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The Concept of Dynamic Capability for Managing Technology and Change

Mohamad Faizal Ahmad Zaidi¹, and Siti Norezam Othman²

Abstract

There are numerous conceptual and empirical studies on the topic of dynamic capability where most of them were demonstrated to address the innovation and technological-related issues. However, there are still many issues surrounding the concept that need further clarification. To explicitly understand how dynamic capability can benefit technology management, this paper reviews the fundamental of dynamic capability concept, the issues surrounding the topics under discussion, and its relevance for managing technology and change. By doing so, the link between dynamic capability and technology management can be clarified. This review paper should benefit both the academicians and students who interested in management of technology and change with the concept of dynamic capability.

Keywords: Dynamic capability; technological capability; technological change; technology management

1. Introduction

The strategy has been shifted from industry-level to firm-level of analysis in explaining the source of competitive advantage where the strategic focus is on the capability building since 20 years ago (Davis, 2004). It is difficult for firms to preserve their competitive advantage when the competitive environment keeps changing as the resources and capabilities of firms are dynamics in nature.

This occurs since their relationship is always changing (Grobler, 2007) together with continuous change of the environment that creates gaps between the firms' current capabilities and the market needs.

¹ School of Technology Management and Logistics, College of Business, Universiti Utara Malaysia.
Email: mdfaizal@uum.edu.my

² School of Technology Management and Logistics, College of Business, Universiti Utara Malaysia.

However, firms will ultimately respond to the changes whenever their performance is at risk. Thus, it is well expected that firms will do something to defend their current positions in the marketplaces. But, there are lots of stories where incumbents no longer remain competitive in the new market settings and their positions are overtaken by much newer and more innovative firms. This is because the way they respond to the market is insufficient and do not match the needs of the changes and their strategy is easily duplicated by competitors. Therefore, the only choice firms have to remain competitive in the marketplaces is by continuously building new capabilities according to the changes to match the changing needs with the processes/skills/routines that are unique and difficult-to-duplicate by competitors, which can be achieved with the concept of dynamic capability (DC).

In general, DC is gaining great attention in strategic management and is becoming an important topic since early 1990s where the discussion about the origin of the concept can be traced back as early as 1959 by Penrose. The concept of DC is designed to achieve sustainable competitive advantage (Teece, Pisano, & Shuen, 1997; Teece, 2007), rent creation (Makadok, 2001; Blyler & Coff, 2003), and performance (Majumdar, 2000; Zott, 2003; Pablo, Reay, Dewald, & Casebeer, 2007). DC is to build new competitive advantage that meets changing market needs in a timely manner where emphasis is put on two aspects which is not major focus in the previous researches. First, the 'dynamic' aspect of DC which refers to the firms' capacity to renew competences such as innovation; second, the 'capabilities' aspect of DC which refers to the firms' ability to create change through integration, building, and reconfiguration of competences to match changing environments.

DC building processes is explained by the idiosyncrasy of the firm which create causal ambiguity that makes it hard to understand the link between DC and performance, hence difficult to tell the source of competitive advantage (Teece, Pisano, & Shuen, 1997). Furthermore, DC is all about processes (Cetindamar, Phaal, & Probert, 2009) and as long as firms have bundle of resources, they can effectively use DC (Majumdar, 2000) by creating new or different set of resources to respond to market changes especially under volatile market conditions (Sirmon, Hitt, & Ireland, 2007). Anyway, it is argued that DC does not directly impact competitive advantage as the effect is through reconfiguration of resources and capabilities.

Meanwhile, as the continuity of firm's business is at the risk when the environment its dealing with is developing very fast (Wu & Wang, 2007) with rapid introduction of new technology and a shorter lifecycle (Wu, 2007), building the right link between firm's technological innovation strategies and NPD activities is crucial (Marsh & Stock, 2006). As such, most studies on DC is about innovation and NPD (Zahra, Sapienza, & Davidsson, 2006) and usually related to the technological capability and change (Teece, Pisano, & Shuen, 1997), such as emerging knowledge economy, global competition and technological advance (Lawson & Samson, 2001), converging technologies (Bhutto, 2005), radical and new innovation (O'Connor, 2008), new product and process creations (Helfat, 1997), rapid development of new products (Deeds, DeCarolis, & Coombs, 1999), and uncertainty of technological knowledge, lack of complementary technologies and developed markets (Marsh & Stock, 2006). This implies that DC concept is closely related and very useful for managing technology and change.

As a results, this paper attempts to further clarify the link between the concept of DC and technology management to increase the knowledge on the above-mentioned fields for the benefit of both the academicians and students.\

2. Concept of Dynamic Capability

From the concept of resource-based view (RBV), sustainable competitive advantage is determined by the possession of bundle of resources with valuable, rare, inimitable, and non-substitutable (VRIN) characteristics, but under unpredictable market condition, looking at the relationship of resources and performance alone to achieve sustainable competitive advantage will be insufficient. This is because when the environment is not stable, the resources are not strongly favoring the competitive advantage of the firms (Wu, 2006). As such, to sustain competitive advantage in highly volatile market, firms must continuously reconfigure the resources to create a series of short-term competitive advantage (Eisenhardt & Martin, 2000). Thus, the strategic focus of firms has changed from the effective ways of managing unique resources to the effective ways of modifying resources in rapid changing environment (Kylaheiko & Sandstrom, 2007). Therefore, in order to deal with changing market needs that affects firms' competitive advantage, the concept of DC is suggested as the theory of RBV is not relevant in the situation of rapidly changing environment, in which resources alone will not be able to be translated into performance (Wu, 2006).

The ability of firms to compete in the market is reflected by the capability they possess (O'Reilly & Tushman, 2008) as it affects the way firms use their assets such as resources and knowledge (Forbes & Wield, 2008). Capability is nontransferable (Makadok, 2001) but does not last very long as it changes over time through the process of accumulation and depletion (Bayer & Gann, 2007). Know-how, learning process, business secret, and reputation are examples of capabilities that create advantage to the firms as these capabilities are difficult to acquire from external business environments (Chen & Lee, 2009) and is intangible in nature (Ayuso, Rodriguez, & Ricart, 2006).

The firms' continuity of competitive advantage under the condition of dynamic environments can be assured when firms consistently develop and renew capabilities over time (Hou, 2008) as new goal appears (Canibano, Encinar, & Munoz, 2006) to respond to opportunities or threats. Thus, the organizational capabilities create competitive advantage (Bayer & Gann, 2007) with the frequency introduction of the new product and/or service to the market (Yalcinkaya, Calantone, & Griffith, 2007) that will create a series of short-term competitive advantage (Eisenhardt & Martin, 2000), hence creating a sustainable competitive advantage. However, not all firms will succeed in pursuing higher level performance (Majumdar, 2000) because of differences that exists between firms. In addition, organizational capabilities are different from DC (Lee & Kelley, 2008) because DC is meta capability (Collis, 1994) or higher level capability (Wang & Ahmed, 2007) that is needed to become higher performers (Cetindamar, Phaal, & Probert, 2009).

In general, the concept of DC that are commonly discussed in literature are environment (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997), assets and resources (Cavusgil, Seggie, & Talay, 2007; Bowman & Ambrosini, 2003), processes and activities (Menon, 2008; O'Connor, 2008), learning processes (Hou, 2008; Cavusgil, Seggie, & Talay, 2007), and specificity and commonality of DC (Menon, 2008; O'Connor, 2008).

3. Resource Base of Dynamic Capability

There are many definitions in literature that stress on resources as important aspect of DC such as definitions by Kaminska-Labbe, Thomas and Sachs (2005), and Zahra, Sapienza and Davidsson (2006).

DC is an internal resource orientation rather than external orientation (Zhou & Li, 2009) where the internal resources and capabilities are the crucial factors to the success of firms in competition (Grobler, 2007). However, even though DC is internal resource oriented, the resource base for DC can be both internal and external to the firms as long as they have access to the resources even if the resources are outside the firms' boundaries such as alliance-based DC and acquisition-based DC in which both are related to the relational capability of DC (Helfat, et al., 2007).

Resource base is referred to the firm's resources or assets consisting of technological assets, complementary assets, financial assets, reputational assets, structural assets, institutional assets, and market assets (Teece, Pisano, & Shuen, 1997) that are divided into tangible and intangible assets (Hitt, Ireland, & Hoskisson, 2005) and controlled or assessed by firms (Grobler, 2007; Helfat & Peteraf, 2003). There are various tangible and intangible assets such as specialized know-how, management capability, alliance experience and financial capital (tangible asset) as suggested by Wu (2010) when investigating the resources relationship with competitive advantage under environmental volatility. In DC study, processes are also treated as resources (Helfat, et al., 2007).

Resource management is a comprehensive process of structuring firm's resource portfolio, bundling the resources to build capabilities, and leveraging those capabilities with the purpose of creating and maintaining the value for customers and owners. Thus, the firms' success is affected by the managerial skills at resources selection and development (Sirmon, Hitt, & Ireland, 2007). In addition, resources coordination and firms' routines are the elements of DC (Hong, Kianto, & Kylaheiko, 2008) where DC is focusing on modifying the firms' resources to match the changing environment (Bowman & Ambrosini, 2003). As the changing of resources positions at various time will cause differences in firms' performance (Zott, 2003), the new or improved resources are always needed whenever major changes happen in the market to respond to the new demands. However, it is difficult to assure that resources possessed by the firms have a potential to create value in the future when the environment is hard to be predicted (Sirmon, Hitt, & Ireland, 2007).

Strategic capabilities are built from resources but possessing of resources does not guarantee capability building for firms. This is because resources and capabilities systems of the firms are dynamic in nature and their relationships are always changing.

With the VRIN characteristics of the firms' assets, the internal processes and efforts are crucial in building DC than the external efforts. Among examples of resources that have been used in empirical researches of DC are technological, alliance, human resources, and planning (Liao, Kickul, & Ma, 2009), specialized know-how, capital, operational management capability, reputation, and cooperative alliance experience (Wu, 2009; Wu & Wang, 2007), resource know-how, capital, and managerial capacity (Wu, 2007), and asset specificity, relationship predictability, market knowledge gap, and type of market (Griffith & Harvey, 2001).

4. Levels of Dynamic Capability

As suggested by literature, DC is not an ordinary resource because it is a resource that is capable of renewing resource. This means resource base can be identified in hierarchical order. For example, the empirical analyses of various categories of resources to firm success was made by Galbreath (2005) where he identified three categories of resources which are; (1) the tangible resources such as financial assets, (2) the assets related to intangible resources such as intellectual property, and (3) the skills related to intangible resources such as capabilities. However, he does not classify capabilities further into core capabilities even though they are different in their effects to the firm success. In addition, it is argued that core capabilities are better than capabilities, and capabilities are better than resources as the sources of competitive advantage according to the hierarchy. Nevertheless, more detailed categories of resources have been suggested by Wang and Ahmed (2007).

Wang and Ahmed (2007) posited that firm's resources and capabilities are in hierarchy order when addressing competitive advantage, which Ambrosini and Bowman (2009) termed as DC typologies. Wang and Ahmed (2007) identified resources as the zero-order, while capabilities as first-order, core capabilities as second-order, and DC as third-order in the hierarchy. They claim DC is the ultimate organizational capabilities and therefore is the source of sustainable competitive advantage instead of simply a subgroup (Lopez, 2005) or subset of capabilities (Teece, Pisano, & Shuen, 1997). However, the categorization of resources and capabilities in hierarchy order are not the first of its kind as Collis (1994) has defined organizational capabilities in three categories after he claims there was so many versions of organizational capabilities definitions in literature. For this reason, he categorized the organizational capabilities as the first category of capability, second category of capability, and third category of capability.

It is agreed that Wang and Ahmed's hierarchy order and Collis's category of capabilities are referring to the ranking in organizational capabilities where DC is the third-order (ultimate) or third category of organizational capabilities. As it is the ultimate of organizational capabilities, DC is therefore different from the rest of organizational capabilities because it enables the firm to innovate outside the routines (Lee & Kelley, 2008). Base on the literature, the second- and third-order capabilities are DC in nature. However, the physical border between the hierarchies is hard to be explicitly determined (Collis, 1994).

5. Focus of Dynamic Capability

The literatures have contributed to the understanding and development of the concept of DC, promoting DC as an important tool to sustain competitive advantage under dynamic environments, drawing guidelines for firms to build DC, analyzing and/or examining the use of DC in various industries, and showing the evidences of successful implementations of DC through case studies. The literatures both in empirical and conceptual offer valuable knowledge as they identify, develop, demonstrate, examine, or explain DC under various setting. As such the interest of scholars in DC are moving around the development and understanding of theory (Teece, Pisano, & Shuen, 1997; Eisenhardt & Martin, 2000; Winter, 2003; Helfat & Peteraf, 2003), the drivers of DC (Chen & Lee, 2009; Chen, Lee, & Lay, 2009), the critical elements of DC (Kylaheiko & Sandstrom, 2007), the key determinants of DC (Deeds, DeCarolis, & Coombs, 1999), the mechanisms for DC (Zollo & Winter, 2002), the effects/impacts of DC (Jantunen, Puumalainen, Saarenketo, & Kylaheiko, 2005; Bhutto, 2005), to examine/analyze DC (Wu, 2009), and to promote/demonstrate the use of DC (Lopez, 2005; Grobler, 2007; Wu, 2007).

At the same time, researches have also taken places in various industries such as manufacturing (Kylaheiko & Sandstrom, 2007), high-tech (Helfat, 1997; Deeds, DeCarolis, & Coombs, 1999; Hung, Chung, & Lien, 2007; Wu, 2009), consumer products (Zhou & Li, 2009), public sector (Pablo, Reay, Dewald, & Casebeer, 2007) and telecommunications, information technology, and mobility industry (Majumdar, 2000; Bhutto, 2005; Wu & Wang, 2007; Cepeda & Vera, 2007).

Meanwhile, the themes that normally studied under DC other than strategic management are strategic alliances (Chen & Lee, 2009; Chen, Lee, & Lay, 2009), entrepreneurship (Jantunen, Puumalainen, Saarenketo, & Kylakeiko, 2005; Wu, 2007), knowledge management and organizational learning (Zollo & Winter, 2002; Cepeda & Vera, 2007; Pablo, Reay, Dewald, & Casebeer, 2007; Chen, Lee, & Lay, 2009), new product development (Deeds, DeCarolis, & Coombs, 1999), R&D (Helfat, 1997), and innovation (Miguel, Franklin, & Popadiuk, 2008; Liao, Kickul, & Ma, 2009).

However, DC has been questioned in several aspects such as the inconsistency of definitions and terms, and its vague relationships with competitive advantage. There is no single definition that is superior than the others to best describe DC as the definition need further clarification (Wang & Ahmed, 2007) and since the concept is still new (Czakon, 2009) and the theory itself is still in great debate (Zahra, Sapienza, & Davidsson, 2006), while some scholars have argued that DC are capable but not necessarily sufficient to achieve competitive advantage.

6. Elements of Dynamic Capability for Technology Management

DC is entrepreneurial in nature where firms' capabilities are developed via learning processes and knowledge management. When related to technology management, DC is crucial in the contexts of highly technological and market turbulence (Lichtenthaler, 2009), thus, the innovative outcomes of resource modification are to address the technological and market changes. The following are the critical underscores of DC regarding technology management.

6.1 Innovation Capability and Dynamic Capability

Product innovativeness is firms' capabilities (Cavusgil, Seggie, & Talay, 2007) where innovative capability is a component of DC (Wang, & Ahmed, 2007). It is evident that the more innovative the firms are, the more DC they become (Miguel, Franklin, & Popadiuk, 2008). In such, most of the studies regarding DC are about innovation and new product development (Zahra, Sapienza & Davidsson, 2006). For instance, the outcomes of DC is associated to innovation as "a set of practices aimed at enabling novel approaches for assembling and integrating resources to achieve innovative outcomes" (Lee & Kelley, 2008, p. 156). In addition, as DC is related to uncertainty and rapidly changing environments (Teece, Pisano, & Shuen, 1997), in order to survive in the environments, firms need to be more "flexible, innovative and creative" (Biedenbach & Soderholm, 2008, p. 124) when reconfiguring resources.

Furthermore, continuously changing in marketplaces may bring early innovation to the firms (Zahra, Sapienza, & Davidsson, 2006) as firms actively sensing and seizing opportunities, and reconfiguring resources.

DC impact innovative strategies on the firms and help in building business model for innovation and technology (Kolk & Puumann, 2008). However, the process of innovation varies among firms as they have different strategy, management style, and competitive environments (Lawson & Samson, 2001). Moreover, different levels of uncertainties require different management approach for innovation (O'Connor, 2008). Research has found that strongly innovative firms are more capable at building DC through knowledge creation than weakly innovative firms. Moreover, strongly innovative firms are more positive towards encouraging employees to take challenges, higher employees commitment, focusing on knowledge creation, and more oriented to external environments (Miguel, Franklin, & Popadiuk, 2008). Similarly, when the level of uncertainty is high, the process of innovation is better for firms with DC (Lee & Kelley, 2008) where the more innovative firms possess more DC than less innovative firms (Wang & Ahmed, 2007).

Increasing level of commitment for innovation alone is just enough to maintain current position without any improvement gains to performance (Lawson & Samson, 2001). Thus, in order to improve performance, firms must continuously search for new opportunities. Therefore, effective innovation is needed as it links the ability of firms to constantly match resources and capabilities with opportunities (Liao, Kickul, & Ma, 2009). In addition, sustaining innovative capabilities is more critical in industry with mature technology (Ray, Ida, Chung-Sok, & Rhaman, 2004). However, innovation does not just create opportunities but also bring constraints to the firms (Consoli, 2008) which can cause competency traps (Liu, 2006).

6.2 Technological Capability and Dynamic Capability

The levels of technological capability are significant at sustaining competitive advantage (Ray, Ida, Chung-Sok, & Rhaman, 2004). However, to sustain competitive advantage, firms need to confront with turbulence in high market and uncertainty of technologies (Kylaheiko & Sandstrom, 2007).

The dynamic of technological capabilities together with the scientific capabilities of firms determine the firms' ability to constantly build new product as the environments are continuously changing (Deeds, DeCarolis, & Coombs, 1999). This allows transformation of resources into performance and generating profits for the firms (Wu & Wang, 2007). Meanwhile, building the link between new product development activities and firms' strategy is crucial for managers (Marsh & Stock, 2006). This is because firms see the worthiness of certain technologies in a different way than others because of different technology base and strategy they have (Tece, 2007).

7. Discussion: Dynamic Capability for Managing Technology and Change

Technology is presented in the ways it is being used to produce goods, as goods itself, or in providing services to customers. In order to become competent and gaining competitive advantages especially in an industry which depends largely on technology, managing of technology is very critical. Like the other things in our lives, technology needs to be managed to get the real benefits out of it. It can be disastrous if not properly managed because the impact of technology is broader not simply on individual firms but also on the society either positively or negatively (White & Bruton, 2007). Hence, technology management is a must in order to create competency to the firms. Technology management is defined by Khalil (2000) as an interdisciplinary field that integrates science, engineering, and management knowledge and practice.

Technology management is very crucial in all disciplines and businesses and not only applicable to the product-based industries but also equally important to the service-based industries. Technology is used in product and service industries as a tool for their competitiveness. Hence, a proper management of technology will bring competitive advantages to the firms where the firms have an edge over rivals in attracting customers and defending against competitive forces (Thompson & Strickland, 2003). Therefore, technology management is crucial for creating and/or sustaining the competency of firms in the fast growing industry with a lot of technologies thrown into the markets.

The management of technological change is highly important and the insufficient reaction of the established companies to technological change can lead to their demise.

In order to reduce the probability of failure in the face of technological discontinuities and to increase the effectiveness of technological decision-making, many researchers called for a more systematic observation of technological trends (Lichtenthaler, 2004). Furthermore, Lichtenthaler (2004) has identified the level of technology and application competence of a company and the maturity of a technology as the most crucial factors in his research of studying technology intelligence in the context of technological change. This shows that technology and competency has a correlation and therefore managing the technological change will improve the competency level of the firms, which can be achieved with DC that is designed to create wealth for the firms operating under environments of rapid technological change with the objective of sustaining competitive advantage by changing the resource base. To sustain the competitive advantage, firms need to confront with the turbulent in the high market and the uncertainty of technologies (Kylaheiko & Sandstrom, 2007).

Changing of technological resources will bring new challenge to the firms' competitiveness (Chen & Lee, 2009). Hence firms must evaluate how technologies evolve and create response to the customers, suppliers, competitors, and policies makers, and change the nature of opportunities and competition. One of the determinants of the firms' success is the efficient and effective transfer of technology in both inside and outside of the firms (Teece, 2007). Changing of technological resources will bring new challenges to the firms' competitiveness (Chen & Lee, 2009) but with DC firms are able to turn resources into performance hence capable of generating profit (Wu & Wang, 2007). Firms' performance will increase when the resources size is greater as DC is getting better (Wu, 2007). Thus, while RBV is focusing on possession of VRIN resources, DC is the ability to create, integrate, and reconfigure resources to create competitive advantage. Hence, DC is designed to renew or modify the resource base.

The threats to competitive advantage is coming from outside the firms when the market dynamism is moderate while in highly volatile market the threats is coming from both inside and outside of the firms (Eisenhardt & Martin, 2000). Meanwhile, globalization and digitized mode of operations were identified as drivers of rapid changing environments, which are known as 'the third revolution' (Kylaheiko & Sandstrom, 2007).

As the uncertainties are significant challenges to the firms in developing new products (Marsh & Stock, 2006), the ability to build new products rapidly is a key to the success of entrepreneurial firms in environments that is characterized by continuously technological change and fierce competition of global markets (Deeds, DeCarolis, & Coombs, 1999) with rapid changing of consumer needs and technological uncertainty (Wu, 2006). As such, changing of technological resources will bring new challenge to the firms' competitiveness (Chen & Lee, 2009). Thus, firms must evaluate how technologies evolve and create response to the customers, suppliers, competitors, and policies makers, and change the nature of opportunities and competition. Therefore, with the concept of DC, firm can manage their technological related assets in the face of technological turbulence.

8. Conclusion

DC concept is extended from the resource base perspective. It is built based on the firm's ability to renew the resource base in form of intangible resources (e.g., processes, skills, routines). These intangible resources when unique and difficult-to-duplicate will become the source of sustainable competitive advantage. When related to technology management, DC is entrepreneurial in nature where the innovative outcome of the renewed resource base is to create and/or respond to the opportunities and threats of the technological change.

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