Journal of Technology and Operations Management – Special Issue, 37-47 (2017)

BRIDGING TECHNOLOGY MANAGEMENT WITH DYNAMIC CAPABILITIES FOR SUSTAINABLE COMPETITIVE ADVANTAGE

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ABSTRACT

This article attempts to explain the concept of technology management (MOT) for sustaining competitive advantage. To better understand how sustainable competitive advantage can be created with MOT, the concept of dynamic capabilities (DCs) that is designed to respond to technological change is brought into the picture. With DCs, this article has characterized MOT's activities and routines as firm's internal and intangible resources that are specific and identifiable with common features, but idiosyncratic in details. With these characteristics, MOT can be unique, difficult to imitate, rare, and valuable to explain the source of sustainable competitive advantage. To achieve this objective, a framework that serves as a basis to table the linkages between MOT and DCs is proposed. With the framework, it becomes clear where DCs' micro-foundations of opportunity sensing, opportunity seizing, and resource transformation can be bridged directly to the existing MOT's activities and routines. Although DCs' micro-foundations, and MOT's activities and routines are adopted directly from the existing literature, this article has managed to clearly defined where the specific MOT's activities and routines are linked to the specific DCs' micro-foundations. As a result, the nature of MOT as a DCs' tool for sustaining competitive advantage has been understood. For future studies, the framework serves as a guideline to systematically investigate the linkages between MOT and DCs.

Keywords: *DCs' micro-foundations, management of technology, MOT's routines and activities, technological capabilities, technological change*

INTRODUCTION

Management of technology (MOT) is an interdisciplinary field that integrates the knowledge of art and science to create wealth (Khalil, 2000). MOT has become critical since the role of firm at advancing technology was being recognized (Nelson & Winter, 2002). Since technology is an important asset of firm (Teece, Pisano, & Shuen, 1997), all MOT's activities and routines are treated as the effective tools for managing technology (Phaal, Farrukh, & Probert, 2006). For instance, technology that exists in forms of processes, methods, techniques, procedures, models, and systems is important to be managed as it is used to produce goods, as a good itself, or in providing services to customers (White & Bruton, 2011). As technological change alters the performance of current technology; the inability of firm to respond sufficiently to change will affect the existing competitive advantage.

As a result, firm must evaluates how technologies evolve and create response to the needs of customers, suppliers, competitors, and policies makers, and change the nature of opportunities and competition with technological capabilities (Teece, 2007). This is important due to the dynamic of technological capabilities that determines the firm's ability to constantly build new product under continuously changing environment (Deeds, DeCarolis, & Coombs, 1999) has challenged the firm's level of competitiveness (Chen & Lee, 2009). In many researches, scholars have characterized dynamic environments as rapidly technological change (Teece, Pisano, & Shuen, 1997), unpredictability and strong competition (Chen & Lee, 2009), complex value nets (Kylaheiko & Sandstrom, 2007), radical and new innovation (O'Connor, 2008), emergence of knowledge economy, global competition and technological advance (Lawson & Samson, 2001), new products and processes creation (Helfat, 1997), converging technologies (Bhutto, 2005), technological change and global competition (Teece, 2007), rapid development of new products (Deeds, DeCarolis, & Coombs, 1999), and uncertainty of technological knowledge, lack of complementary technologies and developed markets (Marsh & Stock, 2006).

However, viewing technological change as a threat will only increase the firm's resistance to change, while failure to understand technological change as a signal for emerging new technology will possibly cause the firm to loss its position in the changing marketplace. Thus, although technological change could be threatening the firm's competitive advantage, it should not be treated simply as a threat. Instead it should be treated as an opportunity to sustain competitive advantage. This is crucial since technological change is an external factor that could not be controlled by any single firm, while the source to this change could be originated from outside the industry itself. Hence, since the rate of technological capabilities are significantly important to achieve competitive advantage (Ray, Ida, Suh, & Rhaman, 2004), firm have to confront with the turbulent in market and uncertainty of technologies (Kylaheiko & Sandstrom, 2007).

Although any technologies can be acquired by any firms, simply possessing of technological capabilities *per se* may not be enough to maintain competitive advantage. Therefore, technology has to be managed in a unique ways where it cannot be easily replicated by others especially under rapidly technological change (Teece, Pisano, & Shuen, 1997). However, the concept of MOT itself has been criticized in the past for lacking of capabilities to create competitive advantage (Chanaron & Jolly, 1999). Fortunately, a concept of dynamic capabilities (DCs) was created to sustain competitive advantage by deploying the firm's internal and external resources under rapidly technological change (Teece, Pisano, & Shuen, 1997). This implies that MOT can be potentially integrated with DCs in order to explain the source of sustainable competitive advantage. By doing this, the nature of MOT as a tool for implement DCs can be understood. To achieve the objective, this article will propose a framework to bridge MOT with DCs and subsequently discusses the linkages between them.

TECHNOLOGY MANAGEMENT FOR COMPETITIVE ADVANTAGE

Firm sees the worthiness of certain technologies differently from the others because of different technology bases and strategies they have (Teece, 2007). Since firms differ in their ability to understand and apply knowledge and differ in term of cost of

transferring the technology, the cumulative experience and learning could influence the cost of technology transfer. The cost will be greater if the knowledge is highly complex but will be lower if the knowledge is highly teachable and codified. Due to the tacitness of the technology will increase the cost of transfer between firms, the more the technology is difficult to be codified and taught, the more likely that the technology to be transfer just within the firm itself (Kogut & Zander, 2003). This suggests that technological capabilities can be the source of competitive advantage.

In the meantime, firm experiences may be insignificant in influencing the tacitness of the knowledge when the knowledge base is changing. Thus, firm with experiences might not necessarily have a benefit and guarantee a continuous success when compared to the less experienced firms, especially under rapidly changing technology. Even if the cumulative technology that the market leader built is impregnable by the rivals within the industry, the real challenge could be coming from outside (Nelson & Winter, 2002). This implies that the ages and numbers of previous transfer of technology are less influencing the tacitness of the knowledge (Kogut & Zander, 2003). In another word, although the technology that is less codified and difficult to imitate can be the source of competitive advantage, without proper management of technology, firm may lose their advantages under rapidly changing technology. As a result, it will be disastrous if technology is not properly managed since the impacts can be broader not simply to the individual firm but also to the society at large (White & Bruton, 2011).

Under globalization and open market, the role of technological capabilities has becoming more critical than ever before (Teece, 2007). Since firm and market are co-evolve (Helfat, et. al., 2007), firm cannot afford to make major mistake under continuously changing environment where the emerging opportunities open to all firms (including from different industry), which will affect the existing profits (Teece, 2007). This happen due to the changes in customers preferences will shape how firm will respond to the market, while at the same time, the firm's technological innovation that create opportunities will also shapes the market (Helfat, et. al., 2007). Therefore, in order to remain competitive, firm has to respond to the source of change (either internal or external to the firm). While the ways firm reacts and responses to the change are critical for its survival, the insufficiency or unwillingness to adjust itself to the change could be the reason for the demise. In fact, when NOKIA smartphone division was acquired by Microsoft, the CEO ended his last speech by saying that 'we didn't do anything wrong, but somehow, we lost'. Obviously, it was not the change that kills NOKIA, but the lack of responses to change did it. As a result, managing technological change with MOT is very critical to sustain competitive advantage. [1]

Although previous studies have questioned MOT for its ability to create competitive advantage in both theories and practices (Brent, & Pretorius, 2007), a recent study has demonstrated that MOT can induces competitive advantage from DCs point-of-view (Bilgihan & Wang, 2016). As a result, this article will demonstrate how MOT can be the source of sustainable competitive advantage with the concept of DCs in mind.

[1] For details, please visit https://www.linkedin.com/pulse/nokia-ceo-ended-his-speech-saying-we-didnt-do-anything-ziyad-jawabra

DYNAMIC CAPABILITIES FOR MANAGING TECHNOLOGY

DCs are famously known as a firm's ability for building, reconfiguring, and integrating resources in response of environmental change (Teece, 2012). This concept is focused at strategic management level where the environmental issue addressed is commonly referred to rapidly technological change (Teece, Pisano, & Shuen, 1997). DCs are generally characterized by the (1) specific and identifiable processes (2) with common features but idiosyncratic in details (3) where the pattern depends on market dynamism (Eisenhardt & Martin, 2000).

DCs are also known to have the following features; (1) it have to be a firm's organizational or strategic routines and assets, (2) it is built on the organizational learning, (3) it is shaped by the firm's history (path dependence), and (4) it should be replicable by the firm (but not necessarily by others) (Cavusgil, Seggie, & Talay, 2007). Since DCs are extended from resource-base view (RBV), it has to be valuable, rare, inimitable, and non-substitutable to create competitive advantage (Teece, Pisano, & Shuen, 1997). Therefore, DCs are very important to assure the survival of firm and for the continuity of business when the environment it dealing with is developing very fast with rapid introduction of new technology and shorter lifecycle (Wu, 2007).

Meanwhile, the history of a mankind has recorded a series of paradigm shifts caused by the advancement in science and technology. As a result of increasing rate of technological change, the dynamic effects of technological capabilities on the firm's competitive advantage have been increasing and becoming a concern in the field of strategic management. By realizing the importance of managing technology, a field of MOT has emerged to shape the firm's strategy with technological capabilities. In general, MOT can be seen as an interdisciplinary field that integrates science, engineering, and management knowledge and practice (Khalil, 2000). It focuses on planning, implementing, and controlling of technological capabilities to achieve the firm's objectives (White & Bruton, 2011). With a focus on the strategic management, technological capabilities are treated as a form of resources in firm.

Specifically, technological capabilities can be seen as embedded in the firm's resources, routines, and competencies that is difficult-to-duplicate by others (Teece, 2009). Therefore, in the context of MOT, DCs are used to explain how technological capabilities are built, reconfigured, and integrated in response to technological change. For instance, MOT was recently defined from a dynamic point of view as a 'development and exploitation of technological capabilities that are changing continuously' (Unsal & Cetindamar, 2015, p.183). Since technological capabilities are not static (White & Bruton, 2011), this article defines MOT based on DCs concept, as a firm's ability to sense, seize, and transform new technology with technological capabilities in response to technological change for sustaining competitive advantage.

BRIDGING TECHNOLOGY MANAGEMENT WITH DYNAMIC CAPABILITIES

According to DCs, firms interpret and respond to technological change at different points and levels. Hence, firm that has unique ability to manage technology that is not easily duplicated or imitated by others can possibly sustain competitive advantage. As

such, MOT can be studied with the concept of DCs to explain sustainable competitive advantage. To demonstrate how the bridging between MOT and DCs can be done, a framework is proposed based on the sensible argument that DC's micro-foundations were constituted by routines (Cavusgil, Seggie, & Talay, 2007; Eisenhardt & Martin, 2000; Teece, 2012; Winter, 2003).

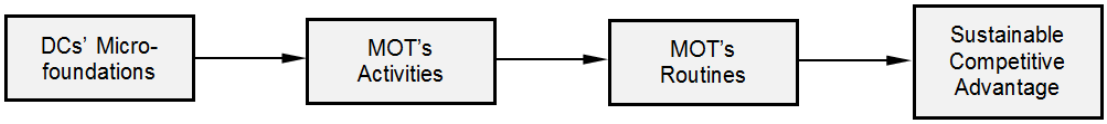

Figure 1
Bridging MOT with DCs

As shown in Figure 1, the concept of DCs can be practiced by tracing down DCs' micro-foundations (Teece, 2007) into MOT's activities (Centidamar, Phaal, & Probert, 2009) that will be subsequently implemented by the routines (Cetindamar, Can, & Pala, 2006; Unsal & Cetindamar, 2015). By adopting the existing literature, DCs' micro-foundations, and MOT's activities and routines are organized in a logical order in accordance to the framework, as shown in Table 1.

Table 1
Bridging MOT's activities and routines with DCs' micro-foundations

DCs Micro-foundations *Teece (2007)*	**MOT Activities** *Cetindamar, Phaal and Probert (2009)*	**MOT Routines** *Cetindamar, Can and Pala (2006)*	**MOT Routines** *Unsal and Cetindamar (2015)*	**DCs terms for MOT**
Opportunity Sensing	✓ Identification ✓ Selection	✓ Forecasting ✓ Technology planning ✓ Technology strategy ✓ R&D development ✓ Technology assessment	*Identification:* ✓ R&D environmental monitoring ✓ Business unit environmental monitoring ✓ Corporate environmental monitoring *Selection:* ✓ Technology road mapping ✓ Technology needs assessment ✓ Business unit technology strategy	Technological Sensing Capability
Opportunity Seizing	✓ Acquisition ✓ Exploitation	✓ Purchasing ✓ Technology acquisition ✓ Technology transfer ✓ Technology integration ✓ Technology utilization ✓ Technology commercialization and marketing	*Acquisition:* ✓ R&D technology strategy ✓ R&D portfolio management ✓ Technology transfer ✓ R&D funding ✓ Product portfolio management *Exploitation:* ✓ Technology adaptation ✓ Post-project support ✓ Business unit business strategy ✓ Product line planning	Technological Seizing Capability
Resource Transformation	✓ Protection ✓ Learning	✓ License/patent ✓ Technology protection ✓ Knowledge management	*Protection:* ✓ Intellectual property management *Learning:* ✓ Post-project audit	Technological Transformation Capability

DISCUSSIONS

As depicted in Table 1, DCs consist of three micro-foundations. First, the opportunity sensing is deployed to scan and monitor any emerging trends in the environment by focusing on the opportunities and threats that might affect the firm's objectives. Second, the opportunity seizing is deployed to select the most promising and emerging trends in the environment and then committed by applying the relevant resources according to the firm's objectives. Third, the resource transformation process is deployed to explore new resource base or to exploit existing resource base according to the selected opportunities (Teece, 2007).

Meanwhile, there are six MOT's activities that can be traced to DCs' micro-foundations, namely identification, selection, acquisition, exploitation, protection, and learning. In details, DCs' opportunity sensing can be implemented to sense new technology in the business environment by performing MOT's activities of identification and selection. Subsequently, DCs' opportunity seizing of new technology can be implemented with MOT's activities of acquisition and exploitation. Meanwhile, to manage the threats of new technology, DCs' resource transformation capacity will be needed. This third DCs' micro-foundation can be implemented with MOT's activities of protection and learning (Cetindamar, Phaal, & Probert, 2009).

In the meantime, MOT's activities can be detailed into routines. According to Cetindamar, Can, and Pala (2006), there are five routines for identification and selection, six routines for acquisition and exploitation, and three routines for protection and learning. For instance, MOT's activities of identification and selection can be detailed down into MOT's routines of forecasting, technology planning, technology strategy, research and development (R&D), and technology assessment. Furthermore, MOT's activities of acquisition and exploitation can be detailed down into MOT's routines of purchasing, technology acquisition, technology transfer, technology integration, technology utilization, and technology commercialization and marketing.

Meanwhile, MOT's activities of protection and learning can be detailed down into MOT' routines of license (or patent), technology protection, and knowledge management. In a recent year, a more precise list of MOT's routines for each activity was introduced by Unsal and Cetindamar (2015). For instance, R&D environmental monitoring, business unit environmental monitoring, and corporate environmental monitoring are the routines for identification activity; while technology road mapping, technology needs assessment, and business unit technology strategy are the routines for selection activity. In addition, R&D technology strategy, R&D funding, and technology transfer are the routines for acquisition activity, while technology adaptation, post-project support, and product line planning are the routines for exploitation (the rest of the routines can be referred in Table 1).

In summary, DCs' micro-foundations have been described as clusters of activities that rooted in the routines (Teece, 2012). In line with this argument, Table 1 has shown that MOT can be a strategic tool for implementing DCs where the micro-foundations can be directly linked to MOT's activities that further detailed into routines. This suggests that MOT's activities and routines are indeed consistent with the concept of DCs. In the context of MOT, DCs' micro-foundations can be described as

technological sensing capability (deployed with MOT's routines for identification and selection), technological seizing capability (deployed with MOT's routines for acquisition and exploitation), and technological transformation capability (deployed with MOT's routines for protection and learning) (Unsal & Cetindamar, 2015). Although the information for MOT in Table 1 are adopted from previous literature, this article has simplified and summarized them based on the framework in Figure 1, as a way to sensibly relate MOT to DCs for sustaining competitive advantage.

CONTRIBUTIONS

Firstly, MOT is a 'soft' technology that exists in a form of 'knowledge, processes, tools, methods, and systems employed in the creation of goods or in providing services' (Khalil, 2000, p.1). Since MOT is an interdisciplinary field that studies the area where art meets science, MOT is referred to as a 'soft' technology to complement with the 'hard' technology. As a 'soft' technology, MOT is deployed for creating and (or) adopting new (hard) technology as a result of technological change. This 'soft' technology exists in the forms of technological sensing, seizing, and transformation capabilities. In the context of this article, MOT with the specific set of activities and routines can exists in the form of knowledge, processes, tools, methods, and (or) systems that are used to respond to technological change by creating and (or) adopting new technology. As a result, this article has clarified the meaning of technological 'resources' according to DCs.

Secondly, this article has promoted MOT as a tool for strategic management that involves planning of the goals, formulating of the actions, and controlling of the results, which is commonly used for decision making and (or) problem solving. In details, there are two perspectives of strategic formulation; the industrial-organization that focuses on formulating strategy with external factors (i.e., forces in the industry), and the resource-base that focuses on formulating strategy with internal factors (i.e., resources of the firm). For this article, DCs (a resource-based perspective) was utilized to justify MOT as a firm's internal and intangible resources, which can be uniquely deployed to sustain competitive advantage under technological change. Although studies on MOT with DCs are not new (e.g., Cetindamar, Phaal, & Probert, 2009), this article has further strengthen the knowledge on DCs and to promote it as one of the best ongoing concept to study MOT (Zaidi & Othman, 2011).

Thirdly, this article is not just suggesting the relevance of DCs for managing technology, but also the details on how DCs can be implemented with MOT's activities and routines. As such, this article has provided a better understanding on the linkages between DCs and MOT, which is also added the details to the concept that was loosely discussed earlier in Zaidi and Othman (2014). According to DCs, firm's resources can be the source of sustainable competitive advantage if they are specific and identifiable with common features, but idiosyncratic in details (Eisenhardt & Martin, 2000). Since MOT's activities and routines were treated as resources that are intangible and internal to the firm (Phaal, Farrukh, & Probert, 2004), and also specific, identifiable but different in quality from firm to firm, MOT are indeed can be the source of sustainable competitive advantage. For instance, although any firm can practice the same six activities of MOT, namely identification, selection, acquisition, exploitation, protection, and learning, but the way these firms implement the activities

and make decisions with them are dissimilar. As a result, this article has suggested MOT as a tool of DCs that can be deployed under technological change.

LIMITATIONS

MOT's activities and routines discussed here are not meant to be exhaustive as there could be other activities and routines in literature but not highlighted. Hence, this article is not dictating but suggesting a set of MOT's activities and routines that can be directly linked to DCs. Meanwhile, although this article has promoted MOT's activities and routines as a DCs' tool to respond to technological change, the activities and routines themselves could also be the reason of change. This implies that technological change could be started by the firm itself, not necessarily by the external factors. In addition, this article has emphasized on the importance of MOT to sustain competitive advantage under technological change; however this does not necessarily imply that MOT is irrelevant under unchanged or stable environment.

CONCLUSIONS

Due to the success of firm at responding to technological change is determined by the firm's ability to sense, seize, and transform technological resources, this article has showcased the possible connections between MOT and DCs to justify the roles of MOT at sustaining competitive advantage. With the concept of DCs, the threats or opportunities from technological change can be managed by deploying the MOT's activities and routines (treated as a DCs' tool). In order to demonstrate how MOT can be the tool for sustaining competitive advantage, the linkages between MOT's activities and routines with DCs' micro-foundations was sensibly demonstrated with a framework. It was found that DCs' opportunity sensing can be bridged to MOT's activities of identification and selection, while DC's opportunity seizing can be linked to MOT's activities of acquisition and exploitation. In addition, DCs' resource transformation can be directed to MOT's activities of protection and learning. Although all MOT's activities and routines, and DCs' micro-foundations are adopted directly from the existing literature, this article has managed to create understanding on how MOT can be the source of sustainable competitive advantage. Despite of the simplicity of framework, this article has added clarification to some of the most basic issues in MOT, which is the relevance of MOT to be a strategic decision making tool.

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