Dynamic capabilities of new product development teams in performing radical innovation projects

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Abstract

Purpose – This paper aims to examine the impact of dynamic capabilities of new product development (NPD) team on project performance, including efficiency and effectiveness.

Design/methodology/approach – Data were collected from NPD team members who have worked on radical new product projects in large manufacturing firms in Thailand. Respondents represented different departments, including research and development (R&D), quality control, production and marketing. These individuals worked in a wide range of large manufacturing industries with an average of more than 500 employees. These industries include food, automotive, auto parts and electric and electronics products.

Findings – The results indicate that NPD team with sensing, learning and integrating capabilities can increase project effectiveness. In addition, teams with high learning, integrating and coordinating capabilities will enhance project efficiency.

Research limitations/implications – First, the research findings may not be generalizable in all aspects to other industries. Second, the use of cross-sectional data in this study may not be appropriate for testing causal relationships among constructs. Third, although the samples of this study were from a wide range of functional areas, the majority were R&D personnel.

Practical implications – To improve project effectiveness, project managers should consider investing in information technologies that provide a wide range of information sources, such as business research databases and academic journals. To improve project efficiency, the managers can establish both formal and informal activities during NPD projects. These social activities can provide opportunities for team members to physically meet and adjust their personal behavior to get along with each other.

Originality/value – These findings provide a wider picture of the beneficial role of dynamic capabilities of NPD teams toward project performance, including efficiency and effectiveness.

Keywords Dynamic capabilities, Project efficiency, Project effectiveness, New product development team

Paper type Research paper

1. Introduction

Sustaining business competitiveness and strategic competence in turbulent business environments place great demand on the capabilities of new product development (NPD) teams. These capabilities, namely dynamic capabilities, refer to the ability of sensing, learning, integrating and coordinating the internal and external competencies of an organization to cope with rapidly changing environments (Pavlou and Sawy, 2011; Teece *et al.*, 1997). Teams with dynamic capabilities can effectively observe, understand and interpret information on existing customers and competitors. Consequently, team members adjust current strategies and develop new ones which will support implementation of radical innovation projects. Dynamic capabilities are therefore essential elements for enhancing competitive advantage amid highly uncertain situations (Teece, 2007).

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Existing empirical studies have emphasized the importance of dynamic capabilities by focusing on the organization level. For example, Arthurs and Busenitz (2006) found that the dynamic capabilities of venture capital can improve financial performance. Similarly, Marcus and Anderson (2006) revealed that the dynamic capability of food retailers improves their businesses and social competence. More recently, Park and Kim (2013) found that the dynamic capabilities of high-tech companies lead to better NPD project performance. However, there are very few studies on dynamic capabilities at the team level. As a team, all members who are involved in an existing project play a vital role in achieving innovation projects (Rothaermel and Hess, 2007). Therefore, this study contributes to existing theory by examining the influence of an NPD team's dynamic capabilities on project performance.

Since NPD teams consist of members from a wide range of functional areas [e.g. research and development (R&D), marketing, quality control (QC), production], each individual has a different perspective, potential and specialization based upon their educational backgrounds and job characteristics. For instance, marketing personnel are responsible for seeking out market potentials and requirements, whereas R&D personnel are in charge of finding and implementing new technical and scientific breakthroughs (Brettel *et al.*, 2011). As these two functions regularly encounter conflict because of different personalities, attitudes and work styles (Darawong, 2017), the success of innovation projects depends upon how well they complement each other during the NPD process. Dynamic capabilities can be a source of diverse resource in the decision-making system (Katila and Ahuja, 2002). Hence, it could be problematic for team managers to enhance dynamic capabilities of NPD teams whose characteristics are primarily cross-functional and complex-structured.

The primary objective of this research is to fill the gap in previous NPD studies by examining the impact of dynamic capabilities at the team level and their effect on project performance. The structure of this study is as follows: Section 2 provides the details of two groups of key study variables of a conceptual model. Section 3 develops an argument of four hypotheses based on a literature review. Section 4 describes the methodology, including sample and research design. Section 5 explains the results of data analysis, including descriptive statistics, reliability and validity of the measurements, correlations between constructs and the results of the structural equation modeling (SEM) output. The last section discusses the results of this study and provides the implications, limitations and future research recommendations.

2. Conceptual framework

2.1 Dynamic capabilities

Typically, dynamic capabilities have been viewed as the ability of an organization to cope with changing business environments to survive and sustain competitiveness (Wang and Ahmed, 2007; Wu, 2010). These capabilities are supported by the contingency theory, suggesting that an organization making optimal decisions depends on both the internal and external environment (Scott, 1981). To strengthen competitive advantage, organizations should utilize resources that fit the environment, size or existing technology. Dynamic capabilities potentially enhance resource use because they collectively involve integration, building and reconfiguration of existing competencies when the external environment changes (Kogut and Zander, 1992; Teece *et al.*, 1997).

The notion of dynamic capabilities was first introduced by Teece *et al.* (1997), who define dynamic capabilities as a firm's abilities to strategically integrate, construct and reconfigure both internal and external resources to respond to changing environments. Later studies extended the definition of this concept, mostly in an organizational aspect. For instance, Eisenhardt and Martin (2000) define dynamic capabilities as the organizational processes

and routines of integration, reconfiguration, gaining and releasing a firm's resources to respond to market change. Moreover, Zollo and Winter (2002) suggest that dynamic capabilities must be learned by organizations through collective activities to systematically generate and modify operational routines to be more effective. Wang and Ahmed (2007) characterize these capabilities as an integral set that encapsulates three main components: adaptive, absorptive and innovative.

The existing literature suggests that dynamic capabilities lead to positive organizational outcomes. Importantly, dynamic capabilities improve organizational competitive advantage (Eisenhardt and Martin, 2000; Wu, 2010), competence (Marcus and Anderson, 2006), financial performance (Arthurs and Busenitz, 2006) and NPD performance (Park and Kim, 2013) regardless of environmental volatility. Although a number of studies provide evidence of the significant role of dynamic capabilities in turbulent environment, they focus mainly on the capability of an entire organization. In particular, very few studies empirically have examined the impact of dynamic capabilities at the team level. Therefore, this research attempts to fill this gap by focusing on the dynamic capabilities of NPD teams that extensively require interconnected coordination between team members.

This research examines four major components of dynamic capabilities: sensing, learning, integrating and coordinating (Pavlou and Sawy, 2011). Altogether, these four components better explain and are more robust to measure the characteristics of dynamic capabilities than the three components developed in other previous studies (Barrales-Molina *et al.*, 2013; Eisenhardt and Martin, 2000; Teece, 2007).

First, sensing capability refers to the ability to scan the business environment to evaluate the movement of markets and competitors and to rapidly reconfigure effective processes before the competition (Teece *et al.*, 1997). This capability enables teams to observe and sense market trends and new technologies that can provide opportunities to their firm. NPD teams with sensing capability can quickly recognize and evaluate changes in both current markets and technology. With regard to market change, NPD teams with sensing capability tends to actively capture market intelligence, identify market needs and interpret competitors' moves in timely manner. In terms of technological change, NPD teams are able to grasp recent technological breakthroughs or new scientific discoveries to implement them into new product projects.

Second, learning capability refers to the ability to determine existing operations to gain new knowledge/skills and revamp such operations (Teece *et al.*, 1997). It is a time-consuming and demanding process for a team to truly understand and implement new knowledge into operational tasks. Learning capability is equivalent to absorptive capacity in that it refers to a firm's ability to identify, assimilate and apply knowledge gained from external sources (Cohen and Levinthal, 1990). This capacity consists of four major components: acquisition, assimilation, transformation and application of new knowledge into current operations. Acquisition involves the ability to search for and obtain new knowledge from external sources. Assimilation is the ability to quickly understand new knowledge. Transformation is the ability to adapt or adjust such new knowledge into a usable form for the current situation. Application is the ability to utilize new knowledge to pursue new market opportunities and develop initiatives.

Third, integrating capability refers to the ability to combine or converge individual knowledge amongst a team. To develop this capability, the knowledge that is created and owned by individuals must be integrated into a collective level or team level (Okhuysen and Eisenhardt, 2002). Integrating capability involves three principles activities: contribution, representation and inter-relations. Contribution relates to the extent to which individuals share their knowledge with other team members in the problem-

solving process (Basaglia *et al.*, 2010; Crowston and Kammerer, 1998). Representation relates to visualizing individuals whose specialization and knowledge fit a specific task (Crowston and Kammerer, 1998; Zirger and Hartley, 1996). Interrelations is the link between individual inputs and overall team processes to cope with changing environments (Helfat and Peteraf, 2003).

Fourth, coordinating capability refers to the ability to orchestrate and deploy tasks, resources and activities to fulfil new assignments (Pavlou and Sawy, 2011). It involves four major activities: identification of compatibility between team members' expertise (Wagner and Hoegl, 2006), resource allocation of the tasks (Helfat and Peteraf, 2003), appointing the right person to the right job (Eisenhardt and Brown, 1999) and synchronization of team members' operations (Dacko *et al.*, 2008). Coordinating capability enables a team leader to better understand each functional plans and demands so that he/she can effectively manage team performance and achieve NPD projects (Adler, 1995; Swink and Song, 2007).

To summarize, these four capabilities (sensing, learning, integrating and coordinating) of NPD team members compose the dynamic capabilities of the entire team. In particular, they are very useful for coping with changing environments and have been shown to have collective effects on performance. For example, Pavlou and Sawy (2011) found that the four components of dynamic capabilities have a collectively a positive impact on NPD performance on firms in the US. Similarly, Park and Kim (2013) found that overall dynamic capabilities had a positive impact on NPD performance in small and medium enterprises (SMEs) in Korea. Extending these studies, the author used a first-order model of dynamic capabilities by examining how each component separately affects the performance of radical innovation projects.

2.2 Radical innovation project efficiency and effectiveness

Although dynamic capabilities seem to have a positive effect on organizational performance, they are useful only in uncertain external environments or changing internal conditions (Teece *et al.*, 1997; Zollo and Winter, 2002). In other words, these capabilities require costly mechanisms and managerial commitment and should only be used when an effective response to frequently changing environments is deemed necessary (Barrales-Molina *et al.*, 2013). Investment in the dynamic capabilities of NPD teams may damage overall performance when the current operations and environment are stable.

As radical innovations are fundamentally new to the firm and existing market, NPD teams experience revolutionary changes in technological resources and market requirements (Dewar and Dutton, 1986). Developing radical innovations are usually separated from routine tasks because they require additional skilled technicians and autonomy. Typically, NPD teams that are responsible for radical innovation projects are dynamic, risk-taking, engaging and under stringent control (Chandy and Tellis, 2000) because they seek for breakthroughs and often encounter high levels of uncertain operational and market environments (O'Connor and Veryzer, 2001). To successfully perform radical innovation tasks within uncertain and changing environments, dynamic capabilities are needed. The scope of this study, therefore, covers the dynamic capabilities of NPD teams that influence the performance of radical innovation projects.

Project performance in this research has two dimensions: project effectiveness and efficiency. First, project effectiveness relates to the quality of a finished product and its ultimate financial and non-financial success in the marketplace. This includes a new product's quality, management's satisfaction and sales achievement. Second, project efficiency relates to the degree to which the amount of resources is used to complete the project relative to the pre-specified budget and time frame. It involves a project team's adherence to its budget and a project's cycle time in terms of the early and later stages of the

development process. Previous studies have demonstrated the importance of project effectiveness and efficiency as the outcomes of cooperation (Olson *et al.*, 2001), integration (Brettel *et al.*, 2011) and trust (Madhavan and Grover, 1998) amongst NPD team members. This study, however, uses the effectiveness and efficiency of radical NPD projects as the outcomes of the dynamic capabilities of an NPD team.

Figure 1 identifies the relationship between four components of dynamic capabilities and two types of radical innovation project performance, including efficiency and effectiveness. The following section discusses the hypotheses linking these two groups of variables.

3. Hypothesis development

Drawing upon the literature on organizational strategy, several studies have demonstrated the positive impact of dynamic capabilities on performance in diverse industries. For example, Marcus and Anderson (2006) found that dynamic capabilities affected the competence of the US food retailers in supply chain management, including supplier relations, customer relations and environmental management. In addition, Wu (2010) found that dynamic capabilities are positively related to Taiwanese technology firms' competitive advantage, including their speed in responding to the market, production efficiency, product quality and speed of innovation. In relation to NPD, a study of 241 high-tech SMEs in Korea by Park and Kim (2013) found that overall dynamic capabilities positively influenced NPD performance. The study included several dimensions, such as sales amount, level of innovativeness, development and speed to market. Moreover, Pavlou and Sawy (2011) collected data from 180 firms in the USA and found that the dynamic capabilities of NPD managers from both intra- and inter-firm units had an indirect positive impact on NPD performance, consisting of process efficiency and product effectiveness. Although most previous studies have revealed similar results in that dynamic capabilities have a positive effect on performance, they examined the aggregate effect of these factors on performance. This research thus extends previous studies by examining the separate effect of each dynamic capability component on project performance.

First, sensing capability enables organizations to quickly scan and detect any changes in their business environments, both market and technological, which could create market opportunities (Teece, 2007). With this capability, Day (1994) suggested that organizations should precisely diagnose current capabilities, predict future demands and select the information that fits their context. In the NPD context, NPD teams encounter unfamiliar technical knowledge and processes for radical innovation projects. The sensing capability may enable a team to obtain sufficient information on the latest innovations in current markets and technologies. From a study of the US manufacturing firms, Bendoly *et al.* (2012) found that information timeliness and novelty generate more revenue from a new product

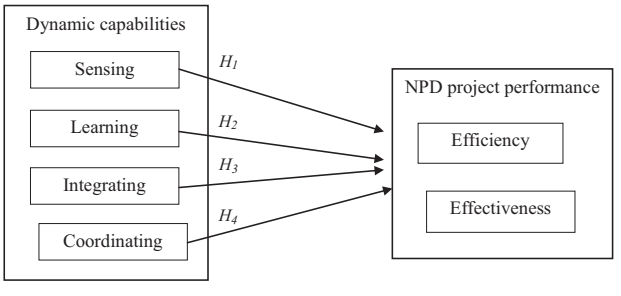

Figure 1.
Conceptual model and hypotheses

project, thereby improving project effectiveness. Moreover, information on new technologies enables NPD teams to find new ways of reducing waste and production time, leading to greater project efficiency. Thus, the following hypotheses can be stated:

H1a. The sensing capability of NPD teams is positively related to project effectiveness.

H1b. The sensing capability of NPD teams is positively related to project efficiency.

Second, learning capability enables teams to gain a deep understanding of market intelligence and then create new knowledge that can be applied to current operations. As suggested by Zahra and George (2002), learning capability is considered as absorptive capacity, which involves the ability to acquire, assimilate, transform and exploit such knowledge. Popaitoon and Popaitoon (2016) found that absorptive capacity is crucial for long-run NPD project success. With this capability, needed information is accumulated and sent to real users who can instantly apply it to their assignment or projects. Baker and Sinkula (1999) collected data from 411 executives in the US and found that learning orientation (i.e. commitment to learning, shared vision and open-mindedness) directly improves product innovation and indirectly enhances organization performance such as sales revenue, market share and profit. Moreover, Alegre and Chiva (2008) found that organizational learning capability improved the performance of Italian and Spanish ceramic tile producers' product innovation. On the NPD team level, learning capability is expected to enable team members to effectively gather all relevant information and knowledge regarding the market, technology, environment, industry and processes. An NPD team can then proceed in development activities by disseminating and exchanging information amongst members. In a study of technology-based companies in the USA, Akgun *et al.* (2006) found that the ability to implement exchanged information in new product projects has a direct positive impact on NPD success, including sales, profitability and market share (i.e. project effectiveness). In addition, teams that apply new knowledge to current operations may reduce development time, making then more efficient. Thus, the following hypotheses can be stated:

H2a. The learning capability of NPD teams is positively related to project effectiveness.

H2b. The learning capability of NPD teams is positively related to project efficiency.

Third, integrating capability refers to the ability of individuals to combine received information with existing the knowledge of current operations (Pavlou and Sawy, 2011). To achieve NPD projects, team members are required to integrate their information and knowledge with both internal and external sources. Information from internal sources is drawn from core functions such as marketing, R&D and manufacturing. When team members integrate this information, their mutual understanding is improved. Sherman *et al.* (2005) found that the integration of current information across functions improves project performance, including product and process proficiency. On the other hand, integrating information with external sources (i.e. suppliers and customers) is also necessary to reduce the uncertainty and equivocality of highly competitive environments. With supplier integration, NPD teams exchange information with close suppliers to cooperatively generate new product ideas and technology. Consequently, these teams can obtain superior access to high-quality raw materials at the early stages of the development process. With customer integration, NPD teams discover market requirements by listening to their customer and subsequently tailoring their products to meet actual demands (Sandmeier *et al.*, 2010). Koufteros and Vonderembse (2005) found that integration with these external parties can improve product quality and innovation, leading to project effectiveness. They also found

that the integration process provides additional professionals who can potentially shorten the critical path and ensure on-time market launches (i.e. project efficiency). Thus, the following hypotheses can be stated:

H3a. The integrating capability of NPD teams is positively related to project effectiveness.

H3b. The integrating capability of NPD teams is positively related to project efficiency.

Fourth, coordinating capability focuses on identifying and incorporating resources (e.g. information, knowledge, personnel) with current tasks and activities. In a study of 240 manufacturing firms in Greece, Protogerou *et al.* (2011) found that dynamic capability, which involves coordinating capability, directly improves firm performance. In the context of NPD teams, this capability enables a team to allocate resources and disseminate information to all members involved in the development process. In addition, a team with coordinating capability is able to effectively assign the right person to the right task. For instance, marketing personnel with expertise in market demands and some technical knowledge should be assigned to work with R&D technicians. Swink and Song (2007) found that coordination activities between marketing and manufacturing departments enhance NPD performance, which captures product quality or market share (i.e. project effectiveness) and time-to-market (i.e. project effectiveness). Thus, the following hypotheses of this study can be stated:

H4a. The coordinating capability of NPD teams is positively related to project effectiveness.

H4b. The coordinating capability of NPD teams is positively related to project efficiency.

4. Research methodology

4.1 Sampling

The sample in this study consisted of NPD team members who represent different departments, including R&D, QC, production and marketing. These individuals worked in a wide range of large manufacturing industries with an average of more than five hundred employees in Thailand. These industries include food, automotive, auto parts and electric and electronics products. Importantly, the sample characteristics were identified based on job responsibility and activities to ensure that the collected data were reliable and valid. In the screening process, target respondents were asked whether they were engaged at any stage of the NPD process (e.g. idea generation, product testing and new product launch). Also, they must have worked on a radical NPD project for at least one year to ensure sufficient knowledge for this study. If this requirement was met, the respondents were contacted and informed of the objectives and scope of this research to solicit their participation.

To obtain correct responses, these respondents were assured that their answers on company product information would be kept anonymous and confidential. As collecting data on radical NPD projects involved company products secrecy, it was quite difficult to gain access and willingness to participate from several manufacturers. For this reason, purposive and snowballing methods were used by personal contact with those who had good relationships with the researcher. As a result, a total of 280 usable questionnaires out of 400 were returned from 14 manufacturing firms, providing a response rate of 70 per cent. In total, 120 respondents were from R&D, 85 from marketing, 55 from QC and 20 from production.

4.2 Measures

Dynamic capabilities have been measured by many researchers in previous studies. For example, Teece (2007) developed three groups of capabilities (i.e. sensing, seizing and transforming) to measure dynamic capabilities. Volberda (1996) measured dynamic capabilities based on organizational flexibility, including operational, structural and strategic flexibility. To better capture the overall characteristics of dynamic capabilities, this study therefore adapted items based on the four components (i.e. sensing, learning, integrating and coordinating) of dynamic capabilities developed by Pavlou and Sawy (2011). Respondents were asked to rate four statements for sensing, five for learning, five for integrating and five for coordinating that best describe an NPD team's dynamic capabilities (Appendix 1). For dependent variable, NPD project performance, including effectiveness and efficiency, was measured using a scale adapted from Olson *et al.* (2001). The respondents rated three statements for both constructs of team performance. These selected items for each construct have been widely used, well-developed and repeatedly tested in the literature. All items in this study were rated on a five-point scale anchored by 1 = strongly disagree to 5 = strongly agree.

Following the back translation method (Brislin, 1980), selected items were first translated into Thai by one person and then retranslated into English by a native speaker. The two translators then jointly reconciled all the differences and refined the wording. A draft of the questionnaire in Thai was pre-tested and subsequently revised by five research associates with experience in several management research projects. After a draft of questionnaire was finalized, it was distributed to target respondents through email or post, using a self-administered method.

5. Results

The descriptive statistics in Table I show the general information on each factor and the correlations amongst all constructs. In terms of dynamic capabilities, NPD team members experienced a slightly high level in all dimensions: sensing ($\bar{x}$ = 3.490, SD = 0.774), learning ($\bar{x}$ = 3.626, SD = 0.623), integrating ($\bar{x}$ = 3.449, SD = 0.722) and coordinating ($\bar{x}$ = 3.665, SD = 0.557). Similar results were found for the level of project effectiveness ($\bar{x}$ = 3.827, SD = 0.574) and efficiency ($\bar{x}$ = 3.108, SD = 0.719). In addition, the assumptions of multivariate analysis were tested. First, the correlations between variables were less than 0.80, indicating that multicollinearity was not a problem (Cohen *et al.*, 2011). Second, the *P* value of the Kolmogorov Smirnov test was less than 0.05, indicating that the normality of study variables was assumed. Third, the scatterplot of the standardized predicted dependent variable by the standardized residuals had a random distribution, indicating the homoscedasticity was assumed.

Table I.
Means, standard deviations and correlations

Variables	Mean	SD	1	2	3	4	5	6
1. Sensing	3.490	0.774	1.000					
2. Learning	3.626	0.623	0.613	1.000				
3. Integrating	3.449	0.722	0.150	0.275	1.00			
4. Coordinating	3.665	0.557	0.541	0.663	0.171	1.00		
5. Effectiveness	3.827	0.574	0.504	0.655	0.328	0.510	1.00	
6. Efficiency	3.108	0.719	0.365	0.453	0.294	0.423	0.592	1.00

Note: All correlations are significant at the 0.05 level (two-tailed)

The results of inferential statistics were analyzed by a SEM procedure, following the two-stage method recommended by Anderson and Gerbing (1988). First, the model's reliability and validity were tested by using SPSS. Second, hypotheses of the theoretical model were tested by SEM techniques that combine factor analysis and path analysis.

5.1 Measurement model

In testing construct validity, Table II summarizes the results of the measurement model with 25 items across six constructs. The fit indices show considerably good statistics. The standardized factor loadings for each indicator are positive for each theoretically assigned construct. All loadings exceed the minimum value of 0.50, as suggested by Hair *et al.* (1998) (Appendix 2).

Construct	Standardized loading	Cronbach's alpha coefficient	Average variance extracted	Construct reliability
Sensing		0.852	0.567	0.837
SEN1	0.638			
SEN2	0.634			
SEN3	0.868			
SEN4	0.839			
Learning		0.882	0.594	0.879
LRN1	0.757			
LRN2	0.820			
LRN3	0.825			
LRN4	0.731			
LRN5	0.713			
Integrating		0.916	0.690	0.917
ITG1	0.831			
ITG2	0.868			
ITG3	0.878			
ITG4	0.829			
ITG5	0.739			
Coordinating		0.847	0.530	0.848
COR1	0.676			
COR2	0.704			
COR3	0.863			
COR4	0.709			
COR5	0.671			
Effectiveness		0.739	0.500	0.748
EFT1	0.725			
EFT2	0.778			
EFT3	0.608			
Efficiency		0.777	0.542	0.780
EFC1	0.716			
EFC2	0.762			
EFC3	0.729			

Notes: All loadings are significant at $p < 0.01$; model fit indices: $\chi^2 = 584.470$, $p = 0.00$, $df = 255$; RMSEA = 0.068; and CFI = 0.917

Table II. Properties of the measurement model

To analyze the reliability of all measures, the Cronbach's alpha coefficient of each construct was computed (Table II). The result showed that all values were above 0.77, which was greater than the value of 0.70, recommended by Nunnally and Bernstein (1994). To measure convergent validity, the values of average variance extracted (AVE) and composite reliability (CR) were analyzed. The result indicated that all values surpassed the critical point of 0.40 and 0.70. To measure discriminant validity, the squared correlations between variables were observed. For example, the square correlation between learning and coordinating capabilities was 0.439 (obtained from 0.663^2). This value was lower than the AVE of the two variables (0.608 and 0.530), providing the evidence for discriminant validity (Fornell and Larcker, 1981). Overall, the reliability and validity of the measurement model were supported by acceptable fit indices [$\chi^2_{(255)} = 584.470$ ($p = 0.00$), a root mean square error of approximation (RMSEA) = 0.068 and comparative fit index (CFI) = 0.917].

5.2 Structural model

The overall structural model fit is considerably good with the following values: $\chi^2_{(258)} = 609.49$, $p = 0.00$; RMSEA = 0.07, CFI = 0.911 (Table III). The variance in project effectiveness and efficiency can be explained by 48.8 and 27.6 per cent, respectively. Project effectiveness is positively influenced by sensing (beta = 0.155, $p < 0.05$), learning (beta = 0.449, $p < 0.01$) and integrating (beta = 0.137, $p < 0.05$) capabilities. In addition, project efficiency is positively influenced by learning (beta = 0.236, $p < 0.10$), integrating (beta = 0.164, $p < 0.05$) and coordinating (beta = 0.189, $p < 0.10$) capabilities. Therefore, *H2a*, *H2b, H3a* and *H3b* are fully supported, whereas only *H1a* and *H4b* are supported.

6. Discussion and implications

This study focuses on the impact of dynamic capabilities on project effectiveness and efficiency. In regard to effectiveness, the results show that sensing, learning and integrating increase team effectiveness. That is, if a NPD team has the capability of sensing the changes in business environments, learning current internal and external activities and integrating different sources of knowledge, they can reach pre-specified new product standards to management's satisfaction. In regard to efficiency, team members with high learning, integrating and coordinating capabilities will enhance team efficiency. As such, learning, integrating and coordinating can reduce development time and control incurred costs within a pre-determined budget. Although

		Effectiveness		Efficiency	
Independent variables	Hypothesis	Standardized regression weight	*t*-value (standard error)	Standardized regression weight	*t*-value (standard error)
Sensing	*H1*	0.155**	1.979 (0.078)	0.113	1.277 (0.089)
Learning	*H2*	0.449***	3.912 (0.115)	0.236*	1.879 (0.126)
Integrating	*H3*	0.137**	2.793 (0.049)	0.164**	2.902 (0.056)
Coordinating	*H4*	0.112	1.125 (0.099)	0.189*	1.662 (0.114)
R^2		0.488		0.276	

Table III. Results

Notes: Model fit indices: $\chi^2 = 609.49$ ($p = 0.00$), $df = 258$; RMSEA = 0.07; CFI = 0.911; *significant at the $p < 0.10$ level; **significant at the $p < 0.05$ level; ***significant at the $p < 0.01$ level

Park and Kim (2013) found that only the aggregated form, not separated form, of dynamic capabilities influence NPD performance, this research finding extends their results into how a single capability can affect the project effectiveness and efficiency of radical NPD projects.

This study suggests two theoretical implications in NPD research. First, this study extends existing theories by examining the separate impacts of each component of dynamic capability on radical innovation projects. The findings show that learning capability is the most important ingredient of an NPD team in achieving target performance. As suggested by Barrales-Molina *et al.* (2013), learning mechanisms such as knowledge codification help to reconfigure existing routines. Second, the study enhances the current understanding on how different dynamic capabilities influence two aspects of NPD team performance: effectiveness and efficiency. To improve both effectiveness and efficiency, learning and integrating capabilities are the critical components of NPD teams.

In addition, two managerial implications can be suggested to NPD team managers or management teams to improve project effectiveness and efficiency. First, learning capability should be enhanced by building knowledge exchange and use in the working environment. In doing so, NPD managers may arrange a forum or seminar that provides opportunities for all involved members to freely communicate their own experiences in NPD and expose to other function-related issues. As suggested by Darawong (2015), frequent communication amongst NPD team members can effectively enhance the ability of absorbing and using both internal and external knowledge. Second, integrating capability can also be enhanced by motivating all team members to contribute to each other's efforts, knowledge and skills in their tasks and activities. Team managers or leaders should use individualized consideration methods by treating, coaching and advising each member to integrate their expertise into collective tasks. In addition, performance appraisal should be based on individual input into a new product project. As suggested by Marsh and Stock (2003), inter-temporal integration in NPD teams can be promoted by managers through activities that gather and transform existing knowledge from prior projects and applying it to future NPD projects.

7. Limitations and future research

This research, however, has a few important limitations that need to be taken into consideration. First, most respondents were limited to three industries (food, electric and electronics and automotive); therefore, the findings of this research may not be generalizable in all aspects to other industries. Future study should obtain a larger sample size from a variety of innovative industries (e.g. agriculture and chemical products) to enhance generalizability of the findings. Second, although the use of cross-sectional data in this study may not be appropriate for testing causal relationships among constructs (Rindfleisch *et al.*, 2008), several empirical studies on innovation have undertaken cross-sectional research designs (Naqshbandi, 2016). Longitudinal studies in future research can establish greater confidence in inferring the causal relationships. Third, although the samples of this study were from a wide range of functional areas, the majority were R&D personnel, who accounted for 42.86 per cent of the total sample. These respondents may have their own perspectives and biases, which could influence their responses. Future research should equally distribute sample groups to better represent an entire NPD team.

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Appendix 1. Survey items measuring dynamic capabilities and project performance

Sensing capability (SEN)

- We frequently scan the environment to identify new business opportunities.
- We periodically review the likely effect of changes in our business environment on customers.
- We often review our product development efforts to ensure they are in line with what the customers want.
- We devote a lot of time implementing ideas for new products and improving our existing products.

Learning capability (LRN)

- We have effective routines to identify, value and import new information and knowledge.
- We have adequate routines to assimilate new information and knowledge.
- We are effective in transforming existing information into new knowledge.
- We are effective in utilizing knowledge into new products.
- We are effective in developing new knowledge that has the potential to influence product development.

Integrating capability (ING)

- We are forthcoming in contributing our individual input to the group.
- We have a global understanding of each other's tasks and responsibilities.
- We are fully aware of who in the group has specialized skills and knowledge relevant to our work.
- We carefully interrelate our actions to each other to meet changing conditions.
- Group members manage to successfully interconnect their activities.

Coordinating capability (COR)

- We ensure that the output of our work is synchronized with the work of others.
- We ensure an appropriate allocation of resources (e.g., information, time, reports) within our group.
- Group members are assigned to tasks commensurate with their task-relevant knowledge and skills.
- We ensure that there is compatibility between group members expertise and work processes.
- Overall, our group is well-coordinated.

Project effectiveness (EFT)

- The new product's quality relative to that of other product recently developed by the firm.
- Management's satisfaction with the product's design and performance.
- The degree to which sales objectives were reached.

Project efficiency (EFC)

- The degree to which the project came in under or over budget.
- The time required to complete the project relative to the anticipated time frame in the early stages of development, including idea generation, concept testing and business assessment.
- The time required to complete the project relative to the anticipated time frame in later stages of development, including prototype development product testing and commercialization.

Appendix 2

Table AI.
Factor analysis[a]

Items	Sensing	Learning	Integrating	Coordinating	Effectiveness	Efficiency
SEN1	*0.860*	0.137	0.053	0.131	0.066	0.006
SEN2	*0.865*	0.098	0.038	0.092	0.085	0.112
SEN3	*0.694*	0.277	0.028	0.209	0.157	0.168
SEN4	*0.629*	0.338	0.044	0.303	0.117	0.036
LRN1	0.317	*0.676*	0.103	0.210	0.078	0.167
LRN2	0.281	*0.750*	0.082	0.189	0.166	0.145
LRN3	0.216	*0.717*	0.081	0.218	0.296	0.089
LRN4	−0.006	*0.830*	0.103	0.268	0.080	0.005
LRN5	0.188	*0.712*	0.128	0.246	0.162	0.105
ITG1	0.041	0.125	*0.837*	0.126	0.115	0.088
ITG2	−0.042	0.078	*0.877*	0.037	0.106	0.034
ITG3	−0.036	0.104	*0.895*	0.046	0.024	0.003
ITG4	0.147	0.112	*0.854*	0.018	0.083	0.081
ITG5	0.090	−0.013	*0.800*	0.038	0.027	0.164
COR1	0.144	0.104	0.065	*0.708*	0.236	0.090
COR2	0.108	0.175	0.056	*0.741*	0.048	0.080
COR3	0.184	0.306	−0.019	*0.765*	0.153	0.088
COR4	0.040	0.230	0.114	*0.769*	−0.038	0.118
COR5	0.277	0.205	0.044	*0.663*	0.098	0.071
EFT1	0.067	0.298	0.114	0.141	*0.742*	0.220
EFT2	0.121	0.149	0.132	0.076	*0.834*	0.131
EFT3	0.377	0.191	0.137	0.252	*0.530*	0.054
EFC1	0.095	0.146	0.016	0.247	0.384	*0.651*
EFC2	0.008	0.167	0.200	0.009	0.109	*0.845*
EFC3	0.187	0.057	0.114	0.190	0.052	*0.813*
Eigenvalue[b]	1.686 (3.010)	3.401 (3.432)	8.354 (3.825)	1.710 (3.295)	1.057 (2.08)	1.423 (2.060)
Percentage of variance[c]	6.893 (13.179)	13.603 (13.693)	33.417 (15.299)	6.839 (13.179)	4.229 (8.073)	5.692 (8.240)

Notes: [a]Principle component analysis. Varimax rotated factors. italic factor loadings of survey items related to the corresponding construct; [b]Eigenvalue of the initial extraction (eigenvalue for the rotated factors); [c]Percentage of variance of the initial extraction (percentage of variance for the rotated extraction); cumulative percentage = 70.522

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