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Full Length Research Paper

The influence of dynamic capability on performance in the high technology industry: The moderating roles of governance and competitive posture

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To better understand how high technology firms develop successful strategies, we examine the effects of the dynamic capability for research and development, marketing, and production on performance. Furthermore, we also explore the separate moderating efforts of governance and competitive posture as they impact the dynamic capability on performance. This research examines the panel data of 242 high technology firms from 2001 to 2007 using Bayesian regression. The findings demonstrate that the impact of dynamic capability for research and development and production on performance is positive. We also find that governance positively moderates the impact of dynamic capability for research and development on performance. In addition, competitive posture positively moderates the impact of dynamic capability for marketing on performance.

Key words: Dynamic capability, governance, marketing, competitive posture, Bayesian.

INTRODUCTION

When we attempt to explain organizational behavior in complex environments, if markets and firms were static then managers could coordinate consumers and producers to create ideal markets. However, this is not the case in contemporary business environments. In the dynamic markets of today competitive advantage depends on the ability to constantly develop organizational capabilities that form the basis for products offered by a firm (Danneels, 2002; O'Shannassy, 2008). Competitive advantage refers to a capability that is difficult to imitate and valuable in helping a firm outperform its competitors (King, 2007; Porter, 1987). Effective strategies allow high-tech firms to position themselves well in the marketplace, while poor strategies can undermine their performance (Zahra and Covin, 1993; Covin, 1993; Zaheer and Bell, 2005).

Due to rapid technological change, high-tech industries typically require a certain level of timely and dynamic strategy (Yasuda, 2005). A high-tech firm's future success depends on its ability to address environmental shifts (Porter, 1985; Utterback, 1994). According to the traditional theoretical framework, firms apply current resources in competitive market expansion. This approach has been useful as a basic tool for analyzing the fundamental issues of strategic decision making (Bae and Gargiulo, 2004). However, previous studies, which emphasize the application of current resources, have often been unable to explain why high-tech firms pursue effective strategic choices when faced with similar challenges caused by increasingly sophisticated external environments (Foss, 1996; Henderson and Cockburn, 1994; Wilbon, 2003).

To maintain competitiveness it is not sufficient to have ample resources and strong organizational capabilities; firms must have dynamic capability for developing and

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renewing both their resources and organizational capabilities (Teece and Pisano, 1994; Wilkens et al., 2004). This is especially true for high-tech firms competing in dynamic markets (Wheeler, 2002). Teece, Pisano, and Shuen (1997) defined dynamic capability as "the firm's ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments." In line with this concept, we adopt Teece's (1997) definition of dynamic capability as the potential capability to renew and reconfigure resources so as to achieve congruence with changing business environments (Lee, et al., 2002; Macpherson et al., 2004; Stalk et al., 1992). Several empirical studies have emerged in recent years to validate the numerous concepts related to dynamic capability (e.g., Ambrosini et al., 2009; Helfat, 1997; Luo, 2000; Stahle, 2008; Teece, 2007; Wang and Ahmed, 2007). However, these works focus on cross-sectional data and fail to investigate the long-term implications of formulating sustainable competitiveness (Zahra and Bogner, 2000). In addition, the focus of interest has been diverse. Various researchers have looked at the nature, antecedents, outcomes, and related variables of dynamic capability. Thus, there is a need to shift the focus to the influence dynamic capability has on performance. This is an important issue for strategic management which is worthy of further research. This study differentiates the effects of different components of dynamic capability by considering the respective moderating roles of governance and the competitive posture that affect firm performance.

This study critically reviews the emergence of the concept from the perspective of high-tech industry to demonstrate the potential benefits of dynamic capability associated with dynamic environments. Dynamic capability suggests that a firm's intangible resources, including research and development capability, marketing capability, and production know-how, can be accumulated and reconfigured into routines to create capabilities responsive to the unpredictable forces of changeable external environments. We argue that advocates of dynamic capability seek to connect the firm's resources to the emerging discourse surrounding the high technology economy, thereby elaborating the complex relationship between dynamic capability and performance.

With this in mind, we set three objectives for our study. First, we empirically examine the relationships between dynamic capability and long term performance by pooling longitudinal data from 242 high-tech firms. Second, we continue the discussion of the model by deliberating the role of potential moderators. A numbers of factors could play the role of moderator for the proposed relationships. The proposed model simultaneously takes the external environment moderating factor (that is competitive posture) and internal environment moderating factor (that is governance) into consideration. We locate the discussion in the context of an ongoing debate about the contribution of dynamic capability to firm performance. The discussion contributes to the development of the model, while shedding light on the contentious debate. Third, in the present study, the limitations of traditional statistics are presented to estimate the dynamic model. Then, we propose an alternative based on a Bayesian approach.

The study commences by introducing the importance of dynamic capability when high-tech firms face fiercely competitive environments. We draw on a review of previous studies on dynamic capability, governance, and competitive posture to develop the hypotheses. This is followed by a presentation of statistical methodology which estimates the parameters of the dynamic model. The final section presents the empirical results and concludes by outlining some managerial challenges that emerge from the findings.

THEORETICAL BACKGROUND AND DEVELOPMENT OF HYPOTHESES

This section delineates the dynamic needs of a high-tech firm, and Figure 1 depicts the effects of dynamic capability on performance. In addition, this Figure 1 shows the moderating effects of governance and competitive posture on the relationship between dynamic capability and performance, which we discuss below.

Dynamic capability

Scholars of strategic management have recently witnessed the emergence of dynamic capability as a concept that promises to explain how some firms appear better able to secure competitive advantage in dynamic markets (Petroni, 1998; Pillai, 2006; Zott, 2003). Dynamic capability, which is an effective strategic alternative, enables high-tech firms to react to changing market conditions by developing and renewing their organizational capabilities, thereby achieving and sustaining competitive advantage (Winter, 2003).

We classify the concept of dynamic capability in the study of management into three types: (1) The nature of dynamic capability and its affecting factors (King and Tucci, 2002; Verona and Ravasi, 2003; Zollo and Winter, 2002). For example, Zollo and Winter (2002) explored the nature and origin of dynamic capability, defining it as "systematic change efforts". (2) The relationships between dynamic capability and performance (Eisenhardt and Martin, 2000; Kor and Mahoney, 2005). For instance, Kor and Mahoney (2005) examined the effect of dynamic capability in R&D and marketing investment on firm-level performance. (3) The application of dynamic capability (Cepeda and Vera, 2007; Madhok and Osegowitsch, 2000). For example, Cepeda and Vera (2007) applied dynamic capability based on knowledge management

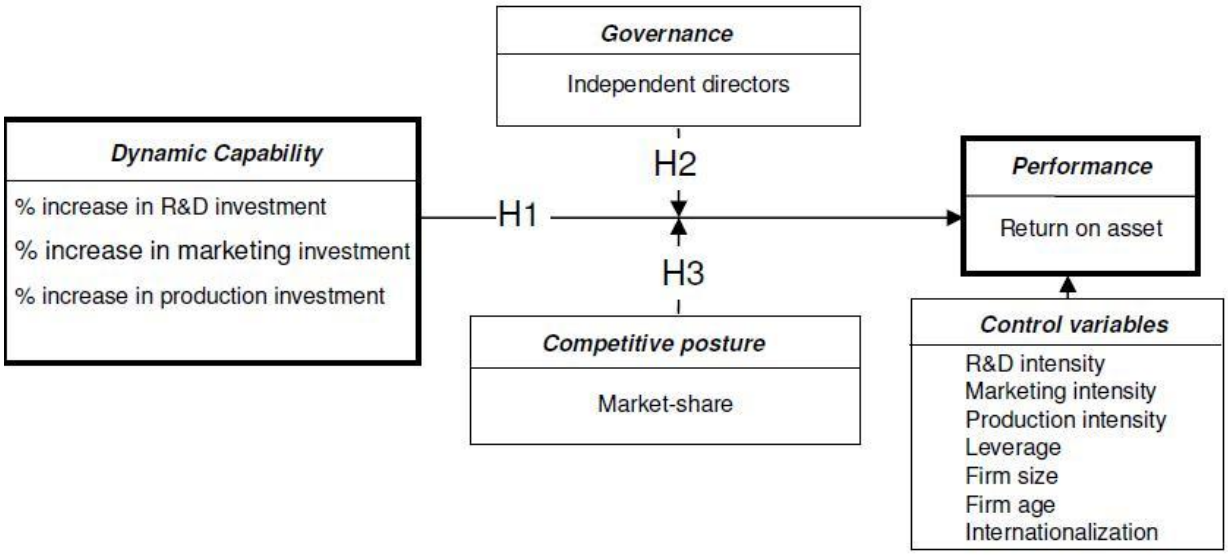

Figure 1. The proposed model.

to analyze the information and communication technology industry in Spain. Departing from prior research, which has discussed variables of dynamic capability such as R&D(Research and Development) (Kotabe, Srinivasan, and Aulakh, 2002) and marketing (Dutta et al., 1999), we herein argue that production capability must also be considered in the high-tech industry. The following section discusses the different components of dynamic capability that may contribute to better performance.

Impact of dynamic capability on performance

According to the resource-based view (RBV) (Penrose, 1959; Teece, 1980; Wernerfelt, 1984), a firm's performance is shaped significantly by the resources it possesses (Mahoney, 2001). The RBV conceives the firm as a bundle of resources, and the firm's performance is ultimately dependent on implementing so-called firm-specific resources (Das and Teng, 2003). This theory claims that the firm accumulates critical resources, skills and capabilities, which have a clear influence on its growth strategy. In this way, the firm's performance is shaped by the evolutionary path it has experienced (Dierickx and Cool, 1989). This phenomenon is sometimes called path dependency, because the performance paths of high-tech firms depend on some prior knowledge and experience (Van Waarden and Oosterwijk, 2006). The term "path dependence" is used to describe the powerful influence of the past on present and future performance (Barney, 1991; Besen and Farrell, 1994; Church and Gandal, 1993).

Increased R&D capability has been positively associated with greater interest in the future level of firm performance (e.g., Al-Horani et al., 2003; Eberhart et al., 2004). The history of a firm's investment in research and development can be especially important if its strategy is to develop significant capability for innovation. The notion of absorptive capacity developed by Cohen and Levinthal (1989) offers a rationale to explain this situation. According to Cohen and Levinthal (1989), a firm's knowledge and competencies are cumulative over time. The cumulativeness condition is the extent to which the current performance builds upon R&D capability obtained in the past. This implies that R&D capability enables the firm to develop and maintain its broader capabilities to identify assimilate and exploit knowledge from the environment. This line of argument suggests that the high-tech firm has higher cumulated R&D capability, revealing a greater propensity to continuously engage in innovative activities. We may expect that R&D capabilities accumulated over time are likely to contribute to a firm's innovative capabilities and allow it to more effectively absorb know-how and enhance performance (Martins and Terblanche, 2003; McGrath, 2001).

Traditionally, marketing capability that focuses on short-term encounters and single transactions is difficult and is insufficient to create and sustain strategic flexibility. Relationships between marketers and partners are considered to be very important in coordinating and creating resources (Kalafatis, 2000; Ritter, 2000) and a long term view must be stressed. Moreover, many of the key concepts of relationships, such as trust and commitment (Morgan and Hunt, 1994), cannot be thoroughly established in buyer-seller relationships without the long-term involvement of marketing capability (Gilliland and Bello, 2002). The high level of environmental

complexity encourages firms to develop an integrated marketing capability that may require a long term commitment (Johnson and Selnes, 2004). When the environment changes drastically, firms that are heavily invested in longer term marketing activities may have an advantage over less flexible players who have invested in shorter term activity. Thus, the history of increased marketing efforts may improve a firm's performance.

Similarly, organizational production capability is based on knowledge (Loasby, 1998). Hence, a firm is a repository of knowledge (Nelson and Winter, 1982). Technological unpredictability results from the fear of being locked into a technology that may become obsolete, thereby decreasing a firm's willingness to invest in manufacturing technologies and operating rules (Agarwal and Bayus, 2002). However, in such a situation, a high-tech firm can easily be eliminated from the market. Therefore, dynamic capabilities in production processes are idiosyncratic to firms. Innovation in the area of technological production is a critical driver of improvement in firm performance, as well as in the survival, growth, and success of firms. Understanding dynamic capability in production is of great importance. This is because this factor has huge impacts on both the levels of firms and sectoral patterns of innovation (Castellacci, 2008; Tellis, 2008). The RBV yields the notion that resource endowment is "sticky", implying that firms continuously investing in production capabilities can obtain continued added-value in the future. When the growth of firm-specific production knowledge and accumulated internal capability for making technological breakthroughs exceeds the growth rate of investment cost, performance is likely to improve. Therefore, we hypothesize as follows:

Hla: The dynamic capability for R&D has a positive impact impact on performance.

Hlb: The dynamic capability for marketing has a positive impact on performance.

Hlc: The dynamic capability for production has a positive impact on performance.

Governance

Although the theory of RBV supports dynamic capability, RBV has neglected the potential problem of the monitoring mechanism. RBV seems incapable of explaining changes of ownership structure that are necessary to compete in dynamic markets. Any resource decision involves a risk. This risk can be reduced by developing proper governance for resource deployment and development (Sanders and Carpenter, 2003; Smith et al., 2005). Governance is defined as a system by which corporations are governed and monitored by shareholders and other stakeholders (Ashbaugh-Skaife et al., 2006; Gillan, 2006; Premuroso and Bhattacharya, 2007). Many previous studies have argued that governance occurs by simultaneous changes in firm-level performance (e.g., Hermalin and Weisbach, 2003; Sundaramurthy, 1996; Westphal and Zajac, 1994; Wright et al., 2002). Agency theory (Eisenhardt, 1989) supports the rationale of governance mechanism, which is an explicit theory that governs the trade-off between principal (investor or stakeholder) and agent (manager). In the economic sense, both parties are interested in the efficient deployment of resources and reductions in risk-bearing costs. Agency theory indicates potential conflicts of economic interests between shareholders and managers as their agents. Due to opportunism (seeking self-interest with guile), it is more difficult for shareholders to monitor managers' strategy decisions (Brown et al., 2000; Jap, 2001; Wathne and Heide, 2000). In the absence of a good governance mechanism, the economic resources of a firm may be deployed inappropriately, and the quality of resource deployment decisions may suffer (Sundaramurthy, 1996). Thus, through efficient monitoring, governance should influence the effect of a firm's dynamic capability on its performance.

Moderating effect of governance on dynamic capability-performance relationships

Long term R&D activity inevitably creates spillovers to shareholders other than managers, especially investors (Hall and Bagchi-Sen, 2002). A firm's R&D strategy may be designed to minimize these spillovers by appropriating a number of possible methods (e.g., patenting) (Delios and Beamish, 1999). In such circumstances, the only interest that is considered is that of the manager. Firms face considerable moral hazard problems, since the behavior managers is often unobservable, and the costs of opportunism are potentially high (Labie, 2001; Vesala, 2007). The outcomes of R&D activities are very uncertain (Connolly and Hirschey, 2005; Lantz and Sahut, 2005), making it difficult for a firm to know what its manager contributes to performance. As a result of these threats, though firms are able to continuously invest in R&D activities, they may be unwilling to do so. From the point of view of investors, this kind of situation could result in a serious lack of interest in R&D investment or an inefficient innovation strategy, unless there is efficient governance. In line with the agency problem, if R&D strategies are chosen to maximize total returns to all investors, some of the interests of investors should be taken into account by governance. Governance monitors managers intensively, rather than leaving them with a broad range of discretion. Therefore, we can see the advantages of governance which carefully monitors of managers' decision-making about long term investment in R&D activity. This kind of governance may encourage value-enhancing R&D investment, resulting in improved performance.

Marketing capability is not uniform across contexts. As a result, the requirements of time, changing circumstances, and governance need to be carefully examined before using relationship-based marketing viewpoints to create efficient marketing strategy (Dyer and Singh, 1998). From a marketing manager's point of view, self-interest and risk aversion may influence decisions and the evaluation of individual efficiency. However, from the viewpoint of marketing division, goal conflict occurs within organizations, even among personnel. From the agency viewpoint, divergence in the interests of marketing managers and shareholders can cause managers to make strategic marketing decisions that are costly to shareholders (Hillman and Dalziel, 2003). Contracts cannot preclude this decision if shareholders are unable to directly observe managerial behavioral. Efficient governance requires procedures for resolving discrepancies about who should have done what (Burik, 2002) and for encouraging managers to act in a manner that is consistent with the interests of shareholders. Therefore, governance can effectively facilitate marketing managers' capability to make economic value-maximizing deployments by reducing diversions that lead to inefficient marketing capability (Smith et al., 2005). We argue that governance may contribute to the positive impact of historical investment of marketing capability on performance by improving the relationships between shareholders and managers.

For a successful process of production innovation, the institutions of governance should be appropriate to the particular high-tech industry of each firm. Governance mechanisms enhance the monitoring and control of production activities, while improving the overall performance of firms (Bhagat and Bolton, 2008; Gompers et al., 2003). Fundamentally, greater monitoring and control ease opportunism and preserve firms' incentives to share knowledge with their managers. Firms can more confidently pool their capabilities with their managers (Core et al., 2006). Therefore, high-tech firms can better implement their dynamic capability for production to pursue high levels of performance. More specifically, certain market niches might require substantial, firm-specific production investments (Goyer, 2001). However, once made, such investments could be subject to the opportunism of managers. Under such circumstances, an efficient system of governance should facilitate the credibility and commitment of managers (Tylecote and Conesa, 1999). Accordingly, we posit that governance is a positive moderator on a firm's performance resulting from dynamic capability for research and development, marketing, and production. Thus, we advance the following hypotheses:

H2a: High-tech firms that invest in dynamic capability for R&D with better governance demonstrate better performance.

H2b: High-tech firms that invest in dynamic capability for marketing with better governance demonstrate better performance.

H2c: High-tech firms that invest in dynamic capability for production with better governance demonstrate better performance.

Competitive posture

RBV shifts the focus from strategy to a firm's internal characteristics by identifying the firm's unique resources of a certain point in time and how they may have been created. However, RBV fails to address the fundamental issue of the firm's competitive posture in an external dynamic market (Kerin et al., 1992; Zahra, 1996). Competitive posture is defined as whether a firm is classified as a pioneer or a follower, which represent the two poles of the continuum of competitive positioning in a competitive environment (King, 2007; Wilbon, 1999). A pioneering posture introduces a new product to the market, while a following posture copies rival technologies (Ali, 1994; Walker et al., 2003). A firm is positioned between these extremes based on different competitive advantages. Competitive posture, which provides an outside-in perspective, shows how to secure above-average performance based on external competitive market positioning.

Moderating effort of competitive posture on dynamic capability-performance relationships

In order to adapt and survive in an external environment, high-tech firms need to allocate their limited resources with a balance between incremental innovation (i.e., less research and development investment) and radical innovation (that is, more research and development investment). A very dynamic environment often encourages a firm to engage in pioneering (higher competitive posture) to preempt the entry of rivals (Utterback, 1994). Since pioneers tend to be heavy investors in R&D, pioneering is also expected to in long term performance results (Pegels and Thirumurthy, 1996). On one hand, a radical innovation in technology involves huge R&D costs for high-tech firms. More importantly, transitions in technologies often cause the demise of or at least the tripping up of giants by rival firms (Sood and Tellis, 2005). The extension and refinement of existing competencies and technologies are likely to trap following firms in states of competitive disadvantage because pioneering firms usually sets the standards for competition (Parayil, 2003). Thus, creating the pace of technological evolution can be a great advantage for a pioneering firm. On the other hand, the ongoing radical innovations of long term R&D activities are likely to control the direction of sectoral technological evolution. This happens because the pioneer can capitalize on a

changing technological paradigm by competitive advantage gained (Dew, 2006; Frietsch and Grupp, 2006). Moreover, through long term R&D, firms with higher competitive posture create barriers for following firms that ultimately lead to increased chances of success. Some scholars have indicated that higher competitive posture that facilitates R&D capability is particularly effective for high-tech firms (e.g., Hooley, Broderick, and Moller, 1998; O'Donnell, Gilmore, Carson, and Cummins, 2002). Therefore, in line with previous studies, this study expects that a high level of competitive posture has a positive impact on the relationship between dynamic capability for R&D and performance.

Introducing a product that is new to both the firm and its target customers requires the greatest expenditure of effort and resources (Van de Poel, 2003). The prime objectives of most new products and market development efforts are to improve performance. However, achieving this objective has become even more difficult due intensifying competitive environments, which may include many new rivals from a global market (Robertson and Patel, 2007). In this regard, to surpass their rivals, pioneering firms are prolific in the introduction of new products (Ahuja et al., Tandon, 2008; Christensen and Bower, 1996). For these pioneering firms the key advantages over rivals include maintaining position as product innovator, capitalizing on distribution strengths, and gaining access to distribution channels (Buzzell and Gale, 1987; Olson et al., 1995). Pioneering firms with higher competitive posture serve as credible market signals to rivals by perpetuating their positive leadership and improving their performance. Thus, competitive posture is a moderator of the effect of dynamic capability for marketing on performance.

Firms known for their firm-specific production prowess often have favorable reputations, which makes it difficult for rivals to attack their markets (Hambrick, 1983). Moreover, the efficiency of past production capability investments depends on the firm's ability to transform them into a source of competitive advantage (Reichstein and Salter, 2006); otherwise, they can erode profit. Idiosyncratic production knowledge at the sectoral level is a surrogate for barriers to entry and risk difference, and that affects all firms in the same sector (Malerba, 2004). At the firm level, pioneering production knowledge must be considered as a sectoral benchmark. A large number of production capability investments by firms with higher competitive postures can also assure the likelihood of increased performance. Although pioneering leads to first-mover advantages (Ali, 1994), the duration and magnitude of these advantages may be diffused to rivals and the advantages are lost (Porter, 1985). Pioneering is conducive to acquiring high profits earlier in a product life cycle, but has little impact on profits later in the cycle (Buzzell and Gale, 1987).

By developing and introducing radical innovations, a pioneering firm can influence the evolution of its sectoral technology by shaping product design and configuration (Geels, 2004), and enriching its performance (Brown and Eisenhardt, 1995; McGrath, 1995). Similarly, few Products manufactured by followers in fiercely competitive environments have lasting success. Indeed, those followers may have difficulty sustaining a high level of performance over time. Thus, in a dynamic environment, a lack of a high competitive posture can undermine the impact of dynamic capability for production on performance. This constraint is particularly critical for following firms, which often lack long term investment in production innovation. Therefore,

H3a: High-tech firms that invest in dynamic capability for R&D with higher levels of competitive posture demonstrate better performance.

H3b: High-tech firms that invest in dynamic capability for marketing with higher levels of competitive posture demonstrate better performance.

H3c: High-tech firms that invest in dynamic capability for production with higher levels of competitive posture demonstrate better performance.

METHODOLOGY

Sample and data

High-tech industries can be defined as those that normally invest at least 10% of their sales in R&D (U.S. Department of Commerce, 1984, 1996). They can also be identified according to the classification suggested by Hall (1994) and Chandler (1994), based on the research intensity of the industries and an informal assessment of those industries that are likely to change faster. This study examines the semiconductor industry in Taiwan. This industry can be classified as a high-tech industry. The semiconductor industry is selected as the empirical sample because it exhibits typical features of high-tech industries, including steep price erosion and stress due to the rapid progress of technology.

The Standard Industry Classification (SIC) code of firms that produce semiconductors and related devices is 3675. The industry classification system is based on the US-based SIC, which was created by the US government (1994). The population of semiconductor firms was derived from the database of Industry and Technology Intelligence Service at the end of 2007. Table 1, which lists a total of 345 semiconductor firms in Taiwan, clearly divides firms into four semiconductor sub-families in the semiconductor sector. The 300 firms ranked by company assets were extracted from 2001 to 2007. However, many firms did not report the type of information we sought for this study, and those with firm-level information missing from the database were eliminated from the sample. A total of 58 firms were omitted, leaving 242 semiconductor firms in our final sample. This final dataset consisted of 242 valid firms from the following semiconductor sub-families: 201 Integrated-Circuit (IC) design firms, 6 IC fabrication firms, 12 IC packaging firms, and 23 IC testing firms. Several firms that are currently considered leaders were part of the sample, including Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Corporation (UMC).

Variables and measures

Performance: In prior studies, most scholars used accounting-based indexes, such as return on asset (ROA), return on equity

Table 1. Taiwanese semiconductor sector.

Sub-family of semiconductor	Number of firms	Number of sample
IC design	262	201
IC fabrication	13	6
IC packing	34	12
IC testing	36	23
Total	345	242

Source: Industry and Technology Intelligence Services (ITIS), 2008.

(ROE), or return on sales (ROS) (Hitt, Hoskisson, and Kim, 1997; Tallman and Li, 1996), to measure management effectiveness (Geringer, Tallman, and Olsen, 2000; Robins and Wiersema, 1995). Managers frequently use these accounting-based indexes to measure a firm's performance. This approach has received support from a number of authors (Aaker and Jacobson, 1987; Hoskisson et al., 1993). We present findings based on an index (that is ROA) as our measure of performance.

Dynamic capability: In general, dynamic capability involves a high degree of uncertainty as to the nature (McCutchen et al., 2004) and timing of output (Arrow, 1962). Therefore, dynamic capability typically involves long-term investment of specialized resources since it does not lead to instant returns. The percentage of respective increases of dynamic capability for R&D, marketing, and production shows the magnitude of changes of a firm's investment over time. For example, the development of a new product depends to some extent on the continuity of the R&D activity involved; and there may be substantial continuity in regard to facilities, equipment, marketing campaign, etc. New outlets may even be created. In high-tech industries, it takes at least 3 years to convert the dynamic capability for R&D, marketing, and production require into a successful product (Kor and Mahoney, 2005). Accordingly, to capture the historical dynamics of investment levels, we establish functions to calculate the average percentage increases of the three proposed indexes of dynamic capability from $T-1$ to $T-3$.

Competitive posture: The ultimate aim of using the data to assess the competitive posture of each firm is to classify firms into groups for subsequent analysis. Competitive posture analysis examines changes in each firm's competitive position compared with the sector level over a seven-year period. To do this, we use the ratio of the firm's revenue in the industry, in other words, the market-share based competitive posture. The association between market share and competitive posture has been assessed by past research (Bogner et al., 1996; Ginsberg and Venkatramen, 1992). Harrison and Kennedy (1997) argue that higher market share indicates that a firm is ranked higher according to the aggressive use of innovative technologies; on the other hand, a lower ratio indicates the attitude of a technological follower.

Governance: In general, the composition of a board of directors is deemed as a critical indicator of good governance (Heracleous, 2001; Hermalin and Weisbach, 1998, 2003; Hillman and Dalziel, 2003). The board should constitute an ideal mechanism by which the interests of shareholders are represented. However, boards of directors in most companies have failed to fulfill this purpose (Fich and Shivdasani, 2006). Therefore, we argue that a board with independent directors is more likely to behave in the interests of all shareholders than those dominated by directors close to the CEO (Bhagat and Black, 2002; Ryan and Wiggin, 2004). Data on governance were collected from the Taiwan Economic Journal Database.

Control variables

Based on the suggestions of Grant, Jammine, and Thomas (1988), we control some variables that are likely to affect performance, including firm size, leverage, firm age, internationalization, and investment intensity. Firm size is a commonly used control variable often related to diversity levels (Segars and Grover, 1995). Smaller firms may contribute a disproportionate share of major innovation. Although large companies have more resources invested in R&D, marketing campaigns, and production equipment than smaller firms, they often choose safer projects that generate fewer radical innovations (Rosen, 1991). Leverage reflects a firm's capital structure and the financial risk faced by a firm, which might limit managers' ability to allocate adequate resources to R&D activity (Smith and Warner, 1979). The financial resources indicator is proxied by the leverage (Graham et al., 2004; Khanna and Tice, 2005). Firm age, an important control variable, is measured by the number of years a firm has been in existence. Younger firms often pursue more radical innovations than older companies (Huergo and Jaumandreu, 2004).

Following Shoham (1996) and Geringer et al. (2000), we use the measure of export intensity, provided by the industrial and economic database of the Taiwan Institute of Economic Research, as the index of internationalization. This seems to be a good indicator relating to external competitive environment and has been widely used. Investment intensity, which is another control variable, significantly affects performance. It is measured for R&D, marketing, and production investment, respectively. Table 2 shows the operationalization, indicators, and sources of all the constructs in the proposed model.

Bayesian regression model

Dynamic systems are often complex, and the relationships between predictors and the resulting outcomes are complex as well. Most traditional statistical methods that make predictions about complex system are imperfect. Thus, a forecasting method is necessary to accommodate this uncertainty. Bayesian methods have been proven to be appropriate for handling such issues and can be used to make dynamic predictions. However, they are not used as much as they could be in the strategic management field (Wang and Hsu, 2007). In conventional statistical methods, the predictor itself is determined by linear regression. An alternate method to derive the dynamic relationships between dynamic capability and performance is to use a Bayesian methodology. One difference between the two approaches is that Bayesian methods allow the incorporation of information external to the study into the analysis. Such information is specified in a prior distribution and is combined with the study data, in the form of the likelihood, to produce a posterior distribution upon which inferences are based (Natarajan and Kass, 2000).

The computation of the posterior distribution for parameters in Bayesian models is often complex. A Bayesian solution can still be obtained through the use of simulation methods, such as the

Table 2. Operationalization of constructs.

Constructs	Variables	Adapted from
Performance	Return on asset = Net profit before taxes /total assets	Tallman and Li (1996); Hitt, Hoskisson, and Kim (1997)
Dynamic capability (DC)	% Increase in R&D development = $\frac{\{[(RDE_{T-1} - RDE_{T-2})/RDE_{T-2}] + (RDE_{T-2} - RDE_{T-3})/RDE_{T-3}]\}}{2}$	Kor and Mahoney (2005)
	% Increase in marketing development = $\frac{\{[(MKE_{T-1} - MKE_{T-2})/MKE_{T-2}] + (MKE_{T-2} - MKE_{T-3})/MKE_{T-3}]\}}{2}$	
	% increase in production investment = $\frac{\{[(IFA_{T-1} - IFA_{T-2})/IFA_{T-2}] + (IFA_{T-2} - IFA_{T-3})/IFA_{T-3}]\}}{2}$	
Competitive posture	Market share= Firm sales/Market sales	Bogner, Thomas, and McGee (1996); Ginsberg and Venkatramen (1992)
Governance	Number of independent directors	Bhagat and Black (2002); Rayan and Wiggin (2004)
Control variables	Firm size= Ln(Total capital)	Segars and Grover (1995)
	R&D intensity $_{T-1}$ = R&D expenditure $_{T-1}$ /Total asset $_{T-1}$	Boulding and Christen (2003)
	Marketing intensity $_{T-1}$ =Marketing expenditure $_{T-1}$ /Total asset $_{T-1}$	
	Production intensity $_{T-1}$ = Increase in fix asset $_{T-1}$ /Total asset $_{T-1}$	
	Leverage= Long-term debt/assets	Smith and Warner (1979)
	Firm age= Number of years since first date of incorporation	Huergo and Jaumandreu (2004)
	Export intensity = Export sales/ total sales	Aulakh, Kotabe, and Teegen (2000)

Notes: 1. RDE : R&D expenditure; MKE : marketing expenditure; IFA : increase in fixed assets 2. Main customer: Customers, who exchange with firm more than 10% of total sale, are included. 3. The fixed asset is stock, which measures the percentage increase in productivity developments, translated into flow of fixed assets in each year. The purpose of this transformation is to use the same calculations as those of R&D and marketing from the accounting viewpoint.

Markov Chain Monte Carlo (MCMC) (Gilks et al., 1996). Gibbs sampling, which offers a broad range of MCMC simulation methods, has been increasingly used in applied Bayesian analyses. The necessary computation routines are now freely available in the WinBUGs software package (http://www.mrc-bsu.cam.ac.uk/bugs/winbugs/contents.shtml) (Spiegelhalter, et al., 2003), which makes Bayesian methods available for more routine use in applied research and only requires the actual model to be specified. The Bayesian graphical modeling approach adopted here is still appealing because it provides a flexible modeling framework, allowing us to venture beyond the confines of analyses provided in standard statistical packages and account fully for all forms of model estimation uncertainty (Spiegelhalter, 1999). A graphic representation of the model appears in Figure 2. Finally, this in turn allows determination of the sensitivity and specificity of the predictor, and subsequently, the likelihood ratio used in calculating the posterior probabilities. A review of previous studies and prior knowledge was first used to examine the dynamic capability-performance relationships and then a Bayesian regression model was fit to the dataset. The Bayesian regression model relating ROA to a predictor is given by:

$$\text{ROA} = A + \sum_{I=1}^{15} B_I X_I + \varepsilon$$

Where X_I represents the predictors and control variables, and ε is an error term. The coefficients B_I are estimated using the MCMC method. The coefficient of A is called the intercept.

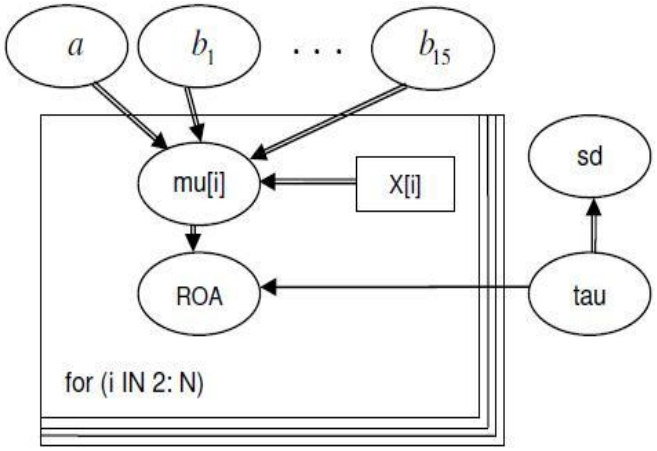

Figure 2. Graphical model for prediction of performance.

ANALYSES AND RESULTS

Descriptive statistics

Table 3 provides information about the descriptive statistics including minimum, maximum, mean, standard deviation, and correlation coefficients for the variables. It is interesting to notice that two pairs of variables are not particularly correlated: production intensity-market share (r=0.00) and export intensity-dynamic capability for R&D (r=-0.00). Conversely, there are two pairs of variables that are high correlation: firm size-market share (r=0.61) and Marketing intensity-R&D intensity (r=0.53). However, neither of the two high correlations exceeded r=0.7, which is the level at which multicollinearity may become a problem.

The mean of ROA is 7.68. This means that high-tech firms have about 7 times the effectiveness in generating profits from assets. The youngest high-tech firm in our sample is established to be about 4 years old and the oldest high-tech firm is 38 years old. The mean firm age is about 14.4 years. We find that the annual growths of high-tech firms in R&D activity and marketing activity are approximately 6% and 2%, but the annual growth of production investment is close to zero. It is possible that only pioneering high-tech firms invest in production innovation (Max=27%). Furthermore, we also find that the 3-year average growth rates for R&D investment and marketing investment are 17 and 6%, but the 3-year average growth rate of production investment is negative. We speculate that Taiwanese high-tech firms gradually transform from production-oriented to R&D-oriented. The average number of independent directors is close to 7 persons. The minimum and maximum numbers of independent directors are 2 persons and 15 persons. The maximum market share is 30%. This means that firms with pioneering competitive posture account for 30% of total market sales. Moreover, the market share of the following firms is close to zero.

Bayesian regression results

Given the cross-sectional and time-series nature of our dataset, the panel data estimation method has the advantage of allowing us to account for some unobserved heterogeneity throughout the firms (Hsiao, 1986). Table 4 provides the empirical results of Bayesian regression. Testing of H1 required consideration of the results of Model 1. The increases of the variables of percentage for R&D and production investment are statistically significant, so H1a and H1c are supported, respectively. In testing the hypotheses related to the moderating effects, this study followed the procedure recommended by Irwin and McClellan (2001). Moderated regression analysis was undertaken to test for significant interaction effects and simple effects of the three variables of dynamic capability. The resultant models are shown in Models 2-3. The results from Model 2 show that governance has a positive moderating effect on the impact of dynamic capability for R&D on performance, so H2a is supported. The results from Model 3 also show that competitive posture has a positive moderating effect on the impact of dynamic capability for marketing on performance, so H3b is supported.

DISCUSSION

Studies of dynamic capability make several broad-brush suppositions. Most scholars assume that local findings are applicable in general and project them into the strategic management context. However, this study has shown how the various components of dynamic capabilities impact performance in different ways. Managers can gain insight into what capabilities are highly valued and then maximize the value of their firm by accumulating these capabilities.

Dynamic capability and performance

Bayesian regression indicates that the dynamic capability for R&D and production are significant determinants of performance. This is an encouraging finding because numerous firms have recently invested heavily in developing R&D activity and strengthen their competitive advantage and improve performance. The findings of this study have two implications for manager. The first is that managers must remember that though they may have developed a good new product or a acquiring idiosyncratic production technologies to novel production process, innovation alone does not always guarantee success in the marketplace for a long period of time (McGrath, 1995). Firms must enhance their capability by continuously investing in R&D and the production of equipment to accumulate firm-specific assets (Hall and Oriani, 2006). More specifically, dynamic capability must

Table 3. Descriptive statistics and correlations.

	Min	Max	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12
1. ROA	-0.44	0.46	0.08	0.13												
2. % increase in R&D investment	-0.07	0.25	0.17	0.34	0.23**											
3. % increase in marketing investment	-0.6	0.28	0.6	3.23	0.01	0.05										
4. % increase in production investment	-2.04	1.24	-1.09	28.96	0.02	0.01	-0.07									
5. Independent directors (t-1)	2	15	6.69	2.26	-0.17*	-0.06	-0.09	-0.01								
6. Market share (t-1)	0.00	0.30	0.02	0.05	0.07	0.02	0.06	-0.09	0.34**							
7. Leverage (t-1)	0.05	0.76	0.31	0.16	-0.35**	0.11	0.05	-0.06	0.09	-0.11						
8. Firm size (t-1)	1.48	4.29	2.71	0.68	0.04	0.11	0.13	-0.13	0.27**	0.61**	0.08					
9. Export intensity (t-1)	0.002	1.55	0.28	1.83	0.24**	-0.00	-0.10	-0.06	0.11	0.25**	-0.17*	0.12				
10. Firm age (t-1)	4	38	14.44	7.55	-0.15	-0.10	-0.13	-0.05	-0.18*	0.09	0.05	0.36**	0.01			
11. R&D intensity (t-1)	0.001	0.29	0.06	0.06	0.02	0.03	-0.06	0.08	0.04	-0.17*	-0.30**	-0.40**	0.08	-0.43**		
12. Marketing intensity (t-1)	0.001	0.10	0.02	0.02	-0.07	-0.13	-0.05	0.01	-0.13	-0.28**	-0.07	-0.47**	0.17*	-0.15	0.53**	
13. Production intensity (t-1)	-0.62	0.27	0.00	0.10	0.23**	0.20*	-0.02	0.02	0.04	0.00	0.09	0.04	0.04	-0.08	-0.09	-0.14

Notes: N=1210 for all variables, ** p<0.01, * p<0.05.

be a part of a comprehensive strategy to achieve cumulative effects. The second implication is the need to recognize the long-term horizons associated with R&D capabilities and idiosyncratic production assets. Managers may have to decide to consistently invest in R&D and production process to keep up with the rapid pace of change in the business environment. At times, firms must endure short term losses to gain long term advantages from R&D activities and innovative production processes. Surprisingly, the result of the impact of dynamic capability for marketing on performance was inconsistent with our expectations. Thus, high-tech firms may not benefit financially from continuous investment in marketing campaigns. We speculate that the high-tech firms in Taiwan can be classified as original designed manufacturing (ODM) and original equipment manufacturing (OEM). Neither of these types of firms has its own brand, making it unnecessary to engage in marketing campaigns (Chen, Wu, and Lin, 2006). This indicates that ODM (or OEM) high-tech firms are more likely to focus on R&D and production capability than marketing capability.

Governance as a moderator of the impact of dynamic capability for R&D on performance

The empirical findings also shed light on why governance only moderates the strength of dynamic capability for R&D on performance. In order to sustain a firm's competitive advantage and continuously produce high performance results, a firm is expected to continue its innovation and capitalize on emerging opportunities; meanwhile, continuous innovation requires a firm to consistently invest in R&D activity. This is especially true in high-tech industries, in which the pace of new technology is remarkably high (Vilkamo and Keil, 2003; Yasuda, 2005). Good governance could contribute to the development of firm competitiveness through the more efficient allocation of limited resources. R&D activity takes place within an internal organization, whose managers decide upon the deployment of resources. However, corporations operate within an external environment and shareholders decide upon the amounts of investments. Therefore, our empirical findings tackle the specific kind of governance mechanism which influences the relationships between managers and shareholders. The most important

Table 4. Bayesian regression analysis of the effects of dynamic capability on ROA.

	Model 1	Model 2	Model 3
% increase in R&D investment [H1a]	10.490***	9.984***	9.362***
% increase in marketing investment [H1b]	0.067	0.070	0.062
% increase in production investment [H1c]	0.079**	0.079*	0.084**
% increase in R&D investment × Director independent $_{T-1}$ [H2a]		0.836*	
% increase in marketing investment × Director independent $_{T-1}$ [H2b]		0.043	
% increase in production investment × Director independent $_{T-1}$ [H2c]		0.001	
% increase in R&D investment × Market share $_{T-1}$ [H3a]			84.710
% increase in marketing investment × Market share $_{T-1}$ [H3b]			103.200*
% increase in production investment × Market share $_{T-1}$ [H3c]			0.927
Independent directors $_{T-1}$	-0.447	-0.546	-0.436
Market share $_{T-1}$	39.940*	39.760*	33.040
Leverage $_{T-1}$	-1.707	-3.305	-0.054
Firm size $_{T-1}$	-2.911**	-2.661	-1.997
Export intensity $_{T-1}$	9.796***	9.998***	8.197**
Firm age $_{T-1}$	0.131	0.119	0.128
R&D intensity $_{T-1}$	35.740**	34.460**	34.930**
Marketing intensity $_{T-1}$	-14.070	-29.350	-26.210
Production intensity $_{T-1}$	29.600***	28.460***	27.260***
Intercept	6.972	7.110	4.589
Number of observations	1210	1210	1210
Number of firms	242	242	242

Notes: 1. ***posterior intervals (2.5%CI - 97.5%CI), **posterior intervals (5%CI - 95%CI), *posterior intervals (10%CI - 90%CI) 2. The longitudinal period is 7 years (2001-2007). 3-year data forms one period of dynamic capability. Therefore, we yield 5 periods data of dynamic capability. 242 firms × 5 periods = 1210 observations.

mechanism of governance is to balance the two sides. Therefore, the finding about the impact of dynamic capability for R&D on performance has unearthed a critical moderator, governance.

Conversely, our empirical findings fail to support the moderating effect of governance on the impact of dynamic capability for marketing on performance. A plausible explanation for this is that marketing activity requires close contact with partners such as suppliers, customers, and investors. Thus it helps if firms are members of shareholder coalitions, since joint resourcing and sharing of returns are invertible to some degree (Dyer and Nobeoka, 2000). Although a firm may have large marketing expenditures without close long term relationships with its partners, this may not in itself lead to increased long term performance (Bae and Gargiulo, 2004; Bell, 2005). In this situation, even with good governance, a marketing campaign still may not enhance the performance (Larson, 1992). In addition, the findings do not support governance as a moderating effect of the impact of dynamic capability for production on performance. A reasonable explanation for this may be that no firm-specific production processes can be developed by firms without any social network relationships with shareholders who provide capital.

Facing a rapidly changing environment, with rapidly

progressing technology, it may be impossible for high-tech firms to develop long term relationships with shareholders because it is easy for technology to become obsolete (Iansiti, 1995). Accordingly, there may be no opportunity to develop innovative production capability because shareholders are unwilling to invest in a high risk industry and are not inclined to get involved in corporate monitoring. More specifically, no outside shareholders are willing to support the finance and governance mechanisms because of their immature relationships with firms (Carpenter et al., 2003). Consequently, there is no firm-specific production capability, which could be invested in long term. Shareholders may not give managers the push that managers need to change their ways and improve their performance (Aguilera, 2005).

Competitive posture as a moderator of the impact of dynamic capability for marketing on performance

The results of Model 3 also highlight the role of competitive posture as a significant moderator of the dynamic capability for marketing on performance. Resource allocation among functional departments and activities also vary among firms pursuing different postures. For instance, marketing budgets account for a larger percentage of a firm's revenues when the firm pursues a pioneering position; on the other hand, they tend to make up a smaller percentage of sales for firms in the low-cost follower position. Our findings suggest that a pioneering posture is likely to stand the best chance for long term success in market leadership and profitability, especially in the high-tech industry. This finding is also supported other studies (Boulding and Chrissten, 2003; Golder and Tellis, 1993). For a pioneer posture, the importance of adapting a long term perspective in marketing investment should be stressed. Though some following firms may achieve performance improvements from short term promotion activities, this is a harmful strategy for pioneering firms. Developing good relationships with business partners over several years is the key strategy (Boulding et al., 2005; Cao and Gruca, 2005). Increasing marketing spending should not be considered a quick means to improve poor performance, even though it may be an effective strategy for improving short term sales. From a relationship marketing paradigm viewpoint, a pioneer's marketing resources should be tied to the firm's long term goals and strategies (Nijssen and Herk, 2009; Slater and Narver, 1994).

Recall that H1a and H1c, which are the respective dynamic capabilities for R&D and production, have significantly positive influence on performance; however, the empirical results of H3a and H3c do not support the moderating effects of competitive posture on these relationships. In other words, managerial attention to investment in R&D and the development of production process technology is necessary no matter what competitive posture a high-tech firm has. This finding is in congruence with Hayes et al. (1988) and Wheelwright and Bowen (1996). It is noteworthy that having dynamic capability for R&D and production is positively associated with higher performance in the overall sample for both pioneers and followers. Production process innovation enhances a firm's value by stimulating growth and improving performance. Traditionally, however, some Taiwanese OEM high-tech firms have slighted R&D investment and production process innovations, thus placing themselves at a disadvantage in comparison to their rivals who vigorously pursue innovation (Wang, Hsu and Fang, 2008). The managers of both pioneering and following firms need to increase R&D and production process innovation in order to improve firm performance.

LIMITATIONS AND RESEARCH DIRECTIONS

The findings of this study need to be evaluated in the context of certain limitations. Further study along these lines would provide fruitful research avenues for strategic management scholars. One limitation of our research is that we investigated a single industry, the semiconductor industry. It would be highly desirable to generalize the study with various types of high-tech firms such as biotechnology, internet, information industry, etc. Future research should determine whether dynamic capability has the same impact on performance in different industries. Another limitation is that we investigated only one dimension of the external environment, competitive posture. Future research could also consider potential external moderating factors, such as hostility of external environment (that is an unfavorable business climate) and heterogeneity of the industry (that is the diversity of the market segments within an industry) (Zahra and Bogner, 2000). Furthermore, although a previous study (Cavusgil et al., 2004) confirmed the use of questionnaires to measure external environmental dimension, only a small portion of the scenario was captured. Other factors such as product life cycle and technological cycle may change the relationship of dynamic capability with performance and might account for a larger portion of the external moderating efforts.

Similarly, we operationalize governance using a single indicator, the independent director. Future research should examine the effects of various contextual indicators on the employment of alternative governance. For example, it may be significant whether ownership is in the form of institutional investment or specialized board committees. Innovation activity, which deals with complex technologies that require implicit supplier and purchaser arrangements, is dependent on ownership patterns that encourage trust and commitment. Our study may also be limited by the data we obtained. The panel data sets were made up of 242 high-tech firms within a 7-year period.

Additional studies might investigate a longer period to determine whether the same relationships hold. This view is in accordance with Boer's (1999) "time lag" to the innovation process, and with other explanations such as the "learning curve plateau" proposed by Carlson (1973) and Song et al. (1998). In sum, this work has made significant progress toward understanding the various dimensions of dynamic capability, including, R&D, marketing and production; in particular, as it pertains to the performance of high-tech firms. It is imperative that managers in the high-tech industry fully understand the complexity of dynamic capability and the role of relative moderators in improving performance. Governance and competitive posture enhance dynamic capability for R&D and marketing, respectively. We hope that our study serves as a building block for such an understanding.

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