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Rigidity and performance threshold: How routinization process affects dynamic capabilities

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Dynamic capabilities view has been considered vital to the long-term survival and adaptation of organizations in dynamic environments. Although, rich literature has probed into how dynamic capabilities are able to address organizational inertia issues and facilitate change, there are still heated debates on questions on dynamic capabilities' heterogeneity and performance. Current thinking was integrated in major researches of routines and dynamic capabilities and a rigorous modelling method was adopted to investigate how routinization process affects reconfiguration of ordinary capabilities. An interesting finding of this research is that there is a threshold effect both on routinization process and dynamic capabilities performance as a result of rigidity and knowledge accumulation. Firms in their effort of reconfiguration of ordinary capabilities should pay special attention on where they position the capabilities around such threshold. To achieve better effect and superior performance, different kinds of dynamic capabilities may be required. The implication of this study may help bridge the diverged views in the field of dynamic capabilities research, and open new avenues for future empirical research.

Key words: Dynamic capabilities, routinization, rigidity, threshold effect.

INTRODUCTION

How organizations tackle routine rigidity has been one of the primary topics in the discussion and advancement of organizational adaption theory. The concept of routines has been considered one of the most decisive features in adaption related selection and retention processes (Hannan and Freeman, 1984; Nelson and Winter, 1982). Traditionally, literature has extensively studied organizational inertia and revealed that the dual characters of organizational routine have the tendency of enabling consistent performance and disabling organization from adaptation in a volatile environment (Amburgey et al., 1990; Hannan and Freeman, 1984). Routine rigidity as part of organizational inertia has attracted attentions from various research steams, among which, dynamic capabilities view has been tackled as one of its foremost goals (Eisenhardt and Martin, 2000; Winter 2003; Zollo and Winter, 2002).

Dynamic capacities theory was proposed by several major researches in the last two decades to tackle organizational inertia and sustain competitive advantages (Døving and Gooderham, 2008; Eisenhardt and Martin, 2000; Helfat et al., 2009; Teece et al., 1997; Teece, 2007;

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Winter, 2003; Zahra et al., 2006; Zollo and Winter, 2002). Dynamic capability is generally defined as the higher-order capabilities that changes operational-level capabilities and learning in new domains. As Wiggins and Ruefli (2005) reveals, the dynamism of environment has subject firms' competitive edge to a much shorter time span. In hypercompetitive or high-velocity environments, firms are facing major difficulty to achieve competitive advantage in the long-term. Circumstances require firms to strive for a solution to find successive temporary advantages by effectively responding to successive environmental shocks (D'Aveni, 1994). Dynamic capabilities theory asserts that firms need to develop such capabilities so as to purposefully create, extend or modify its resource base (Helfat et al., 2009) or sense and then seize opportunities quickly and proficiently (Teece, 2000).

A major obstacle that hinders further development of dynamic capabilities theory is the diverged views between two seminal papers by Teece et al. (1997) and Eisenhardt and Martin (2000) (Di Stefano et al., 2014; Peteraf et al., 2013). One of the diverged views in these two papers is concern with how routinization of organizational processes influences dynamic capabilities heterogeneity. Routinization is the extent to which organizational process become routine and organizations achieve stability and accountability (Hannan and Freeman, 1984; Nelson and Winter, 1982). The concept of routine is also considered an important micro-foundation and building blocks for organizational (dynamic) capabilities that sustain organizations' competitive advantage. However, to what extant organizations should routinize their process and capabilities has been a source of major debate between the two seminal papers. Research that follows Teece et al. (1997) has emphasized that both dynamic capabilities and operational capabilities should rely on large and complex routinized process, whereas research that follows, Eisenhardt and Martin (2000) argued that flexible and reduced routinization on organizational process should be the answer to build both operational and dynamic capabilities. Peteraf et al. (2013) suggest reconciling in such diverged theoretical views could help the future development for dynamic capabilities theory. Another major stream of debate is the link between dynamic capability and its performances. Teece et al. (1997) and some later researchers assume direct link of dynamic capabilities-performance link that asserts dynamic capability rent generation and superior performance. In contrast, Eisenhardt and Martin (2000) and Zott (2003) for example, showed dynamic capabilities as indirectly linking to performance and may only create superior performance under certain condition. Such debate has also hampered further development of theory and empirical researches.

In light of these debates, a fundamental question is asked: how does organizational process routinization affect reconfiguration of operational capabilities? Further, how does such relation affect dynamic capabilities-performance link? The authors wish to provide a nuanced view to explain such gap in major theoretical development as well as empirical results from a perspective of routinization and reconfiguration of operational capabilities (processes). A method of rigorous modeling method for our research was adopted. Parting from previous research that focus on managerial action or resource configuration, the current research finds out that timing of capability reconfiguration along the routinization process of organizational capabilities may be an important factor.

THEORETICAL BACKGROUND

Dynamic capabilities and debates on heterogeneity and performance links

Teece et al. (1997) defined dynamic capabilities as "the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments." First, they categorized the nature of the concept as being an "ability" (or "capacity"), stressing the essential role of strategic management. Such a definition has be an extended resource based view by categorizing it as a special kind of capability. Dynamic capabilities are to integrate (or coordinate), build and reconfigure internal and external resource and operational capabilities. Makadok (2001) further reported such synthesis view of RBV and proposed dynamic capabilities as resource picking and capability building mechanisms. As special resources and capabilities considered within RBV, Teece et al. (1997) considers dynamic capabilities as heterogeneous across firms because they rest on firm specific paths, unique asset positions, and distinctive processes. In contrast, Eisenhardt and Martin (2000) asserted dynamic capabilities as best practices with only indirect link to competitive advantages that exhibit commonalities across firms. Later research tends to see two seminal papers by taking diverged views on many aspects of dynamic capabilities (Di Stefano et al., 2014; Peteraf et al., 2013).

The first divergence reside in the nature of dynamic capabilities, although major researches generally agree that dynamic capability follows evolutionary economics perspective (Nelson and Winter 1982) emphasizing the fundamental elements such as routine, path dependency and organizational learning, and that the creation and evolution of dynamic capabilities are embedded in organizational processes (Barreto, 2010). The differentiated views question a unified understanding of its heterogeneity. One question in particular of such debate is the relation between dynamic capabilities and routinization of organizational process. Sub-stream research around Teece et al. (1997) contended that dynamic capabilities rely on large complex routinization, whereas others following Eisenhardt and Martin (2000) insisted on reduced routinization (Peteraf et al., 2013; Schreyögg and Kliesch-Eberl, 2007; Wohlgemuth and Wenzel, 2016). Another major debate is dynamic capabilities' outcomes, of which the dynamic capabilities performance is in the center of such heated discussion. Teece et al. (1997) contend that dynamic capabilities directly generate competitive advantage and sustain firm performances. Makadok (2001) used resource based perspective to explain that dynamic capabilities have two rent generating mechanisms. However, Eisenhardt and Martin (2000) argued that dynamic capabilities in reaching superior performance are only necessary but not sufficient. Zott (2003) also sees dynamic capabilities as indirectly linked to performances through modification of resource base, and such links are moderated by timing, cost and learning effect.

Although, such two streams have generated much discussion, a center element seems to be oversight by major researchers, which is routinization of organizational processes and capabilities. Dynamic capabilities literature has generally reached consensus on the role that routine played in the creation and development of dynamic capabilities. However, the process of creation of routines did not receive enough attention. Especially, the development of routine major properties seems to be missed in the conversation of dynamic capabilities and routinization and performance implications. As the concept of routine has been considered to have great importance, it is believed that there may be a hidden research avenue for bridging the theoretical divergence in developing dynamic capabilities theory.

Organizational routine and implication on dynamic capability

Routines are described by prior literature as "repetitive pattern of activity" (Nelson and Winter, 1982) or "the building blocks of capabilities, with a repetitive and context-dependent nature" (Becker, 2008b). Routines are also operationalized as organizational processes, together with organizational resources, to achieve certain goals (Grant, 1991). Process routinization is replication of known processes, which establishes and maintains organizational routines. It is also defined as a process in which knowledge from previous experiences accumulates in tacit forms (that is, in the minds of human actors) and results in quasi-automatic, uniform, response behavior to varied stimuli. As capabilities consist of routine or routine bundles, it can be easily seen that routinization process holds a center role in the creation and evolution of organizational capabilities. Thus, to understand how routinization process influence capability configuration, several important routine characteristics and the development of these characteristics should be highlighted.

Together with this dual nature of routine stability and change, several other characteristics are also incorporated in this research. These characteristics are reoccurrence (or repetition) (Winter, 1990; Pentland and Rueter, 1994), storage of knowledge (especially tacit knowledge) (Cohen and Bacdayan, 1994; Gilbert, 2005), stability (Nelson and Winter, 1982) and generative system that allows routine to variate (Feldman and Pentland, 2003; Pentland and Rueter, 1994; Pentland et al., 2012). Traditional literature primarily sees organizational routines as stable, exhibiting low variance in actions and in performance along its reoccurrence and development path (Nelson and Winter, 1982; Cohen and Bacdayan, 1994; Feldman and Pentland, 2003; Gersick and Hackman, 1990; Hannan and Freeman, 1984). Routines are considered to be able to maintain repeatable and reliable performance of organizational activities (Nelson and Winter, 1982). As it ensures stability, it is also considered to be primary source of organizational inertia or capability rigidity (Amburgey et al., 1990; Hannan and Freeman, 1984). Recent researches on routines, however, believe that routines are generative systems rather than source of singular stability or rigidity and may be a source of change and flexibility that also have endogenous variance within the routine. Such variation in routines may also enable organization change and flexibility (Adler et al., 1999; Amburgey et al., 1990; Feldman and Pentland, 2003; Feldman, 2000; Levitt and March, 1988; Nelson and Winter, 1982). Thus, it is believed that these distinct and comprehensive characteristics of routine can exert great influence on the dynamic capabilities, especially its reconfiguration of operational capabilities. In the following part of the paper, the authors built such a model that captures the current thinking in the field of routine research but also simple enough to capture its effect on the process.

MODEL

The current study model is designed to examine how the nature of routininzation process influences dynamic capabilities reconfiguring ordinary capabilities while controlling for other mechanisms covered in previous research such as variation and rigidification of routines. The authors wish to build such a model that reflect the current thinking in the routine (Feldman and Pentland, 2003; Feldman, 2000; Pentland et al., 2012) and dynamic capabilities research (Eisenhardt and Martin, 2000; Teece et al., 1997; Zollo and Winter, 2002). The model focuses on capabilities reconfiguration process rather than resource reconfiguration process (Zott, 2003). Capabilities were treated as routines and its reconfiguration as a variation-selection-retention process with emphasis on organizational learning mechanism (Zollo and Winter, 2002).

Preliminaries assumptions on routine's characteristics

Repetition

An obvious feature of organizational routines is recurrence (Egidi and Narduzzo, 1997; Winter, 1990; Cohen and Bacdayan, 1994; Cohen et al., 1996; Pentland and Rueter, 1994; Pentland, 1992). An activity that occurs only once cannot be a routine. Routines are "recurrent interaction patterns" (Feldman and Pentland, 2003; Becker, 2008a). In practice, they are repeated executions of similar tasks. Therefore, routines are units of organized activities that are repeated over time. The recurrence feature leads to an executable capability for repeated performance (Cohen et al., 1996).

Storage of knowledge

Routines are restored in organizational procedural memory (Cohen and Bacdayan, 1994). An activity is repeated because it previously provided a desirable result. In other words, routines are created and reinforced by past successes (Levitt and March, 1988). Thus, routines are remembered by doing (Nelson and Winter, 1982). Routines offer a way of capturing, codifying and sharing knowledge on procedures and best practices. Organizational routines are stored as procedural memory (Cohen and Bacdayan, 1994).

Stability

Repeated activities lead to repeated performance. Therefore, behaviors and their results are predictable (Nelson and Winter, 1982). Increasing repetition can enhance the predictability of a process (Nelson and Winter, 1982) due to reinforcement by past successes (Leavitt and March, 1988).

Generative

According to Pentland et al. (2012), routines are seen as generative system that could generate endogenous variation. a Denotes a variation ratio.

Baseline routinization model

A set of activities must be performed to accomplish any task. If the task is accomplished repeatedly, the activities in the set will naturally be automatically repeated. In this repetition process, it is assumed that the number of activities in the set remains constant; however, in a generative routine system, any activity may be replaced with a new activity. It is assumed that if an activity is variates, the original activity will never be performed again. In other words, when an activity is repeated i times, this implies that the activity has not changed from the first time to the $i+1\text{st}$ time. The probability that an activity in a routine may be variate when it is repeated i times is a_i, where $i \in (0,1,2,\cdots,n)$.

The experience accumulation mechanism relies on memory and suggests that the more frequent an event is, the greater the likelihood that previous experiences will be repeated (Zollo and Winter, 2002). This situation may hinder changes to the previous experience. Therefore, the probability of change to the previous experiences will decrease with their repetition. In this respect, the following assumption is presented. The probability a_i is assumed to decrease with the repetitions i.

According to this assumption, if the changing force of the activity remains constant, then $a_i \geq a_j$, where $i < j$ and $i, j \in (0,1,2,\cdots,n)$. R_n^i denotes the number of activities that are repeated i times in the set when the task is accomplished n times continuously. C_n denotes the number of new activities in the set when a task is accomplished n times.

$$C_n = C_{n-1}a_0 + R_{n-1}^1 a_1 + \cdots + R_{n-1}^j a_j + \cdots + R_{n-1}^{n-2} a_{n-2} + R_{n-1}^{n-1} a_{n-1} \tag{1}$$

$$C_{n-1} = C_{n-2}a_0 + R_{n-2}^1 a_1 + \cdots + R_{n-2}^j a_j + \cdots + R_{n-2}^{n-2} a_{n-2} \tag{2}$$

The number of activities in the set is constant.

$$C_{n-1} + \sum_{j=1}^{n-1} R_{n-1}^j = C_{n-2} + \sum_{j=1}^{n-2} R_{n-2}^j \,. \tag{3}$$

From (3),

$$R_{n-1}^{n-1} = C_{n-2} - C_{n-1} + \sum_{j=1}^{n-2}\left(R_{n-2}^j - R_{n-1}^j\right) \tag{4}$$

(2) − (1), we have (5).

$$C_{n-1} - C_n = \left(C_{n-2} - C_{n-1}\right)a_0 + \sum_{j=1}^{n-2}\left(R_{n-2}^j - R_{n-1}^j\right)a_j - R_{n-1}^{n-1}a_{n-1} \tag{5}$$

Substituting (4) into (5) yields

$$C_{n-1}-C_n=\left(C_{n-2}-C_{n-1}\right)\left(a_0-a_{n-1}\right)+\sum_{j=1}^{n-2}\left(R_{n-2}^{j}-R_{n-1}^{j}\right)\left(a_j-a_{n-1}\right) \qquad (6)$$

When $n=0,1$, then

$$C_0=C_1+R_1^1=C_1+C_0\left(1-a_0\right), \qquad (7)$$

and

$$C_0 \ge C_1 \qquad (8)$$

It is assumed that

$C_j \ge C_{j+1}$, where $j\in\left(1,2,\mathrm{L}\ \ ,n-2\right)$. (9)

According to the definition,

$$R_{n-2}^{j}=C_{n-2-j}\prod_{i=0}^{j-1}\left(1-a_{j-i}\right) \qquad (10)$$

and

$$R_{n-1}^{j}=C_{n-1-j}\prod_{i=0}^{j-1}\left(1-a_{j-i}\right) \qquad (11)$$

According to Equation 9 and comparing Equation 10 with 11 yields

$$R_{n-2}^{j}\ge R_{n-1}^{j}. \qquad (12)$$

Substituting Equations 8, 9 and 12 into 6 yields

$$C_n \le C_{n-1}. \qquad (13)$$

Based on inductive reasoning, Equation 13 is satisfied for all n.

If the number of activities in the set remains constant, then the number of activities repeated i times when the task is accomplished m times exceeds the number of activities repeated i times when the task is accomplished n times by one, if $n>m$ and the changing force on the activities is invariant for every task. Therefore, $R_m^i \ge R_n^i$, where $i=0,1,\mathrm{L}\ \ ,m$. The number of new activities decreases with increase in the number of tasks accomplished if the variation level on the activities in the set is constant for every task (that is, $C_n \le C_{n-1}$).

The above result is used to analyze the routinization process. An activity will become a routine after a sufficiently large number of repetitions. Let $¡_n^k$ be the number of activities repeated more than k times when the task is accomplished n times ($n\ge k$). Therefore,

$$¡_n^k=\sum_{j=k}^{n}R_n^j$$

and

$$¡_{n-1}^k=\sum_{j=k}^{n-1}R_n^j$$

Previous result yields $R_{n-1}^j \ge R_n^j$

Therefore,

$$\sum_{j=1}^{k-1}R_{n-1}^j \ge \sum_{j=1}^{k-1}R_n^j$$

and

$$\sum_{j=1}^{n-1}R_{n-1}^j-\sum_{j=1}^{k-1}R_{n-1}^j \le \sum_{j=1}^{n}R_n^j-\sum_{j=1}^{k-1}R_n^j$$

Moreover,

$$¡_n^k \ge ¡_{n-1}^k \qquad (12)$$

Thus, no matter how many repetitions are needed for an activity to become a routine, the activity set will ultimately become a routine set. A routine embraces the properties of recurrence, memory, predictability, and eventually, automation. That is, a number of repetitions is needed for an activity to become a routine, N, and if n is large enough, $R_i \in ¡_n^N$, then $p_{(O_i|R_i)}\left(M_{R_i}\left(k>N\right)\right)\to 1$.

If the number of activities in the set remains constant as assumed, the number of activities is repeated more than i times when the task is accomplished m times and is less than the number of activities repeated more than i times when the task is accomplished n times by one, if $n>m$ and the variation possibility on the activities in the set is invariant for every task. Therefore, $¡_n^i \ge ¡_m^i$, where $i=0,1,\mathrm{L}\ \ ,m$.

Thus, the number of routines in the activity set will increase as the number of task repetitions increases under the condition that the variation possibility on the activities in the set is invariant for every task. Therefore, the recurrence process is a routinization process. The activities become stable, predictable and automatic routines.

The above analysis gives us a clear view of the routinization process baseline scenario. Organizations generally tend to prefer stable and repeated performance, routinization process without exogenous interference such as dynamic capability, although endogenously variate on a certain level still tends to reach rigid state after certain time of repetition. Further, ordinary capability underpinned by routines and processes will also rigidify without dynamic capability, although to certain extent, it can be variate. Thus, the first proposition is reached:

Proposition 1: Organizational capabilities, although able to change, ultimately will reach a state of stability.

Rigidity model

The authors modeled rigidities associated with capability, they built rigidity model based on Gilbert (2005)'s thinking that rigidity needs to consider factors from resources and tacit knowledge, and that rigidification is a self-reinforcing process. Let $R_i = \lambda e^{ir}$ denote the rigidity of an activity that is repeated i times, λ is a parameter that represents the associated resource and explicit knowledge, and r is the parameter that represent tacit knowledge accumulation mechanism. Thus, the e^{ir} will indicate the volume of accumulated tacit knowledge.

The rigidity of the activities in the set is defined in the following manner:

$$\Re_n = C_n \times \lambda e^r + R_n^1 \times \lambda e^{2r} + \cdots + R_n^j \times \lambda e^{(j+1)r} + \cdots + R_n^n \times \lambda e^{(n+1)r},$$

$$\Re_{n-1} = C_{n-1} \times \lambda e^r + R_{n-1}^1 \times \lambda e^{2r} + \cdots + R_{n-1}^j \times \lambda e^{(j+1)r} + \cdots + R_{n-1}^{n-1} \times \lambda e^{nr},$$

$$R_n^n = \left(C_{n-1} - C_n\right) + \sum_{j=1}^{n-1}\left(R_{n-1}^j - R_n^j\right),$$

$$\Re_n = C_n \times \lambda e^r + \sum_{j=1}^{n-1}\left(R_n^j \times \lambda e^{(j+1)r}\right) + \left[\left(C_{n-1} - C_n\right) + \sum_{j=1}^{n-1}\left(R_{n-1}^j - R_n^j\right)\right] \times \lambda e^{(n+1)r}$$

and

$$\Re_n - \Re_{n-1} = \left[\left(C_{n-1} - C_n\right)\lambda\left(e^{(n+1)r} - e^r\right) + \sum_{j=1}^{n-1}\left(R_{n-1}^j - R_n^j\right)\lambda\left(e^{(n+1)r} - e^{(j+1)r}\right)\right]$$

Thus,

$$\Re_n - \Re_{n-1} \geq 0$$

If the number of activities in the set remains invariant as assumed, then the rigidity of the activities in the set increases as the number of times the task has been accomplished increases, if the variation possibility on the activities in the set is invariant for every task.

From the above model, the authors took a closer look at how rigidity reinforce itself in a routine repetition process. Rigidity without the interference of dynamic capabilities, will accumulate with repetition through a non-linear course. Thus, we have our second proposition:

Proposition 2: Organizational rigidities without variation in routines, will self-reinforce and accumulate in a non-linear fashion.

Rigidity with consideration of variation in routines

In the rigidity model, the parameter r implies the different learning mechanisms associated with different routines. We study the evolutionary character of rigidity in the routinization process. If a routine is repeated n times with no variations, its rigidity is expressed as $R_n = \alpha e^{nr}$. If the routine variate after it is repeated i number of times, where $i < n$, then the new routine is repeated $n-i$ times. According to Teece et al. (1997) and Sydow et al. (2009), endogenous variations in routines are influenced by past knowledge and path dependence. In considering such effect, the new routine's rigidity is denoted as $R_{i,n-i} = \alpha e^{ir} + \alpha e^{(n-i)r}$.

Let

$$y = R_n - R_{i,n-i} = \alpha e^{nr} - \alpha e^{ir} - \alpha e^{(n-i)r}$$

$$\frac{\partial y}{\partial n} = \alpha r e^{nr} - \alpha r e^{(n-i)r} = \alpha r e^{(n-i)r}\left(e^{ir} - 1\right) \geq 0 \quad (14)$$

From Equation 14, the difference increases with increase in the number of times a task is accomplished. In other words, there exists a certain n^*, where if $n > n^*$, then

$R_n > R_{i,n-i}$.

$$\frac{\partial y}{\partial i} = -\alpha r e^{ir} + \alpha r e^{(n-i)r} = \alpha r\left(e^{(n-i)r} - e^{ir}\right)$$

$$i = \frac{n}{2}, \frac{\partial y}{\partial i} = 0 \text{ and } \frac{\partial^2 y}{\partial i^2} = -\alpha r^2 e^{ir} - \alpha r^2 e^{(n-i)r} < 0$$

Therefore, the maximum y is expressed in the following manner:

$$y_{\max} = \alpha e^{nr} - 2\alpha e^{\frac{n}{2}r} = \alpha e^{\frac{n}{2}r}\left(e^{\frac{n}{2}r} - 2\right) \quad (15)$$

Where,

$$e^{\frac{n}{2}r} - 2 = 0$$

$$n^* = \frac{\ln 4}{r} \quad (16)$$

Thus, if $n < \ln 4/r$, then $R_n < R_{i,n-i}$ for any $1 \le i \le n-1$, or, if $n > \ln 4/r$, then $R_n < R_{i,n-i}$

From the above result, if $n < \ln 4/r$, then $y_{\max} < 0$, $R_n < R_{i,n-i}$ for any $1 \le i \le n-1$, which implies that rigidity is overcome more effectively when the activity is repeated frequently. However, $n > 1$ only occurs under the condition that the tacit knowledge learning mechanism parameter is less than $\ln 2$. A sufficiently small tacit knowledge learning mechanism parameter is more effective in overcoming rigidity when the routine is repeated many times. For example, if $r = 0.01$, then $n^* = 138$; rigidity is surmounted more effectively when the activity is repeated up to 138 times than any number less than 138. Otherwise, even though the tacit knowledge learning mechanism parameter is small enough, in the end, there exists a certain n^*; if $n > n^*$, then $R_n > R_{i,n-i}$.

This result means that rigidity accumulation has a threshold in the repetition of routines. The threshold was defined as a number of routines repetition times, before which, the endogenous variation in routines may be selected and retained and after which, the endogenous variation in routines may not be selected and retained. When repetition times is less than this threshold, the endogenous variation can usually survive selection and retention process, which means that desirable change to capability is possible. However, when the repetition times are large than this threshold, which means that the accumulated rigidity is very large, any change to routines and capabilities will be eliminated if there is no exogenous forces such as dynamic capability to retain it. There is thus a third proposition:

Proposition 3a: Without exogenous intervention, endogenous variation to routines and change to capabilities can only be selected and retained before the rigidity threshold.

Proposition 3b: Without exogenous intervention, endogenous variation to routines and change to capabilities will not be selected and retained after the rigidity threshold, and capabilities become rigid.

This model result also has a more interesting implication for dynamic capabilities to exert influences. Consider the case that variation before the threshold number of repetition. A variation in routine before reaching the threshold cannot only survive, but also it can push the threshold forward, which means, for the next variation, the new n^* will be larger, because it is a repeated process. Thus, firms may be able to develop certain type of dynamic capability that creates conditions to continuously engender timely variation and proper process to select and retain such variation. This implication echoes with thinking in continuous improvement literature such as Adler et al. (1999, 2009), which emphasize routinization of process innovation.

The second case is what firms can do when the repetition times already surpass the threshold. When rigidity is already accumulated too large to let any endogenous variation survive, the model indicate two things for firms to do to make $R_n < R_{i,n-i}$. The first is to adjust λ, the resource and explicit knowledge base. The second is to adjust $e^{(n-i)r}$, that is, the tacit knowledge base and its learning mechanism. These two directions are all within the scope of dynamic capabilities (Eisenhardt and Martin, 2000; Teece et al., 1997; Zollo and Winter, 2002). However, these two directions have different level of influence over rigidity as our model indicates. Adjusting the tacit knowledge learning mechanism has much greater effect than that of resource and explicit knowledge base.

Firms that are more tempted to routinize its operational capabilities in pursuit of efficiency and stabilities, are more likely to find themselves in a situation that is already behind the threshold. For such firms, fostering endogenous variation-selection-retention process will be ineffective because no variation can survive selection and retention as our model shows; it will only become a cost burden as Winter (2003) contended. However, firms in this case can pursue a second direction that is more effective, which is altering their organizational learning mechanism such as Zollo and Winter (2002) asserts.

There is also a very interesting theoretical implication for the question whether dynamic capabilities are heterogeneous. The model and analysis in this part indicate that for firms in reconfiguring their operational capabilities, there may be two directions for them to choose based on their operational emphasis. Thus, we have our fourth and fifth proposition:

Proposition 4: Dynamic capabilities are heterogeneous before and after the rigidity threshold, but share commonalities before or after the rigidity threshold.

Proposition 5a: Dynamic capabilities that foster endogenous variation in routines and change in capabilities are effective when rigidity has not accumulated enough to surpass the rigidity threshold.

Proposition 5b: Dynamic capabilities that alter resource base and change organizational learning mechanism are effective when rigidity has accumulated enough to surpass the rigidity threshold.

Modelling rent for capability reconfiguration

Routinization can lead to efficiency. Although, rigidity accumulates in the routinization process, it can also lead to efficiency. According to the above results on rigidity accumulation, rigidity increases with the repetition of routines. Therefore, efficiency increases with the repetition of routines. Let a be the revenue parameter to determine the value from efficiency. We assume that the cost parameter of this effort is b.

Let z be capability building rent. That is to say, for example, if the new market or technological opportunity indicates broad benefit to change into, the numerical value of z will be large. We also set organizations achieving the full potential of new market or technological opportunities in the process of capability change will be constrained by learning effect. Such effect is denoted by e^{-r}, which is also influenced by repetitions. π is the potential value of achieved change. We have the following model:

$$\pi = a\left(\sum_{j=1}^{i}\left(z-e^{-jr}\right)+\sum_{j=i+1}^{n}\left(z-e^{-(j-i)r}\right)\right)-b\left(e^{ir}+e^{(n-i)r}\right) \quad (17)$$

$$\pi = anz-\frac{2ae^{-r}}{1-e^{-r}}+a\frac{e^{-(i+1)r}+e^{-(n-i+1)r}}{1-e^{-r}}-b\left(e^{ir}+e^{(n-i)r}\right) \quad (18)$$

$$\frac{\partial \pi}{\partial i} = a\frac{-re^{-(i+1)r}+re^{-(n-i+1)r}}{1-e^{-r}}-b\left(re^{ir}-re^{(n-i)r}\right)=0$$

$$i^{*}=\frac{n}{2} \quad (19)$$

Using (19),

$$\pi = anz-\frac{2a}{e^{r}-1}+2a\frac{1}{e^{r}-1}e^{-\frac{n}{2}r}-2be^{\frac{n}{2}r}, \quad (20)$$

$$\frac{\partial \pi}{\partial n} = az-ar\frac{1}{e^{r}-1}e^{-\frac{n}{2}r}-bre^{\frac{n}{2}r}=0$$

$$e^{\frac{n}{2}r}=\frac{a\frac{1}{e^{r}-1}+\sqrt{\left(a\frac{1}{e^{r}-1}\right)^{2}+\frac{4abz}{r}}}{2b} \quad (21)$$

$$n^{*}=\frac{2\ln\left(\frac{a}{b}\frac{1}{e^{r}-1}+\sqrt{\left(\frac{a}{b}\frac{1}{e^{r}-1}\right)^{2}+\frac{4az}{br}}\right)-2\ln 2}{r} \quad (22)$$

From Equation 22, result of this model shows that there is an optimal n^{*} for capability building to bring the highest rent and performance of dynamic capability. Thus, the performance of dynamic capabilities reconfiguring ordinary capabilities is also influenced by the rigidity threshold effect. That is to say, for every capability, there should be an optimal timing to select and retain a positive variation in its associated routines. This result indicates that high level of routinization or reduced level of routinization may not the best choice for firms. However, in reality, firms may find it very hard to always catch the best timing for every capability reconfiguring opportunities due to effect such as bounded rationality (Simon, 1991). It should be practical for firms to consider how to position their capabilities emphasis in light of such threshold.

First, if a capability such as an operational process (e.g. production) has a traditional emphasis on efficiency and reliable performances and has a high task frequency, managers that are associated with such operational process will probably find themselves in a situation already behind the optimal timing for reconfiguration. In such situation, managers should resist the temptation of fostering too much variation in routines but rather, they should reduce the level of routinization by focusing on reduction of reconfiguration cost such as enhancement on translating tacit knowledge to explicit knowledge (Nonaka, 2008).

Second, if a capability such as a strategic process (e.g.

restructuring, merger and acquisition, building alliances), has an emphasis on successful rate and low task frequency, managers of such capabilities probably find themselves in a situation that is before the threshold. Such capabilities in order to gain better performances, should focus on more routinization of processes such as emphasizing experiential learning and accumulation, knowledge articulation and codification (Zollo and Winter, 2002). Thus, the sixth and seventh proposition:

Proposition 6: Dynamic capabilities that reconfigure ordinary capabilities have an optimal performance along the repetition trajectory of associated routines.

Proposition 7a: Dynamic capabilities that reconfigure high task frequency capabilities should emphasize reduced level of routinization.

Proposition 7b: Dynamic capabilities that reconfigure low task frequency capabilities should emphasize high level of routinization.

DISCUSSION

Dynamic capabilities are embedded in routine organizational processes to implement effective change (Eisenhardt and Martin, 2000; Teece et al., 1997). The differentiated views in dynamic capability theoretical development still fail to reach a unified understanding of its heterogeneity and performance links. One question in particular in heterogeneity debate is the relation between dynamic capabilities and routinization of organizational process. Sub-stream research around Teece et al. (1997) contended that dynamic capabilities rely on large complex routinization, whereas others following Eisenhardt and Martin (2000) insisted on reduced routinization (Peteraf et al., 2013; Schreyögg and Kliesch-Eberl, 2007; Wohlgemuth and Wenzel, 2016). Another major debate is dynamic capabilities' outcomes, of which the dynamic capabilities performance is in the center of such heated discussion. Teece et al. (1997) contend that dynamic capabilities directly generate competitive advantage and sustain firm performances. Makadok (2001) uses resource based perspective to explain that dynamic capabilities have two rent generating mechanisms. However, Eisenhardt and Martin (2000) argued that dynamic capabilities in reaching superior performance are only necessary but not sufficient. In addressing relevant questions concerning dynamic capabilities, Zott (2003) offers a perspective to investigate dynamic capabilities with the consideration of timing, which reveals that the heterogeneity of firm performances links to dynamic capabilities may have their roots in the time that firms choose to reconfigure resources. However, Arend and Bromiley (2009) indicated that such conclusion is clouded by established economic theories and thus render such perspective specious. The organizational population school holds the view that organizational environment favors firms with the most inert structure and routines, which makes successful firms almost impossible to change strategic directions (Hannan and Freeman, 1984). Such paradoxical views on dynamic capabilities left many questions unanswered, such as underdeveloped prescriptions (for example, how and when to reconfigure resources and capabilities) (Williamson, 1999) or unclear cost-benefit parameters concerning dynamic capabilities (Lavie, 2006).

In light of these debates, a rigorous modeling method was adopted to investigate the relationship between routinization and dynamic capabilities. The authors wish to provide a nuanced view to explain such gap in major theoretical development as well as empirical results from the perspective of routinization and reconfiguration of operational capabilities (processes). From previous research that focuses on managerial action or resource configuration, a very interesting finding of the current research is that along the trajectory of routine repetition and rigidity accumulation, there is threshold effect that may provide some new answers to why dynamic capabilities may be heterogeneous and with unclear performance links. It was found that in the process of routinization or routine repetition, there is a threshold both in rigidity accumulation, which is a result of development in multiple routine characteristics.

The implication of this threshold for dynamic capabilities heterogeneity debate is that in consideration of existence of such threshold, reconfiguring ordinary capabilities may need to take different approach considering before and after the threshold. Before routinization reach such threshold, a kind of dynamic capabilities that foster timely and rhythmic variation in routine activities and proper selection and retention of desirable variation may be more effective. Whereas, for capabilities and its routinization process that have already passed such threshold, fostering variation mechanism may not be very effective, because the threshold indicates that when the extent of routinization passes such threshold, new variation will not survive selection because previous routine patterns have too much associated rigidity. In such situation, managers of such capability or associated organizational process need to adopt dynamic capabilities that not only adjust resource base, but also need to alter mechanism of tacit knowledge learning to increase their understanding of new routines, such as enhancing experiential accumulation, knowledge articulation and codification.

The implication of this threshold for dynamic capabilities-performance link debate is that in considering the existence of such threshold, capabilities need to be routinized to certain extent for firms to gain both enough efficiency and capability building rent. However, the exact extent of routinization or the perfect timing within the trajectory of routine repetition is usually very hard to catch for every capability. A practical view should be differentiating separate positions a capabilities routinization emphasis along the routine repetition trajectory. In this view, dynamic capabilities that reconfigure high task frequency and efficiency orientated capabilities should emphasize more on reduced routinization, whereas dynamic capabilities that reconfigure low task frequency capabilities with emphasis on successful ratio should highlight reduced routinization.

Thus, firms that implement dynamic capabilities may be particularly different in their approaches considering such threshold. One example of such contrast is how Toyota and IBM adopt dynamic capabilities to implement change. Toyota has been a universally reorganized firm as the advocator of continuous improvement. Adler et al., (1999) research illustrates in detail how a venture by Toyota implements changes and learnings in a form of continuous improvement and innovation. The manufacturer adopts multiple measures to create environments and systems that encourage its employees to make improvement in the interim of their daily operation. Such dynamic capabilities emphasize and facilitate continuous change in the forms of Kaizen program (referring to continuous improvements in the daily operations) and major changeovers (referring to major innovations and integration of new production directions). Such settings for continuous change are a good illustration of how firms position themselves before the threshold to implement dynamic capabilities. Whereas in Harreld et al.'s (2007) research on IBM restructuring approach, a total shift of direction in certain time point was considered and labeled as a form of dynamic capability. In mid-1980s, IBM enjoyed a dominant place in the computer industry; however, in the early 1990s, the company suffered slow growth and lost its advantages in the industry, and had to make major job cuts after 70 years of avoiding layoffs to ensure its survival. In facing such disastrous situation, the company adopted a series of transformations in its strategy and business operation from production to solution services. These efforts placed heavy emphasis on changing organizational learning mechanisms and strategic execution. The company was later successfully restructured as a leading information technology service firm. Such route taken by IBM is a very good example of how firms behind the threshold should act to implement dynamic capabilities.

The main contribution of this research is that routinization was linked with dynamic capabilities' heterogeneity and performances. The findings on the threshold effect of routinization could open new avenues for explaining and integrating the divergence in dynamic capability theoretical development. Is there a threshold effect from routinization process that may require different types of dynamic capabilities? This question is also a new research avenue for future empirical testing and theoretical extension.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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