational factors, such as organisational form, incentives structures, as well as managerial antecedents, such as, individual knowledge development and sharing and managerial cognitions are important factors that also contribute to firm's absorptive capacity. Hence, future studies could include the stated factors as to explain current framework.

Thirdly, it is suggested by some of the prior research about learning of firm from external knowledge search strategies may different under different environment conditions (Laursen & Salter, 2014; Cruz-Gonzalez et al., 2015). In this vein, as to comprehend to knowledge, it is suggested that future research should develop a model incorporate environment conditions as moderator as to explain the linkages of external knowledge search, absorptive capacity and PIP as to explain firms learning process under different environment conditions.

Finally, the data for the current study were gathered at one point in a time and this present as the limitation of this study. Indeed, development absorptive capacity is a path-dependent process, thus, cross-sectional data analysis may not capture the dynamics of firm's learning from external knowledge search activities. Therefore, future research could further apply longitudinal designs as to provide insights in how firm generate competitive advantages from knowledge coming from external sources and how these learning mechanisms affect firm's PIP across the time.

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Appendix A
Respondents' profile

Job Position	Frequency	Percentage (%)
Product Manager or R&D Manager	84	61.3
Equivalent To Product Manager or R&D Manager	52	38.0
Missing	1	0.7
Length of Service		
<5 years	15	10.9
>5 to 10 years	29	21.2
>10 to 15 years	27	19.7
>15 to 20 years	25	18.2
>20 to 25 years	20	14.6
>25 years	21	15.3
Firm's Age		
< 10 years	17	12.4
>10 to 20 years	40	29.2
>20 to 30 years	44	32.1
>30 to 40 years	19	13.9
> 40 years	17	12.4
Firm's Size		
< 75 employees	45	32.8
75 - 200 employees	44	32.1
> 200 employees	48	35.1
Types of Industry		
Basic Metal	1	0.7
Chemicals including Petroleum	10	7.3
Electrical and Electronics	20	14.6
Fabricated Metal	8	5.8
Food, Beverage and Tobacco	21	15.3
Machinery	7	5.1
Manufacturing of Furniture	12	8.8
Medical, Precision and Optical Instruments	5	3.6
Non-Metallic Mineral	5	3.6
Paper, Printing, and Publishing	7	5.1
Plastic	9	6.6
Rubber	3	2.2
Textile, Wearing Apparel and Leather	3	2.2
Transportation	1	0.7
Wood and Wood Products, including Furniture	6	4.4
Others	19	13.9
Total	137	100.0

Appendix B
Convergent validity of measurement model

Factor	Factor Loading	Standard Error	t	α	CR	AVE
Absorptive capacity				**0.947**	**0.953**	
Acquisition				0.922	0.942	0.764
da1	0.796***	0.053	14.955			
da2	0.884***	0.030	29.028			
da3	0.925***	0.013	70.878			
da4	0.919***	0.014	65.560			
da5	0.841***	0.028	29.766			
Assimilation				0.916	0.934	0.670
db1	0.701***	0.050	13.957			
db2	0.713***	0.051	13.853			
db3	0.840***	0.025	33.363			
db4	0.894***	0.019	47.241			
db5	0.787***	0.043	18.445			
db6	0.886***	0.020	44.087			
db7	0.885***	0.019	47.075			
Transformation				0.947	0.958	0.793
dc1	0.874***	0.020	43.337			
dc2	0.845***	0.027	31.420			
dc3	0.888***	0.021	41.912			
dc4	0.936***	0.011	82.996			
dc5	0.926***	0.011	83.012			
dc6	0.870***	0.021	40.724			
Exploitation				0.909	0.943	0.846
dd1	0.895***	0.025	35.378			
dd2	0.943***	0.011	88.129			
dd3	0.921***	0.017	52.983			
Product Innovation Performance				**0.914**	**0.923**	
Financial performance				0.959	0.971	0.892
Aa1	0.939***	0.014	68.149			
Aa2	0.926***	0.019	48.172			
Aa3	0.960***	0.007	131.399			
Aa4	0.953***	0.010	94.443			
Product Performance				0.890	0.919	0.695
ab6	0.803***	0.029	27.602			
Ab7	0.803***	0.039	20.542			
Ab11	0.851***	0.031	27.282			
ab12	0.862***	0.028	31.119			
Ab13	0.848***	0.029	29.370			
Product Innovativeness				0.923	0.945	0.813
ab14	0.860***	0.031	27.718			
ab15	0.893***	0.023	39.631			
ab16	0.922***	0.018	50.161			
ab17	0.929***	0.016	57.614			
Product Development Speed and Cost				0.783	0.874	0.697
Ab8	0.838***	0.022	37.433			
ab9	0.835***	0.035	23.938			
Ab10	0.832***	0.038	21.919			
Collaboration breadth	1.000	0.000	0.000		1.000	1.000
Collaboration depth	1.000	0.000	0.000		1.000	1.000
Firm Size	1.000	0.000	0.000		1.000	1.000
Firm Age	1.000	0.000	0.000		1.000	1.000

Note: Significant level (*** p<.001), t - t value, CR- Composite Reliability, α-Alpha value, AVE-Average Variance Extracted value

Appendix C
Discriminant validity based on Fornell-Larcker criterion assessment

	Ac	As	Tr	Ex	FP	PP	PI	PDCS	CB	CD	Size	Age
Ac	(0.874)											
As	0.524	(0.819)										
Tr	0.448	0.670	(0.890)									
Ex	0.405	0.447	0.567	(0.920)								
FP	0.279	0.388	0.265	0.220	(0.945)							
PP	0.450	0.477	0.490	0.393	0.454	(0.834)						
PI	0.402	0.334	0.312	0.298	0.287	0.502	(0.902)					
PDSC	0.219	0.353	0.342	0.315	0.307	0.575	0.372	(0.835)				
CB	0.432	0.254	0.226	0.288	0.234	0.351	0.334	0.128	1			
CD	0.387	0.387	0.288	0.189	0.352	0.487	0.498	0.323	0.444	1		
Size	0.029	0.085	0.169	0.035	0.227	0.215	0.158	0.190	0.085	0.115	1	
Age	0.001	-0.034	-0.026	0.033	0.049	0.085	0.057	0.196	0.033	-0.023	0.328	1

Note: FP-Financial Performance, PDSC-Product Development Speed and Cost, PP-Product Performance, PI-Product Innovativeness, Ac-Acquisition, Ac-Assimilation, Tr-Transformation, Ex-Exploitation, CB-Collaboration Breadth, CD-Collaboration Depth, Size- Firm Size, Age-Firm Age. Diagonal elements are square root of the AVE; Off-diagonal elements are the correlations among the constructs.

Appendix D
Discriminant validity based on loadings and cross-loadings of items

	EX	PDCS	AS	TS	AC	FP	PP	PI	CD	CB	AGE	SIZE
dd1	0.895	0.231	0.344	0.441	0.412	0.122	0.348	0.319	0.180	0.328	0.005	-0.067
dd3	0.921	0.246	0.427	0.549	0.358	0.210	0.348	0.250	0.121	0.263	-0.033	0.064
dd2	0.943	0.384	0.457	0.567	0.352	0.264	0.387	0.258	0.221	0.213	0.113	0.087
ab10	0.181	0.832	0.240	0.213	0.185	0.177	0.452	0.275	0.266	0.082	0.199	0.071
ab9	0.290	0.835	0.207	0.174	0.091	0.222	0.406	0.314	0.183	0.010	0.185	0.188
ab8	0.307	0.838	0.410	0.435	0.255	0.349	0.564	0.337	0.344	0.205	0.119	0.205
db2	0.279	0.152	0.713	0.403	0.428	0.184	0.187	0.258	0.200	0.262	-0.001	-0.078
db1	0.452	0.238	0.701	0.457	0.488	0.183	0.319	0.219	0.207	0.171	-0.004	-0.035
db5	0.371	0.297	0.787	0.527	0.372	0.367	0.421	0.332	0.381	0.234	-0.064	0.195
db3	0.295	0.295	0.840	0.559	0.464	0.370	0.367	0.259	0.339	0.176	-0.059	0.020
db6	0.393	0.350	0.886	0.661	0.382	0.336	0.456	0.258	0.339	0.184	0.002	0.166
db7	0.470	0.353	0.885	0.641	0.461	0.355	0.515	0.294	0.345	0.251	-0.028	0.107
db4	0.291	0.303	0.894	0.550	0.420	0.399	0.418	0.297	0.379	0.185	-0.039	0.077
dc2	0.540	0.326	0.587	0.845	0.431	0.235	0.512	0.294	0.291	0.262	-0.026	0.182
dc6	0.442	0.302	0.581	0.870	0.348	0.234	0.407	0.265	0.227	0.155	0.059	0.163
dc1	0.516	0.304	0.622	0.874	0.407	0.179	0.416	0.213	0.225	0.202	-0.087	0.097
dc3	0.452	0.288	0.598	0.888	0.431	0.228	0.399	0.304	0.251	0.217	-0.022	0.152
dc5	0.552	0.269	0.579	0.926	0.356	0.248	0.409	0.277	0.253	0.166	-0.038	0.146
dc4	0.524	0.335	0.610	0.936	0.420	0.290	0.471	0.313	0.286	0.205	-0.021	0.163
da1	0.308	0.157	0.318	0.260	0.796	0.199	0.314	0.304	0.309	0.293	0.031	-0.007
da5	0.420	0.246	0.513	0.468	0.841	0.283	0.440	0.375	0.349	0.419	-0.082	0.069
da2	0.332	0.201	0.379	0.347	0.884	0.229	0.362	0.344	0.307	0.295	0.040	-0.017
da4	0.367	0.189	0.526	0.421	0.919	0.263	0.437	0.337	0.368	0.455	0.027	0.054
da3	0.329	0.158	0.514	0.428	0.925	0.235	0.392	0.387	0.352	0.398	0.004	0.013
aa1	0.195	0.266	0.348	0.245	0.233	0.939	0.362	0.208	0.292	0.215	0.002	0.207
aa2	0.114	0.277	0.315	0.171	0.298	0.926	0.417	0.298	0.334	0.244	0.019	0.222
aa4	0.301	0.339	0.411	0.314	0.267	0.953	0.469	0.291	0.356	0.224	0.062	0.216
aa3	0.213	0.275	0.388	0.265	0.255	0.960	0.461	0.281	0.341	0.200	0.096	0.214
ab6	0.238	0.425	0.387	0.397	0.405	0.442	0.803	0.513	0.452	0.325	0.115	0.255
ab7	0.204	0.365	0.275	0.299	0.319	0.277	0.803	0.421	0.411	0.263	0.076	0.269
ab13	0.410	0.527	0.454	0.443	0.409	0.448	0.848	0.365	0.367	0.244	0.062	0.116
ab12	0.412	0.551	0.423	0.447	0.405	0.316	0.862	0.387	0.375	0.342	0.092	0.107
ab11	0.362	0.520	0.434	0.443	0.331	0.397	0.851	0.405	0.423	0.286	0.010	0.155
ab15	0.291	0.455	0.362	0.352	0.373	0.215	0.473	0.893	0.474	0.343	0.060	0.070
ab14	0.245	0.329	0.254	0.198	0.392	0.304	0.428	0.860	0.445	0.307	0.092	0.132
ab16	0.243	0.237	0.249	0.237	0.364	0.267	0.422	0.922	0.382	0.259	0.007	0.181
ab17	0.291	0.313	0.336	0.331	0.321	0.250	0.484	0.929	0.489	0.294	0.045	0.187
CD	0.189	0.323	0.387	0.288	0.387	0.352	0.487	0.498	1.000	0.444	-0.023	0.115
CB	0.288	0.128	0.254	0.226	0.432	0.234	0.351	0.334	0.444	1.000	0.033	0.085
AGE	0.033	0.196	-0.034	-0.026	0.001	0.049	0.085	0.057	-0.023	0.033	1.000	0.328
SIZE	0.035	0.190	0.085	0.169	0.029	0.227	0.215	0.158	0.115	0.085	0.328	1.000

Note: FP-Financial Performance, PDSC-Product Development Speed and Cost, PP-Product Performance, PI-Product Innovativeness, Ac-Acquisition, As-Assimilation, Tr-Transformation, Ex-Exploitation, CB-Collaboration Breadth, CD-Collaboration Depth, Size- Firm Size, Age-Firm Age

Appendix E
Collinearity assessment

Endogenous	Exogenous	VIF
PIP	Absorptive Capacity	1.262
	Collaboration Depth	1.373
	Collaboration Breadth	1.312
Absorptive Capacity	Collaboration Depth	1.246
	Collaboration Breadth	1.246

Note: VIF-Variance Inflation Factor

Appendix F
Effect size result

	f²	Effect
Absorptive capacity -PIP	0.281	Medium
Collaboration depth-Absorptive capacity	0.093	Small

Appendix G
The result of predictive relevance Q²

Variables	Q² Redundancy	Effect
Absorptive capacity	0.098	Small
PIP	0.221	Medium

Appendix H
Summary of mediation analysis

	Total Effect	Direct Effect	Indirect Effect				Percentile (CI)	
	a.b+c´	(a/b/c´)	(a·b)	Std. error	t value	p value	Lower 2.5%	Upper 97.5%
Hypothesized Effect								
Collaboration breadth -> PIP		0.045						
Collaboration depth -> PIP		0.362***						
Collaboration breadth -> AC		0.223**						
Collaboration depth -> AC		0.304***						
Collaboration breadth -> AC -> PIP	0.138		0.093	0.037	2.476	0.014	0.026	0.169
Collaboration depth -> AC -> PIP	0.488		0.126**	0.038	3.324	0.001	0.048	0.191
AC -> PIP		0.415***						
Size -> PIP		0.143*						
Age -> PIP		0.081						

Note: Significant level (* $p < .05$), (** $p < .01$), (*** $p < .001$).