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Achieving a firm's competitive advantage through dynamic capability

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Abstract

Purpose – The purpose of this paper is to propose a quantitative model to help managers diagnose what dynamic capabilities a firm needs to address the demands of a rapidly changing environment.
Design/methodology/approach – A two-firm model based on the VRIO framework is built using quantitative techniques to assist top management in formulating and implementing strategies regarding when and how to develop a firm's dynamic capabilities for achieving a competitive advantage. This model is developed by considering both internal and external competences, with the former measured by the features of the organizational capabilities of the focal firm and latter evaluated by comparing the relative utilities of the dynamic capabilities of the two competing firms.
Findings – Three resource allocation strategies are introduced to guide a firm to leverage dynamic capability that generates strong organizational performance. The first two strategies are, respectively, synergy oriented, focussing on acquiring various knowledge or experiences of a capability, and uniqueness oriented, emphasizing the depth of knowledge and technology of the capabilities. The third one is a hybrid of the first two strategies.
Originality/value – The proposed model is useful to help top management determine how and when to renew, bundle, and leverage resources and capabilities in a dynamic environment. It enables decision makers to detect changes in the competitive environment and take corrective action in a timely and appropriate manner.

Keywords Dynamic capabilities, Competitive advantage, Resource allocation, Strategy formulation, VRIO framework

Paper type Research paper

Nomenclature

i, j	the companies i and j	k_i (t)	the synergy rate of capabilities of company i at time t
t	the time	E_i (t)	the maximum performance of capability of company i at time t
ε_i (t)	the performance of capability of company i before competition at time t	α_{ji} (t)	the intensity of the competitiveness of company j's capability with regard to company i's at time t
v_i (t)	the performance of capability of company i after competition at time t		

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b_i (t)	the sales of company i at time t	c_{Mi} (t)	the costs invested in the marketing of company i at time t (i.e. sell, general, and administrative expenses)
c_{Pi} (t)	the costs invested in manufacturing the product of company i at time t (i.e. cost of goods sold)		
c_{Ri} (t)	the costs invested in R&D of company i at time t (i.e. R&D expenses)		

1. Introduction

Dynamic capabilities refer to the ability to devise new resources and reconfigure existing ones to address issues that arise in the external environment (Teece *et al.*, 1997; Helfat and Peteraf, 2003; Schilke, 2014). The last two decades of research on competitive advantage assessment have tended to focus on the dynamic capability view, which is built on the resource-based view (RBV) (Teece, 2007; Helfat and Winter, 2011; Schilke, 2014; Helfat and Peteraf, 2015). In order to successfully manage their dynamic capabilities, firms should first identify the required resources and capabilities before renewing and bundling current resource to enhance performance (Sirmon *et al.*, 2008; Andersén, 2011; Lin *et al.*, 2012; Schilke, 2014). However, the procedure for identifying such needs can be costly and may result in disrupting the ongoing learning process for acquiring innovative capabilities, and it is possible that significant costs over the margin may arise when there is no compelling need for change (Zollo and Winter, 2002; Winter, 2003; Schilke, 2014). In order to avoid such situations, a firm's dynamic capability should be developed in the right way and at the right time to achieve better performance than that seen by competitors (Teece, 2007; Helfat and Peteraf, 2009; Barreto, 2010; Li and Liu, 2014). A number of scholars have proposed systemic frameworks to explain how dynamic capability can be leveraged to enhance competitive advantage (e.g. Drnevich and Kriauciunas, 2011; Schilke, 2014). Such works have concluded that dynamic capabilities have a positive effect on firm performance in a dynamic environment, and the greater the environmental dynamism, the stronger the positive relationship (Drnevich and Kriauciunas, 2011; Li and Liu, 2014). Moreover, several mathematical regression equations and models have also been proposed to measure dynamic capabilities by considering competition among rival firms (Makadok, 2001, 2002; Schilke, 2014). The results of these studies offer guidance to firms regarding how their time, effort and resources should be allocated, and what the expected outcomes are after implementing such strategies.

The studies mentioned above have tended to focus on the following issues. First, in order to better understand and manage dynamic capabilities scholars have highlighted the role of such capabilities and explained how process management affected them (Helfat and Peteraf, 2003, 2009; Winter, 2003; Pablo *et al.*, 2007; Helfat and Winter, 2011). Second, to find out the relationship between dynamic capabilities and environment, researchers have examined the efficiency of dynamic capabilities under different levels of environmental dynamism (Aragón-Correa and Sharma, 2003; Zahra *et al.*, 2006; Oliver and Holzinger, 2008; Schilke, 2014). Third, scholars have assessed the contributions of dynamic capabilities to performance in order to better understand the link between them (Adner and Helfat, 2003; Drnevich and Kriauciunas, 2011; Li and Liu, 2014). Many previous studies concluded that a significant value of dynamic capabilities is that they enable firms to better sense opportunities and threats in the environment in order to make more timely and beneficial decisions (e.g. Adner and Helfat, 2003; Barreto, 2010; Schilke, 2014). However, in a more dynamic environment it is more difficult to build

and use dynamic capabilities to achieve a competitive advantage. It is thus of interest to develop an objective tool to help managers diagnose what dynamic capabilities a firm needs to address the demands of a rapidly changing environment.

Barney's VRIO framework plays an important role in RBV, and measures organizational resources in terms the degree to which they are valuable, rare, inimitable, well organized, and have the potential to generate a sustained competitive advantage, temporary advantage, competitive parity, or disadvantage (Barney, 1995; Cardeal and António, 2012; Kozlenkova *et al.*, 2014). This approach has been widely used to describe how a firm's sustained competitive advantage can be achieved by applying its resources and capabilities under different scenarios, and thus it could be useful to determine how to build and leverage dynamic capabilities at the right time. When such capabilities leveraged, the VRIO framework enables firms to better manage them, and thus achieve better outcomes. A model based on the VRIO framework was developed in this study to assist top management in formulating and implementing strategies regarding when and how to build, integrate, reconfigure, and reposition resources effectively and efficiently. In addition, most data sets used with the VRIO framework analysis in the literature were collected based on the insights and knowledge that top managers or experts have gained from their experiences, and so these usually lack objectivity and methodological robustness (Ittner and Larcker, 2003; McWilliams, 2011; Cardeal and António, 2012; Huy, 2012; Lin *et al.*, 2012). Therefore, a more objective analytical tool, namely, a mathematical model, is proposed in this work to deal with this issue.

2. Theoretical background

While an organizational capability aims to utilize resources (e.g. capital and labor) in order to achieve certain results (e.g. produce better goods and profits) (Hill *et al.*, 2014), dynamic capabilities are used to integrate and reconfigure a firm's existing resources to deal with a changing environment (Teece *et al.*, 1997). An efficient capability allows a firm to spend fewer resources or create more outputs than its rivals (Jacobides *et al.*, 2012), and dynamic capabilities enable a firm's capabilities to align with markets more appropriately (Drnevich and Kriauciunas, 2011; Li and Liu, 2014). It is often necessary to reallocate resources to create efficient dynamic capabilities and then leverage them in an appropriate manner, so that a firm's competitive advantages can be attained (Drnevich and Kriauciunas, 2011; Hill *et al.*, 2014; Li and Liu, 2014). In order to better exploit these capabilities in pursuing a competitive advantage, this work proposes a systematic framework to formulate and implement related strategies based on theories of organizational capabilities, as well as the relationships among organizational capabilities, dynamic capabilities, and competitive advantage.

2.1 Theories of organizational capabilities

In general, the complicated concepts of business operations can be broken down into several important organizational functions, such as manufacturing, marketing, human resources, R&D, and finance. Among these the capabilities of manufacturing, marketing, and R&D are the more critical ones, and are often discussed in ways that seek to enable a firm to transform its resources into valuable products (Markeset and Kumar, 2003; Hill *et al.*, 2014; Lin *et al.*, 2014). A better manufacturing capability can create products with higher value than those of competitors (Hill *et al.*, 2014; Lin *et al.*, 2014), while a better marketing capability adds more value through better advertising and after-sales service, and better R&D capability allows a firm to produce innovative products, high quality that can attract more customers (Trainor *et al.*, 2011; Maier *et al.*, 2012).

In general, the uniqueness of organizational capabilities and the synergies among them are considered as the critical drivers for organizational performance (Hill and Jones, 2012; Hill *et al.*, 2014). The reasons for this are as follows. First, an organizational capability may be unique to a specific firm, which can be developed through organizational learning (Zollo and Winter, 2002; Helfat and Peteraf, 2003; Teece, 2007). The more resources that are invested in executing the operating routines of a particular activity, the more relevant practices and experiences are accumulated, and so the focal task can then be performed even better or faster (Helfat and Peteraf, 2003; Teece, 2007). The knowledge and skills a firm learns in this process, and how such learning occurs, will differ from one firm to the others, and, like intangible assets, they are difficult for rivals to emulate due to their tacit nature (Figueiredo, 2002; Li and Gao, 2003; Hsu and Wang, 2012). A firm's organizational capabilities can thus contribute to organizational performance based on their uniqueness.

Second, bundling a firm's capabilities appropriately can create valuable synergies (McGee and Shook, 2000; Sirmon *et al.*, 2007; Golnam *et al.*, 2014; Tang and Rai, 2014), and dynamic capabilities can be used to leverage these (Montealegre, 2002; Schreyögg and Kliesch-Eberl, 2007; Tang and Rai, 2014). For example, a product with high quality, high visibility, and unique functions should be produced by bundling manufacturing, marketing, and R&D capabilities effectively and efficiently.

2.2 The relationships among organizational capabilities, dynamic capabilities, and competitive advantage

In Barney's (1995) VRIO framework there are four types of competitive outcomes, reflecting the different effects of organizational resources on a company's competitiveness: a firm gains a sustained advantage when its resources and capabilities fulfill the VRIO requirements; the advantage is temporary when the resources and capabilities are valuable and rare; if valuable is the only characteristic of the firm's resources and capabilities, it has competitive parity; and a firm is in a disadvantageous position when it does not possess any valuable resources and capabilities. Further, the framework describes how to achieve a sustainable competitive advantage based on different scenarios of resources and capabilities. One way to expand the application of Barney's VRIO analysis in capability evaluation is to include the concept of environmental dynamism analysis (Warren, 2008; Knott, 2009; Agarwal *et al.*, 2012). Bundling resources and capabilities to better match a firm's dynamic capabilities to its environment helps to achieve a competitive advantage.

Based on the VRIO criteria, and because synergies are developed by integrating valuable experiences and knowledge (Jarratt and Katsikeas, 2009; Cardeal and António, 2012), the factors of "valuable" (V) and "well-organized" (O) can be used to determine the degree of synergy that can be obtained. The uniqueness of a firm's capabilities can be measured by the attributes "rareness" (R) and "inimitability" (I), because a capability is rare when it is not widely possessed by other competitors and is inimitable (Allred *et al.*, 2011). The theoretical framework used in this work is illustrated in Figure 1, which shows how the key theoretical themes link together.

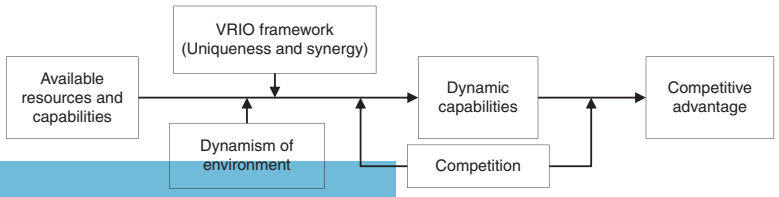


Figure 1.
The theoretical framework

Based on such system, a quantitative model is constructed to assess a firm's dynamic capabilities with regard to achieving a competitive advantage by adopting the VRIO attributes, which consider both internal scrutiny and scanning of the external environment. To ensure an objective assessment of such capabilities, the variables in the proposed model will be designed to be measured by financial indicators that can be obtained from financial reports (Song *et al.*, 2007; Tang and Liou, 2010; Lin *et al.*, 2014). A measurement of a firm's inherent dynamic capabilities is developed by assessing the impact of competition on bundling and leveraging capabilities, based on earlier studies which argue that a competitive advantage should be evaluated by taking into account any interactions between rivals (Dixit *et al.*, 2009; D'Aveni *et al.*, 2010; Hinterhuber, 2013). The proposed model thus enables a firm to identify its competitive position, and formulates appropriate strategies based on a firm's own dynamic capabilities for adapting to its specific competitive situation (Sirmon *et al.*, 2007; Ployhart and Moliterno, 2011).

3. The proposed model

Makadok (2001) provided a two-firm model to investigate how to allocate time and effort to select resources and build capabilities, with the aim of maximizing the expected profit. While a firm's competitive strengths can be identified by internal scrutiny, the opportunities that exist with regard to a firm and its major industry rivals need to be found by scanning the external environment (Makadok, 2001, 2002). Moreover, firms can pursue a sustained competitive advantage by creating better matches between the configuration of their resources and the external environmental conditions (Teece and Pisano, 1994). Based on this concept, our model is developed by considering both internal and external competences, with the former measured by the features of the organizational capabilities of the focal firm, and the latter evaluated by comparing the relative utilities of the dynamic capabilities of the two competing firms. More importantly, recalling the significant contributions of manufacturing, marketing, and R&D to organizational performance, as were mentioned previously, these capabilities are used as the basis of the proposed model.

3.1 The VRIO based model

The efficiency of an organizational capability can be assessed using an output/input ratio, as based on the efficiency measurement perspective. For example, Hill and Jones (2012) viewed the ratio of R&D to sales (R&D/Sales) as an indicator of R&D efficiency of a company, while Lin *et al.* (2014) employed financial data COGS, R&D, SG&A, and sales to evaluate the efficiencies of a firm's manufacturing, R&D, and marketing capabilities, respectively. In order to develop the proposed model using quantitative techniques, the efficiencies of organizational capabilities and the utility of dynamic capabilities are measured by an input-output approach (Hill and Jones, 2012; Hill *et al.*, 2014; Lin *et al.*, 2014).

The variable $\varepsilon_i(t)$ is defined as the absolute efficiency of company i's organizational capabilities before a period of competition at time t, and the variable $v_i(\varepsilon_i(t), \varepsilon_j(t))$ indicates the relative utility of company i's dynamic capabilities after competing with company j. Companies i and j are competitors. The influnece of company i's organizational capabilities on the improvement of the utility of its dynamic capabilities can be denoted by $dv_i(\varepsilon_i(t), \varepsilon_j(t))/d\varepsilon_i(t)$ (i.e. the influence of $\varepsilon_i(t)$ on $v_i(\varepsilon_i(t), \varepsilon_j(t))$), and the procedures used to obtain the measurements based on the VRIO framework are outlined below.

3.1.1 Synergy of organizational capabilities – valuable (V) and well organized (O). Synergy is one of the most important characteristics of organizational capabilities, as a basis of well organized, varied, and valuable knowledge can enhance the positive effect of dynamic capabilities on organizational performance, based on the integration of information, experiences, and skills (Draganidis and Mentzas, 2006). Recalling the description of organizational capabilities, these abilities are cumulative and recursive and can be improved through learning and training (Montealegre, 2002; Schreyögg and Kliesch-Eberl, 2007). Therefore, the synergy of organizational capabilities, denoted as k_i (t), has a positive effect on the improvement of the utility of dynamic capabilities, and the following equation can be derived:

$$\frac{dv_i\left(\varepsilon_i(t), \varepsilon_j(t)\right)}{d\varepsilon_i(t)} = k_i(t) \tag{1}$$

R&D and marketing are assigned as the components of integrated capabilities in this study, because, for example, R&D can be carried out to improve the quality and functions of a product, while marketing can improve after-sales service and a firm's reputation (Balsam *et al.*, 2011; Donelson, 2011). The expenses related to the R&D and marketing of company i at time t are denoted by $c_{\mathrm{R}i}$ (t) and $c_{\mathrm{M}i}$ (t), respectively. The more the company invests in R&D and marketing the more experience and practice can be accumulated, and thus the related actions can be performed better or faster (Helfat and Peteraf, 2003; Teece, 2007), and thus such spending can be used to enhance firm performance, such as higher product quality and better brand awareness (Balsam *et al.*, 2011; O'Brien and David, 2014). The terms $(c_{\mathrm{P}i}(t) + c_{\mathrm{R}i}(t))/c_{\mathrm{P}i}(t)$ and $(c_{\mathrm{P}i}(t) + c_{\mathrm{M}i}(t))/c_{\mathrm{P}i}(t)$ represent the values added by R&D and marketing in relation to the unit manufacturing cost, respectively. They can be simplified as $1 + c_{\mathrm{R}i}(t)/c_{\mathrm{P}i}(t)$ and $1 + c_{\mathrm{M}i}(t)/c_{\mathrm{P}i}(t)$. The utility of the synergy created by R&D and marketing can be determined by the result of $1 + c_{\mathrm{R}i}(t)/c_{\mathrm{P}i}(t)$ multiplied by $1 + c_{\mathrm{M}i}(t)/c_i(t)$, as described in the following equation:

$$\frac{dv_i\left(\varepsilon_i(t), \varepsilon_j(t)\right)}{d\varepsilon_i(t)} = k_i(t) = \left(1+\frac{c_{\mathrm{R}i}(t)}{c_{\mathrm{P}i}(t)}\right) \cdot \left(1+\frac{c_{\mathrm{M}i}(t)}{c_{\mathrm{P}i}(t)}\right) \tag{2}$$

When organizational performance gradually approaches the maximum level (i.e. ε_i (t)→E_i (t), with E_i (t) being the maximum value), continued improvement is difficult to achieve, because there is little room for further growth (Hatch and Dyer, 2004). In addition, a company's organizational capabilities are developed through learning. Based on the concept of a learning curve, improvements in this usually come very quickly at the beginning and then the learning rate gradually falls to almost nothing (Linton and Walsh, 2013). It thus becomes more difficult for a firm to increase its capabilities to create more organizational performance when the growth in performance approaches the maximum level (Sáenz-Royo and Salas-Fumás, 2013), and $1-\varepsilon_i(t)/E_i(t)$ is derived to describe this limitation, and Equation (2) can thus be modified by including this, as seen in the following equation:

$$\frac{dv_i\left(\varepsilon_i(t), \varepsilon_j(t)\right)}{d\varepsilon_i(t)} = \left[\left(1+\frac{c_{\mathrm{R}i}(t)}{c_{\mathrm{P}i}(t)}\right) \times \left(1+\frac{c_{\mathrm{M}i}(t)}{c_{\mathrm{P}i}(t)}\right)\right] \times \left(1-\frac{\varepsilon_i(t)}{E_i(t)}\right) \tag{3}$$

Regarding the influence of ε_i (t) on $v_i(\varepsilon_i(t), \varepsilon_j(t))$, the term $1 - \varepsilon_i(t)/E_i(t)$ implies the effect of increasing one unit ε_i (t) on boosting $v_i(\varepsilon_i(t), \varepsilon_j(t))$ is less significant when $\varepsilon_i(t) \cong E_i(t)$ than when $\varepsilon_i(t) \ll E_i(t)$. Equation (3) is illustrated in Figure 2, in which $\varepsilon_i(t)$ and $v_i(\varepsilon_i(t), \varepsilon_j(t))$ are described on the x and y axes, respectively, and the slope of the tangent on the curve is $dv_i(\varepsilon_i(t), \varepsilon_j(t))/d\varepsilon_i(t)$. This curve traces the change in organizational performance, and it is used by company i to measure the performance of its own capabilities without competition.

In addition, because the highest organizational performance can be achieved with the maximum performance of a firm's capabilities, E_i (t) (Hill and Jones, 2012), this study uses the following equation to measure the value of E_i (t), in which the term b_i $(t) - c_{Pi}$ (t) represents the profits of company i at time t, where b_i (t) denotes the sales of company i at time t:

$$E_i(t) = \frac{b_i(t) - c_{Pi}(t)}{c_{Pi}(t)} \tag{4}$$

The development of valuable organizational capabilities will result in better organizational performance (Cardeal and António, 2012). In the event, however, that a specific capability is not rare and inimitable, and then its value will be reduced because competitors can also achieve this. For example, a rival will thus be able to offer the same or a very similar product to take market share from the focal firm (Cardeal and António, 2012; Weigelt, 2013). Although the level of efficiency can be obtained by Equation (3), this equation should be expanded to include the influence of competition, because the focal company needs an objective tool to help it to explore the characteristics of a specific capability, in order to identify the determinants of the related competitive advantage. The following section presents a number of equations in which factors such as R and I are used to describe the competitive situations in this context in more detail.

3.1.2 Uniqueness of organizational capabilities – rare (R) and inimitable (I). Organizational performance is based on organizational capabilities and resources, and will change when new competitors enter the market (Weigelt, 2013). For example, in 1988 Walmart pioneered the use of an electronic data interchange system, which shortened the order cycle time, thus leading to much better organizational performance. A few years later, however, this advantage was gradually neutralized when its major rival imitated this approach. Based on this perspective, the proposed model should

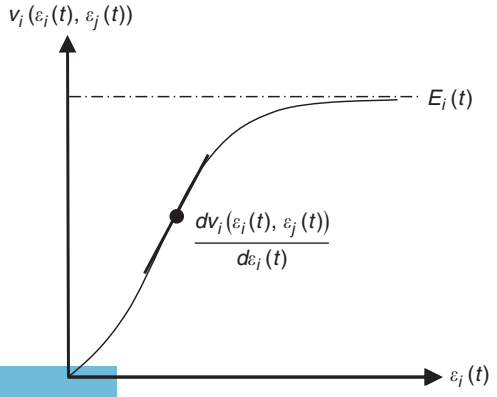


Figure 2.
The curve of the influence of εi (t) on vi (t) without competition at time t

include the competition between two rivals' capabilities. This can be illustrated in Figure 3, in which the curve shown in Figure 2 shifts down to a lower position.

Taking into account external competition, the term $\alpha_{ji}(t)\times\varepsilon_j(t)$ can be used to describe the fall in the curve in Figure 3, and Equation (3) can be revised as follows:

$$\frac{dv_i\left(\varepsilon_i(t),\varepsilon_j(t)\right)}{d\varepsilon_i(t)}=\left[\left(1+\frac{c_{\mathrm{R}i}(t)}{c_{\mathrm{P}i}(t)}\right)\times\left(1+\frac{c_{\mathrm{M}i}(t)}{c_{\mathrm{P}i}(t)}\right)\right]\times\left(1-\frac{\varepsilon_i(t)}{E_i(t)}\right)-\alpha_{ji}(t)\times\varepsilon_j(t) \quad (5)$$

In Equation (5), the terms after the second minus sign denote the efficiencies neutralized by a competitor. The competition between companies i and j is more intense when both of them try to achieve better performance (Pacheco-de-almeida and Zemsky, 2012). The variable $\alpha_{ji}(t)$ represents the intensity of the competitiveness of a rival (i.e. company j) with regard to the focal company (i.e. company i) which is measured by the uniqueness of the rival's organizational capabilities. Because unique organizational capabilities are based on accumulated knowledge and skills which enable a firm to implement tasks better or faster (Helfat and Peteraf, 2003; Teece, 2007), a company can thus generate stronger organizational performance by using the same resources. Therefore, the ratio of the expected change in organizational performance to the percentage change in invested resources is used as the measurement of variable $\alpha_{ji}(t)$ (Penman, 2005; Pacheco-de-almeida and Zemsky, 2012), and the following equation can be derived:

$$\alpha_{ji}(t)=1+\frac{\Delta b_j/b_j(t-1)}{\Delta c_{\mathrm{P}j}/c_{\mathrm{P}j}(t-1)} \quad (6)$$

In which the variables $b_j(t)$ and $c_{\mathrm{P}j}(t)$ represent the sales and manufacturing costs of company j at time t, and Δb_j and $\Delta c_{\mathrm{P}j}$ are the changes in sales and in manufacturing costs of company j from time $t-1$ to t, respectively.

3.2 The solution of the model

Integrating Equation (5) with respect to $\varepsilon_i(t)$ will obtain the function of $v_i(t)$. By doing this the proposed model equations, Equations (7) and (8), can be derived to express $v_1(\varepsilon_1(t), \varepsilon_2(t))$ and $v_2(\varepsilon_1(t), \varepsilon_2(t))$, respectively, with w and q being constants.

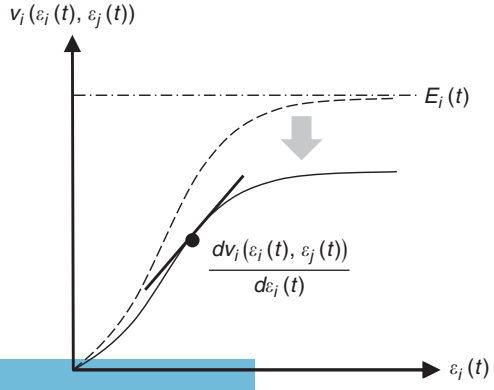


Figure 3. The curve of the influence of $\varepsilon i(t)$ on $vi(t)$ with competition at time t

Two companies, denoted as company 1 and company 2 (i.e. $i, j = 1, 2$, and $i \neq j$), compete with each other for profits gained by their functional capabilities:

$$v_1(\varepsilon_1(t), \varepsilon_2(t)) = \varepsilon_1(t) \times \left[\left(1+\frac{c_{R1}(t)}{c_{P1}(t)}\right) \times \left(1+\frac{c_{M1}(t)}{c_{P1}(t)}\right) \times \left(1-\frac{\varepsilon_1(t)}{E_1(t)}\right) - \alpha_{21}(t) \times \varepsilon_2(t)\right] + w \tag{7}$$

$$v_2(\varepsilon_1(t), \varepsilon_2(t)) = \varepsilon_2(t) \times \left[\left(1+\frac{c_{R2}(t)}{c_{P2}(t)}\right) \times \left(1+\frac{c_{M2}(t)}{c_{P2}(t)}\right) \times \left(1-\frac{\varepsilon_2(t)}{E_2(t)}\right) - \alpha_{12}(t) \times \varepsilon_1(t)\right] + q \tag{8}$$

Finding the solution of the above model can enable a company to understand how it and its rival affect each other (Robinson *et al.*, 2002; Allon *et al.*, 2011). A competitive system will ultimately end up in a steady state, if the state remains constant or unchanging (Gottman *et al.*, 2005). Herein, the steady state is solved by setting the differential equations to equal 0 (Gottman *et al.*, 2005), so that the following equations are obtained. The details are shown in Appendix 1:

$$\varepsilon_1(t) = E_1(t) - \frac{E_1(t)\alpha_{21}(t)}{k_1(t)} \times \varepsilon_2(t) \tag{9}$$

$$\varepsilon_2(t) = E_2(t) - \frac{E_2(t)\alpha_{12}(t)}{k_2(t)} \times \varepsilon_1(t) \tag{10}$$

By solving Equations (9) and (10) simultaneously, the solutions of this competition model are determined, as shown in the following equations, in which the variables k_i (*t*) and α_{ij} (*t*) are replaced by Equations (4) and (6), respectively:

$$\varepsilon_1(t)^* = \frac{\frac{c_{P1}(t)\cdot c_{P2}(t)}{(b_1(t)-c_{P1}(t))\cdot(b_2(t)-c_{P2}(t))}\cdot\left(1+\frac{c_{R2}(t)}{c_{P2}(t)}\right)\left(1+\frac{c_{M2}(t)}{c_{P2}(t)}\right)\frac{\Delta b_2\cdot c_{P2}(t-1)}{\Delta c_{P2}\cdot b_2(t-1)} - \frac{c_{P1}(t)}{(b_1(t)-c_{P1}(t))}\cdot\left(1+\frac{c_{R1}(t)}{c_{P1}(t)}\right)\left(1+\frac{c_{M1}(t)}{c_{P1}(t)}\right)\left(1+\frac{c_{R2}(t)}{c_{P2}(t)}\right)\left(1+\frac{c_{M2}(t)}{c_{P2}(t)}\right)}{\frac{c_{P1}(t)\cdot c_{P2}(t)}{(b_1(t)-c_{P1}(t))\cdot(b_2(t)-c_{P2}(t))}\cdot\frac{\Delta b_1\cdot c_{P1}(t-1)\cdot\Delta b_2\cdot c_{P2}(t-1)}{\Delta c_{P1}\cdot b_1(t-1)\cdot\Delta c_{P2}\cdot b_2(t-1)} - \left(1+\frac{c_{R1}(t)}{c_{P1}(t)}\right)\left(1+\frac{c_{M1}(t)}{c_{P1}(t)}\right)\left(1+\frac{c_{R2}(t)}{c_{P2}(t)}\right)\left(1+\frac{c_{M2}(t)}{c_{P2}(t)}\right)} \tag{11}$$

$$\varepsilon_2(t)^* = \frac{\frac{c_{P1}(t)\cdot c_{P2}(t)}{(b_1(t)-c_{P1}(t))\cdot(b_2(t)-c_{P2}(t))}\cdot\left(1+\frac{c_{R1}(t)}{c_{P1}(t)}\right)\left(1+\frac{c_{M1}(t)}{c_{P1}(t)}\right)\frac{\Delta b_1\cdot c_{P1}(t-1)}{\Delta c_{P1}\cdot b_1(t-1)} - \frac{c_{P2}(t)}{(b_2(t)-c_{P2}(t))}\cdot\left(1+\frac{c_{R1}(t)}{c_{P1}(t)}\right)\left(1+\frac{c_{M1}(t)}{c_{P1}(t)}\right)\left(1+\frac{c_{R2}(t)}{c_{P2}(t)}\right)\left(1+\frac{c_{M2}(t)}{c_{P2}(t)}\right)}{\frac{c_{P1}(t)\cdot c_{P2}(t)}{(b_1(t)-c_{P1}(t))\cdot(b_2(t)-c_{P2}(t))}\cdot\frac{\Delta b_1\cdot c_{P1}(t-1)\cdot\Delta b_2\cdot c_{P2}(t-1)}{\Delta c_{P1}\cdot b_1(t-1)\cdot\Delta c_{P2}\cdot b_2(t-1)} - \left(1+\frac{c_{R1}(t)}{c_{P1}(t)}\right)\left(1+\frac{c_{M1}(t)}{c_{P1}(t)}\right)\left(1+\frac{c_{R2}(t)}{c_{P2}(t)}\right)\left(1+\frac{c_{M2}(t)}{c_{P2}(t)}\right)} \tag{12}$$

The variables in the proposed model are financial factors, and the inclusion of these indicators enables a company to make a more objective assessment of its functional capabilities (Song *et al.*, 2007). The definitions of the variables and notations used in the model are summarized in Nomenclature.

3.3 A discussion of competition behavior between companies

Companies 1 and 2 will both achieve competitive advantages when their resource portfolios deliver the stable solution state (i.e. $\varepsilon_1(t)^* > 0$ and $\varepsilon_2(t)^* > 0$). Their resource allocation strategies, however, may fail to converge to the solution (i.e. $\varepsilon_1(t)^* \leqslant 0$ or $\varepsilon_2(t)^* \leqslant 0$). This section discusses the competitive behavior between companies 1 and 2 under all possible results of the model which are determined by solving Equations (9) and (10). There are four possible situations obtained by drawing the lines of the equations, and the corresponding competitive scenarios are shown in Figure 4. This figure enables company 1 to identify whether its capabilities are advantageous.

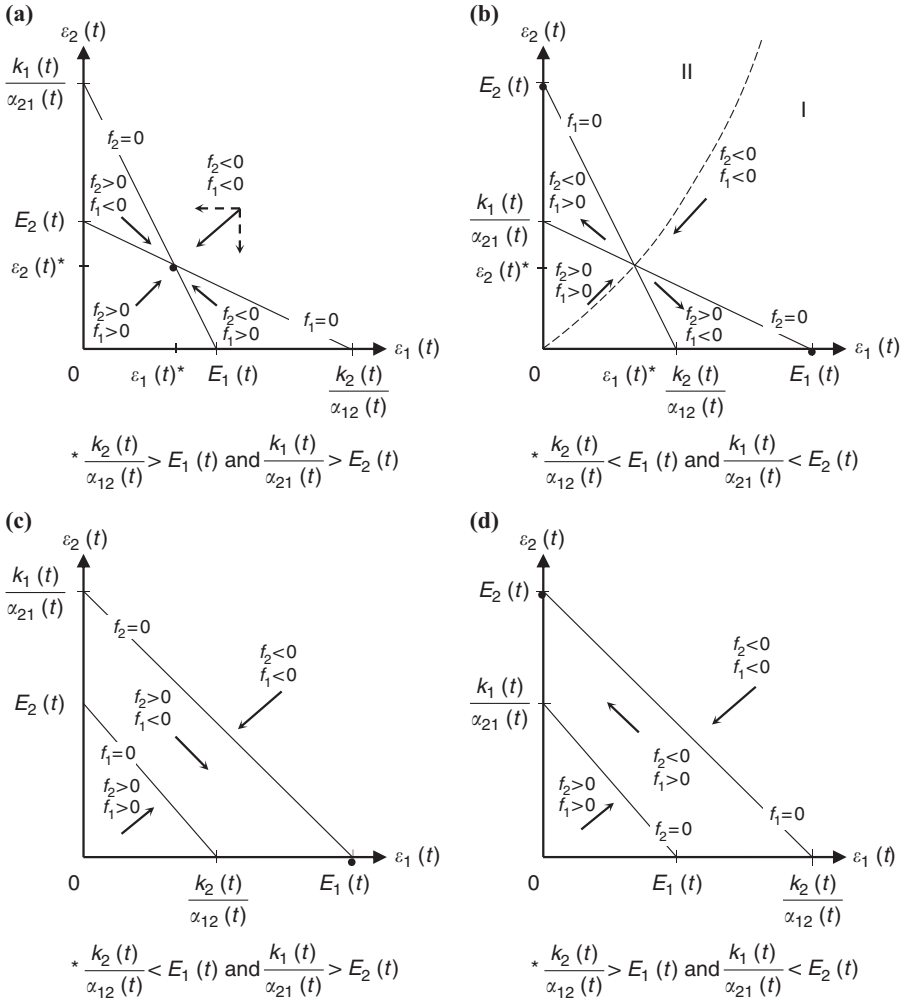


Figure 4.
The possible outcomes of competition for company 1 at time t

Notes: (a) Competitive parity; (b) temporary competitive advantage; (c) sustainable competitive advantage; (d) disadvantage

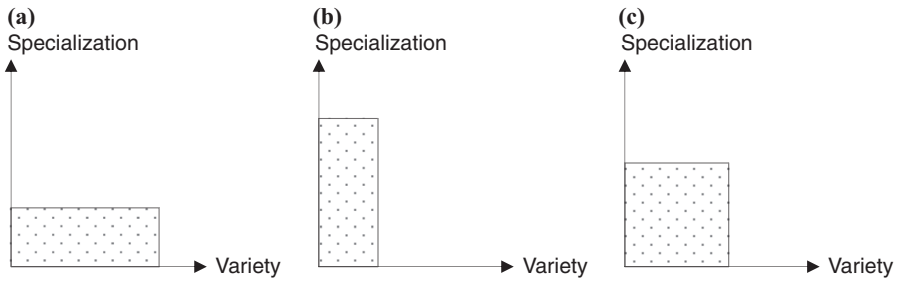
In each graph in Figure 4, the lines labeled $f_1 = 0$ and $f_2 = 0$ are the sets to possible solutions. These two lines divide the graphs into several different regions, in which a resultant force drives the steady states of the competition (Gottman *et al.*, 2005). Every resultant force (shown as a solid arrow) is found by combining the vertical and horizontal forces (shown as vertical and horizontal dashed arrows). For example, in the upper-right-hand region in Figure 4(a), the horizontal force would decrease $\varepsilon_1(t)$ due to $f_1 < 0$ (i.e. horizontal dashed arrow) and the vertical force would decrease $\varepsilon_2(t)$ because of $f_2 < 0$ (i.e. vertical dashed arrow). The resultant forces in Figure 4(a) point out the direction of generating a steady state, and the stable solution exists at point ($\varepsilon_1(t)^*$, $\varepsilon_2(t)^*$). This means that both companies' capabilities achieve competitive parity.

Using the same analytical concept, the stable steady states are at the points ($E_1(t)$, 0) and (0, $E_2(t)$) and the solution ($\varepsilon_1(t)^*$, $\varepsilon_2(t)^*$) is unstable in Figure 4(b). Following the direction pointed by arrows, when the point ($\varepsilon_1(t)$, $\varepsilon_2(t)$) is in region I, it will move toward ($E_1(t)$, 0) and company 1's capabilities gain a competitive advantage. On the other hand, if the point ($\varepsilon_1(t)$, $\varepsilon_2(t)$) ends up at (0, $E_2(t)$) because it is in region II, then company 2's capabilities has a competitive advantage. Therefore, in this situation, the extent to which the advantage is achieved depends on the rival companies' initial existing capabilities. In Figure 4(c) and (d) only one stable steady state exists in each of them by following the directions of the arrows. In Figure 4(c), the system ultimately ends up in the stable steady state at point ($E_1(t)$, 0), which means only company 1 achieves a sustained competitive advantage at the end of the competition. In contrast, in the situation described in Figure 4(d) company 1 will face a disadvantage. In summary, the forces in the four graphs can be used to point out the directions of generating steady states. Adopting the proposed model enables the focal company (i.e. company 1) to identify its competitive advantage based on its dynamic capabilities.

4. Application of the model for formulating strategies

A company has to continually devote resources to learning and developing knowledge and technology in order to gain or maintain a competitive advantage. The proposed model reveals the resource allocation principles for each type of competitive situations, as shown in Figure 4 (Barney, 1991; Gandomi and Zolfaghari, 2013). In this model variables $k_i(t)$ and $\alpha_{ij}(t)$ have significant influences on the ability to gain a competitive advantage. Recalling their definitions, $k_i(t)$ represents the synergy of company i's capabilities and $\alpha_{ij}(t)$ denotes the uniqueness of these capabilities. Due to limited resources, the allocation methods derived from the model can be provided as a means to: increase the value of $k_i(t)$, increase the value of $\alpha_{ij}(t)$, and simultaneously increase both of these. Therefore, three possible resource allocation strategies can be formulated and used as a means of transforming the competitive situations (see Figure 5).

The first strategy, synergy oriented, is shown in Figure 5(a). This focusses on increasing the value of $k_i(t)$, as this enables company i to acquire various knowledge or experiences in the field regarding R&D and marketing. The second strategy is uniqueness oriented (see Figure 5(b)), in which company i can gain more knowledge and technology about manufacturing based on its investment in increasing the value of $\alpha_{ij}(t)$. Finally, the hybrid strategy shown in Figure 5(c) is a compromise between the first two strategies. Detailed discussions regarding these strategies and their expected performances are presented below.



Notes: (a) Synergy oriented: $k_i\,(t)\uparrow$; (b) uniqueness oriented: $\alpha_{ij}\,(t)\uparrow$; (c) hybrid: $\alpha_{ij}\,(t)\uparrow$ and $k_i\,(t)\uparrow$

Figure 5. The resource allocation strategies

4.1 Competitive parity

The proposed model expresses the conditions of competitive parity as inequalities $k_1(t) > \alpha_{21}(t)\cdot E_2(t)$ and $k_2(t) > \alpha_{12}(t)\cdot E_1(t)$ in Figure 4(a). That is, the synergy of company *i*'s organizational capabilities is greater than the result of company *j*'s available maximum organizational performance multiplied by the uniqueness of company *j*'s capabilities. This implies that both companies pursue the synergy-oriented strategy by, for example, working to enhance the quality and function of their own products, while boosting their brand reputation. However, this will result in a lack of the resources needed to gain more specialized capabilities to enhance organizational performance, and thus the capabilities the firms own will be valuable but common. It is worth noting that, based on the analysis of the VRIO framework, valuable but common resources lead to competitive parity (Barney, 1995), and the finding of the proposed model is consistent with this argument. More resources should thus be invested in developing unique capabilities if a company wants to change its situation from competitive parity to one with a sustainable advantage. The uniqueness-oriented strategy is therefore appropriate for the firm in this context, and the resource allocation principle is to increase $\alpha_{12}\,(t)$ until its value is larger than $k_2(t)/E_1(t)$. Therefore, the first proposition in this study is formulated as follows:

P1. If a firm tries to gain a sustained advantage with its competitive parity capability, it should emphasize the specialization of knowledge rather than the variety of technology.

4.2 Temporary competitive advantage

The conditions with regard to a temporary competitive advantage are $k_1(t) < \alpha_{21}(t)\cdot E_2(t)$ and $k_2(t) < \alpha_{12}(t)\cdot E_1(t)$ (see Figure 4(b)). Companies 1 and 2 both devote most of their efforts and time to accumulating knowledge (i.e. higher values of the terms $\alpha_{21}\,(t)\cdot E_2\,(t)$ and $\alpha_{12}\,(t)\cdot E_1\,(t)$), so the resulting valuable and specialized abilities can be used to obtain their own competitive advantages. However, the smaller synergy rate $k_i\,(t)$ implies that the operation of manufacturing system is less complex, so these two companies' capabilities can easily be substituted for each, and so their competitive advantages are only temporary. Therefore, the appropriate strategy for company 1 in this situation is a synergy-oriented strategy, and the method to transform the competitive situation is to increase $k_1\,(t)$ by investing more resources in R&D and marketing. Once $k_1\,(t)$ is larger than $\alpha_{21}\,(t)\cdot E_2\,(t)$, the competitive condition

$k_1(t) < \alpha_{21}(t) \cdot E_2(t)$ will be transformed to $k_1(t) > \alpha_{21}(t) \cdot E_2(t)$, which is the condition in Figure 4(c), and company 1 will take preemptive action to sustain its competitive advantage. The second proposition is thus formulated as follows:

P2. If a firm tries to gain a sustained advantage with its temporary competitive capability, it should emphasize the variety rather than the specialization of its knowledge.

4.3 Sustained competitive advantage

In Figure 4(c), company 1 gains a sustained competitive advantage when $k_1(t) > \alpha_{21}(t) \cdot E_2(t)$ and $k_2(t) < \alpha_{12}(t) \cdot E_1(t)$. Because of the high synergistic effect (i.e. the value of k_1 (t)), company 1 has valuable, inimitable, and well-organized capabilities. Moreover, the higher value of $\alpha_{12}(t) \cdot E_1(t)$ implies that company 1 also has specialized capabilities, so the abilities are more distinct and this degree of specialization can more seriously challenge company 2. In this situation, the resources are allocated appropriately to ensure that the capabilities of company 1 are effective and efficient in creating better organizational performance. Therefore, a balanced allocation of resources enables company 1 to sustain its competitive advantage, and so the firm can execute a hybrid strategy to increase $k_1(t)$ and $\alpha_{12}(t)$. The third proposition is thus formulated as follows:

P3. If a firm tries to maintain its advantage with its own sustainable competitive capability, it should emphasize both the variety and the specialization of knowledge.

4.4 Disadvantage

The conditions in Figure 4(d) are $k_1(t) < \alpha_{21}(t) \cdot E_2(t)$ and $k_2(t) > \alpha_{12}(t) \cdot E_1(t)$, in which company 1 faces a disadvantage because its capability is imitable, non-organized (i.e. low k_1) and not unique (i.e. low α_{12}). Although company 1 faces such a difficult situation, it is possible to change the circumstance if the company attempts to spend more time and efforts on enriching its knowledge and enhancing the synergy and uniqueness of its capabilities (i.e. increasing k_1 (t) and $\alpha_{12}(t)$). A hybrid strategy, however, will fail to change the competitive conditions at the same time due to the limited resources at the firm's disposal. It is thus more suitable for company 1 to first try and obtain more diverse knowledge and technology, and then to seek opportunities to develop unique and inimitable capability through such skills. In this study the synergy-oriented strategy is recommended for changing the condition $k_1(t) < \alpha_{21}(t) \cdot E_2(t)$ until $k_1(t) > \alpha_{21}(t) \cdot E_2(t)$, and then adopting a uniqueness-oriented strategy will enable the company to transform $k_2(t) > \alpha_{12}(t) \cdot E_1(t)$ to $k_2(t) < \alpha_{12}(t) \cdot E_1(t)$. Therefore, the fourth proposition is as follows:

P4. If a firm has a disadvantaged capability it should first increase the variety of its technology and then develop greater specialization of knowledge to gain a sustained advantage.

A brief summary regarding the strategies and resource allocation principles of the four types of competitive scenarios for the focal company (i.e. company 1) is shown in Table I.

5. Empirical study

The implementation of the proposed model in order to derive a resource allocation strategy that can be used to develop dynamic capabilities is illustrated by using an empirical case drawn from the semiconductor industry, which plays a critical role in global economic development, and the use of such a model is thus highly desirable in this context. Three stages are identified in the following empirical test (see Figure 6). The first stage is to collect the necessary data from financial reports. In the second stage, the competition between the focal firm and its rival is assessed using the proposed model. Finally, an appropriate strategy can be formulated based on the results in the last stage.

5.1 Stage one: data collection

Well-developed businesses which may serve as benchmarks for formulating strategies were chosen in this study in order to apply the proposed model to a real world context. Although there are 194 companies in the global semiconductor industry (i.e. those covered by SIC Code 3674), only three had complete records in the S&P COMPUSTAT database during the period 2001-2010 by which their organizational performances can be measured, and their returns on invested capital were all positive and higher than the average (Copeland *et al.*, 1996; Jablonsky and Barsky, 2001). The financial data for the sample firms can be used to obtain the parametric data of the proposed model by using Equations (2), (4), and (6). The results are shown in Table II and the details of the calculations are given in the Appendix 2.

Scenarios	Strategies	Resources allocation	Satisfied conditions
Competitive parity	Uniqueness-oriented strategy	$\alpha_{12}(t)\uparrow$	$k_2(t) < \alpha_{12}(t) \cdot E_1(t)$
Temporary advantage	Synergy-oriented strategy	$k_1(t)\uparrow$	$k_1(t) > \alpha_{21}(t) \cdot E_2(t)$
Sustained advantage	Hybrid strategy	$\alpha_{12}(t)\uparrow$ and $k_1(t)\uparrow$	–
Disadvantage	Synergy-oriented strategy and uniqueness-oriented strategy	$k_1(t)\uparrow$ and then $\alpha_{12}(t)\uparrow$	$k_2(t) < \alpha_{12}(t) \cdot E_1(t)$ and $k_1(t) > \alpha_{21}(t) \cdot E_2(t)$

Table I. The strategies and resource allocation principles for focal company (company 1)

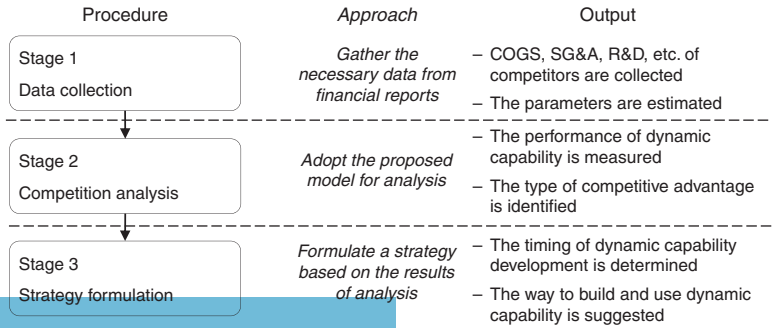


Figure 6. The three-stage process of proposed model implementation

Table II.
The parametric data of the competing companies

	$t=2002$			$t=2003$			$t=2004$			$t=2005$			$t=2006$			$t=2007$			$t=2008$			$t=2009$			$t=2010$		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
$\alpha_{ij}(t)$	1.01	1.01	1.47	1.33	1.01	1.30	1.99	1.83	2.11	3.19	1.76	1.32	1.45	1.01	2.32	1.93	1.87	1.71	1.49	1.19	2.17	2.03	1.50	2.60	2.33	1.01	2.58
$E_i(t)$	1.62	2.19	0.59	1.65	2.65	0.64	1.64	2.57	0.67	1.56	2.44	0.69	1.41	1.86	0.76	1.39	1.83	0.74	1.30	2.10	0.81	1.30	2.33	0.70	1.54	3.15	0.87
$k_i(t)$	2.70	2.99	1.47	2.74	3.15	1.50	2.44	2.98	1.48	2.76	2.85	1.50	2.87	2.90	1.47	2.63	2.60	1.55	2.50	2.83	1.76	2.68	3.12	1.68	2.71	3.62	1.71

5.2 Stage two: competition analysis

The competitive situations between any two of companies A, B, and C can be analyzed by substituting the values of the data into Equations (9) and (10) (see Appendix 3). Figure 7 summarizes the competition at different time points.

In Figure 7, the competition between companies A and B is dynamic. These two firms' dynamic capabilities led them to competitive parity in 2002, 2003, 2006, and 2008, and to have temporary competitive advantages in 2004, 2005, and 2007. Moreover, due to the dynamic capabilities that each firm had, in 2009 and 2010 company A faced a disadvantage while company B enjoyed the competitive advantage. However, in the competition between companies A and C and between B and C, company C always had a disadvantage during the whole time period.

5.3 Stage three: strategy formulation

Appropriate strategies for the focal firm under the different competitive situations identified in stage two are provided to build and leverage its dynamic capabilities according to the proposed propositions which are summarized in Table III.

First, in 2002, 2003, 2006, and 2008, companies A and B were in the situation of competitive parity. This implies that their dynamic capabilities were not efficient enough to achieve the advantage at these times, and it is thus necessary for them to renew and reconfigure their existing organizational resources and capabilities. According to *P1*, they should emphasize the specialization of knowledge rather than variety of technology, so, for example, company B is recommended to increase $\alpha_{BA}(t)$ to change the condition from $k_A(t) > \alpha_{BA}(t) \cdot E_B(t)$ to $k_A(t) < \alpha_{BA}(t) \cdot E_B(t)$ by adopting

Year	Companies A and B	Companies A and C	Companies B and C
2002	$\varepsilon_1(t)=1.62-0.61\varepsilon_2(t)$ $\varepsilon_2(t)=2.19-0.74\varepsilon_1(t)$	$\varepsilon_1(t)=1.62-0.88\varepsilon_2(t)$ $\varepsilon_2(t)=0.59-0.40\varepsilon_1(t)$	$\varepsilon_1(t)=2.19-1.07\varepsilon_2(t)$ $\varepsilon_2(t)=0.59-0.40\varepsilon_1(t)$
2003	$\varepsilon_1(t)=1.65-0.61\varepsilon_2(t)$ $\varepsilon_2(t)=2.65-1.12\varepsilon_1(t)$	$\varepsilon_1(t)=1.65-0.78\varepsilon_2(t)$ $\varepsilon_2(t)=0.64-0.57\varepsilon_1(t)$	$\varepsilon_1(t)=2.65-1.10\varepsilon_2(t)$ $\varepsilon_2(t)=0.64-0.43\varepsilon_1(t)$
2004	$\varepsilon_1(t)=1.64-1.23\varepsilon_2(t)$ $\varepsilon_2(t)=2.57-1.72\varepsilon_1(t)$	$\varepsilon_1(t)=1.64-1.42\varepsilon_2(t)$ $\varepsilon_2(t)=0.67-0.90\varepsilon_1(t)$	$\varepsilon_1(t)=2.57-1.82\varepsilon_2(t)$ $\varepsilon_2(t)=0.67-0.83\varepsilon_1(t)$
2005	$\varepsilon_1(t)=1.56-0.99\varepsilon_2(t)$ $\varepsilon_2(t)=2.44-2.73\varepsilon_1(t)$	$\varepsilon_1(t)=1.56-0.75\varepsilon_2(t)$ $\varepsilon_2(t)=0.69-1.46\varepsilon_1(t)$	$\varepsilon_1(t)=2.44-1.13\varepsilon_2(t)$ $\varepsilon_2(t)=0.69-0.81\varepsilon_1(t)$
2006	$\varepsilon_1(t)=1.41-0.49\varepsilon_2(t)$ $\varepsilon_2(t)=1.86-0.93\varepsilon_1(t)$	$\varepsilon_1(t)=1.41-1.13\varepsilon_2(t)$ $\varepsilon_2(t)=0.76-0.75\varepsilon_1(t)$	$\varepsilon_1(t)=1.86-1.49\varepsilon_2(t)$ $\varepsilon_2(t)=0.76-0.52\varepsilon_1(t)$
2007	$\varepsilon_1(t)=1.39-0.99\varepsilon_2(t)$ $\varepsilon_2(t)=1.83-1.36\varepsilon_1(t)$	$\varepsilon_1(t)=1.39-0.90\varepsilon_2(t)$ $\varepsilon_2(t)=0.74-0.93\varepsilon_1(t)$	$\varepsilon_1(t)=1.83-1.21\varepsilon_2(t)$ $\varepsilon_2(t)=0.74-0.90\varepsilon_1(t)$
2008	$\varepsilon_1(t)=1.30-0.62\varepsilon_2(t)$ $\varepsilon_2(t)=2.10-1.10\varepsilon_1(t)$	$\varepsilon_1(t)=1.30-1.13\varepsilon_2(t)$ $\varepsilon_2(t)=0.81-0.68\varepsilon_1(t)$	$\varepsilon_1(t)=2.10-1.61\varepsilon_2(t)$ $\varepsilon_2(t)=0.81-0.54\varepsilon_1(t)$
2009	$\varepsilon_1(t)=1.30-0.73\varepsilon_2(t)$ $\varepsilon_2(t)=2.33-1.51\varepsilon_1(t)$	$\varepsilon_1(t)=1.30-1.26\varepsilon_2(t)$ $\varepsilon_2(t)=0.70-0.85\varepsilon_1(t)$	$\varepsilon_1(t)=2.33-1.94\varepsilon_2(t)$ $\varepsilon_2(t)=0.70-0.63\varepsilon_1(t)$
2010	$\varepsilon_1(t)=1.54-0.57\varepsilon_2(t)$ $\varepsilon_2(t)=3.15-2.03\varepsilon_1(t)$	$\varepsilon_1(t)=1.54-1.46\varepsilon_2(t)$ $\varepsilon_2(t)=0.87-1.18\varepsilon_1(t)$	$\varepsilon_1(t)=3.15-2.25\varepsilon_2(t)$ $\varepsilon_2(t)=0.87-0.51\varepsilon_1(t)$

Figure 7.
The competitive situations between the sample companies

uniqueness-oriented strategy. In 2004, 2007, and 2009, company B successfully increased the value of $\alpha_{BA}(t)$ and ensured that $k_A(t) < \alpha_{BA}(t) \cdot E_B(t)$, so it gained the competitive advantage at these time points.

Second, in 2004, 2005, and 2007, companies A and B both had temporary competitive advantages, and could pursue a synergy-oriented strategy to improve their performance, as stated in *P2*. However, they both failed to simultaneously create better synergy or maintain the uniqueness of their capabilities, so that the competitive situation either remained unchanged or returned to competitive parity.

Third, in the competition between companies A and B in 2009 and 2010, company B gained a sustained competitive advantage. Following *P3*, company B had an opportunity to maintain its advantage if it bundled the available capabilities appropriately to create both synergy and greater uniqueness, and this would be an effective and efficient way to enhance performance. At these time points the competitive condition $k_A(t) < \alpha_{BA}(t) \cdot E_B(t)$ and $k_B(t) > \alpha_{AB}(t) \cdot E_A(t)$ was maintained, and this implies that company B implemented the hybrid strategy in an effective manner.

Fourth, although company A attempted to increase $k_A(t)$ and $\alpha_{AB}(t)$ in 2009 and 2010, its dynamic capabilities were still less efficient than company B, and thus the conditions for obtaining a competitive advantage (i.e. $k_A(t) > \alpha_{BA}(t) \cdot E_B(t)$ and $k_B(t) < \alpha_{AB}(t) \cdot E_A(t)$) were not reached.

5.4 Discussion

The proposed model is useful to help top management determine how and when to renew, bundle, and leverage resources and capabilities in a dynamic environment. It enables decision makers to detect changes in the competitive environment and take corrective action in a timely and appropriate manner. When competitors change their behavior or the requirements of external environment change, the competitive situation can be analyzed immediately by updating the data. The results offer guidance to users regarding what strategy should be implemented and what competitive conditions need to be reached to acquire or sustain the competitive advantage.

6. Conclusion

Dynamic capabilities are viewed as a source of sustainable competitive advantage. To obtain better performance, companies need to develop and manage their dynamic capabilities in response to the contingent environment. A quantitative model is developed based on Barney's VRIO framework to explain the competitive positions of

Year	Company A	Company B	Company A	Company C	Company B	Company C
2002	US	US	HS	SS and US	HS	SS and US
2003	US	US	HS	SS and US	HS	SS and US
2004	SS	SS	HS	SS and US	HS	SS and US
2005	SS	SS	HS	SS and US	HS	SS and US
2006	US	US	HS	SS and US	HS	SS and US
2007	SS	SS	HS	SS and US	HS	SS and US
2008	US	US	HS	SS and US	HS	SS and US
2009	SS and US	HS	HS	SS and US	HS	SS and US
2010	SS and US	HS	HS	SS and US	HS	SS and US

Notes: US, uniqueness-oriented strategy; SS, synergy-oriented strategy; HS, hybrid strategy

Table III.
The suggested dynamic capability development strategies for sample companies

two firms by measuring their available capabilities. This model is useful for a range of purposes, including analyzing the strengths of a company, comparing competitors on the basis of relative competitive advantage and identifying how to adjust a firm's capabilities. The mechanism of mutual competition in the proposed model is described by mathematic formulas, which in turn describe the conditions of the four competitive scenarios: competitive parity, temporary advantage, sustained advantage, and disadvantage. More specifically, the relative utilities of these two firms' capabilities are evaluated by comparing the firms' performance, by which the competitive positions can be analyzed and derived in a quantitative manner. Finally, a strategy for building dynamic capabilities can be proposed based on the result of this analysis. As the empirical example demonstrates, if the focal company aims to gain the competitive advantage it has to ensure that the relative utility of its dynamic capability is better than that of its rivals. Three resource allocation strategies for dynamic capability development are proposed to help companies achieve a competitive advantage. Based on the results of the analysis, appropriate strategic objectives and actions can be identified and then implemented.

The study also highlights the practical value of the VRIO framework as a tool to support strategic decision making. There are two points to be made regarding the managerial implications of this study for the field of strategic management. First, the application of the VRIO framework is extended to support the development of dynamic capabilities by considering the competition from a major rival. Previous studies which used the VRIO framework did not consider a changing environment (Lin *et al.*, 2012). The proposed model involves exploring the rivalry between existing competitors within an industry using the VRIO framework, in order to provide more insights into the prevailing industrial environment. Since competition is dynamic so dynamic strategies are needed to allocate resources in order to better respond to environmental change. The results of this study indicate that the proposed model can be used to assess and develop a firm's dynamic capabilities in order to enhance the company's internal strengths, better grasp environmental opportunities, neutralize external threats, and avoid internal weaknesses. We successfully introduced a new application area for the VRIO framework of the RBV by inserting dynamic competition into the scenario of the model. Second, the traditional VRIO framework has been used in a descriptive way, while the proposed model enables top management to make decisions using arithmetic data, thus helping decision makers to avoid subjective biases and validate the intuitively inferred values (Lin *et al.*, 2012, 2014). As the example shows, the results of the analysis can also help managers to make more confidence profit forecasts, because the firm's competitive environment can be more accurately assessed. The proposed model's specificity enables easier conversion from the formulation of a strategy to detailed implementation plans with clear and measurable targets. With prudent implementation and the accurate identification of resources and capabilities, firms have a greater chance of leveraging their dynamic capabilities and acquiring a sustainable competitive advantage.

Although the findings of this study indicate the model's usefulness, its assumptions might undermine its application in several ways. For example, the proposed model uses financial analysis to quantify the performance indicators. Future research may consider a number of other factors, such as non-financial indicators, as the measures of dynamic capabilities and firm performance. Moreover, the benefits of the quantitative approach used in this work can be limited, are it is only useful for the cases when the required financial data is available. In addition, the model is only able to help managers

to detect their firms' competitive situations in order to adjust their resource allocation strategies, and the current study did not analyze the dynamic games that can occur between competing firms after they have adjusted their dynamic capabilities. Despite these limitations, the current study provides an innovative and a reliable approach to confront strategic issues in a holistic manner. The model can also help firms to formulate strategies to acquire sustainable advantage by exploiting their internal strengths, and by responding to the environmental opportunities that exist at a certain time point (i.e. it is a static approach). Future research could extend the model to involve multiple players across different industries.

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Further reading

Arend, R.J. and Bromiley, P. (2009), "Assessing the dynamic capabilities view: spare change, everyone?", *Strategic Organization*, Vol. 7 No. 1, pp. 75-90.

Appendix 1

$$\text{Let } \frac{dv_i\left(\varepsilon_i(t), \varepsilon_j(t)\right)}{d\varepsilon_i(t)} = 0$$

$$k_i(t) \times \left(1 - \frac{\varepsilon_i(t)}{E_i(t)}\right) - \alpha_{ji}(t) \times \varepsilon_j(t) = 0$$

$$k_i(t) \times \left(1 - \frac{\varepsilon_i(t)}{E_i(t)}\right) = \alpha_{ji}(t) \times \varepsilon_j(t)$$

$$1 - \frac{\varepsilon_i(t)}{E_i(t)} = \frac{\alpha_{ji}(t)}{k_i(t)} \times \varepsilon_j(t)$$

$$\frac{\varepsilon_i(t)}{E_i(t)} = 1 - \frac{\alpha_{ji}(t)}{k_i(t)} \times \varepsilon_j(t)$$

$$\varepsilon_i(t) = E_i(t) - \frac{E_i(t)\alpha_{ji}(t)}{k_i(t)} \times \varepsilon_j(t)$$

$$i, j = \{1, 2\} \text{ but } i \neq j$$

$$\therefore \begin{cases} \varepsilon_1(t) = E_1(t) - \frac{E_1(t)\alpha_{21}(t)}{k_1(t)} \times \varepsilon_2(t) \\ \varepsilon_2(t) = E_2(t) - \frac{E_2(t)\alpha_{12}(t)}{k_2(t)} \times \varepsilon_1(t) \end{cases}$$

Appendix 2

Table AI. The financial data of the sample companies (millions of US dollars)

Years	Company A				Company B				Company C			
	Sales	COGS	SG&A	R&D	Sales	COGS	SG&A	R&D	Sales	COGS	SG&A	R&D
2001	191	74	64	30	26,539	9,649	8,260	3,994	1,215	888	287	81
2002	193	74	66	31	26,764	8,389	8,543	4,054	1,085	684	231	68
2003	192	73	68	30	30,141	8,253	8,736	4,365	1,069	651	213	86
2004	254	96	78	33	34,209	9,591	9,466	4,778	1,267	760	240	94
2005	239	93	84	42	38,826	11,295	10,833	5,145	1,261	748	248	94
2006	253	105	111	41	35,382	12,354	11,969	5,873	1,532	870	279	101
2007	285	119	111	43	38,334	13,535	11,156	5,755	1,566	898	310	133
2008	295	128	113	41	37,586	12,123	11,180	5,722	2,055	1,137	491	261
2009	287	125	121	45	35,127	10,549	10,887	5,653	1,769	1,038	424	199
2010	455	179	170	70	43,623	10,512	12,885	6,576	2,313	1,240	524	248

The parametric data of the proposed model are $k_i(t)$, $E_i(t)$, and $\alpha_{ij}(t)$ and they can be determined by using Equations (2), (4), and (6), respectively. Take, for example, the value of company A's parametric data in 2010:

$$k_A(2010) = \left(1+\frac{c_{RA}(2010)}{c_{PA}(2010)}\right)\cdot\left(1+\frac{c_{MA}(2010)}{c_{PA}(2010)}\right) = \left(1+\frac{170}{179}\right)\times\left(1+\frac{70}{179}\right)\cong 2.71$$

$$E_A(2010) = \frac{b_A(2010)-c_{PA}(2010)}{c_{PA}(2010)} = \frac{455-179}{179}\cong 1.54$$

$$\alpha_{Aj}(2010) = 1+\frac{(b_A(2010)-b_A(2009))/b_A(2009)}{(c_{PA}(2010)-c_{PA}(2009))/c_A(2009)} = 1+\frac{(455-287)/287}{(179-125)/125}\cong 2.33$$

Appendix 3

Take for example, the competition between companies A and B in 2010. The values of the necessary variables are from Table II, which are k_A (2010) = 2.71, k_B (2010) = 3.62, E_A (2010) = 1.54, E_B (2010) = 3.15, α_{AB} (2010) = 2.33, and α_{BA} (2010) = 1.01:

$$\varepsilon_A(2010) = E_A(2010)-\frac{E_A(2010)\alpha_{BA}(2010)}{k_A(2010)}\times\varepsilon_B(2010)$$

$$\Rightarrow \varepsilon_A(2010) = 1.54-\frac{1.54\times 1.01}{2.71}\times\varepsilon_B(2010)$$

$$\therefore \varepsilon_A(2010) = 1.54-0.57\times\varepsilon_B(2010) \quad \text{(A1)}$$

$$\varepsilon_B(2010) = E_B(2010)-\frac{E_B(2010)\alpha_{AB}(2010)}{k_B(2010)}\times\varepsilon_A(2010)$$

$$\Rightarrow \varepsilon_B(2010) = 3.15-\frac{3.15\times 2.33}{3.62}\times\varepsilon_A(2010)$$

$$\therefore \varepsilon_B(2010) = 3.15-2.03\times\varepsilon_A(2010) \quad \text{(A2)}$$

For Equation (A1), when $\varepsilon_A(2010) = 0$, $\varepsilon_B(2010) = 1.54/0.57 = 2.70$, and when $\varepsilon_B(2010) = 0$, $\varepsilon_A(2010) = 1.54$. For Equation (A2), when $\varepsilon_A(2010) = 0$, $\varepsilon_B(2010) = 3.15$, and when $\varepsilon_B(2010) = 0$, $\varepsilon_A(2010) = 3.15/2.03 = 1.55$. Therefore, the competition situation between companies A and B can be described as Figure A1.

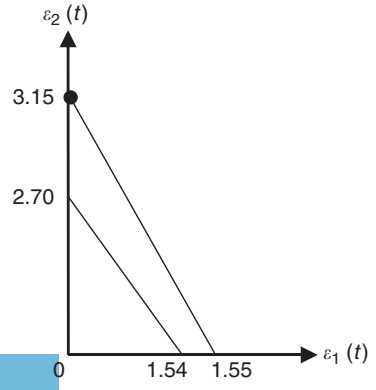

Figure A1.
The competition situation between companies A and B in 2010

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