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VALUE, RARENESS, COMPETITIVE ADVANTAGE, AND PERFORMANCE: A CONCEPTUAL-LEVEL EMPIRICAL INVESTIGATION OF THE RESOURCE-BASED VIEW OF THE FIRM

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The resource-based view of the firm (RBV) hypothesizes that the exploitation of valuable, rare resources and capabilities contributes to a firm's competitive advantage, which in turn contributes to its performance. Despite this notion, few empirical studies test these hypotheses at the conceptual level. In response to this gap, this study empirically examines the relationships between value, rareness, competitive advantage, and performance. The results suggest that value and rareness are related to competitive advantage, that competitive advantage is related to performance, and that competitive advantage mediates the rareness-performance relationship. These findings have important academic and practitioner implications which are then discussed.

INTRODUCTION

The resource-based view of the firm (RBV) assumes that resources, or 'stocks of available factors that are owned or controlled by the firm' (Amit and Schoemaker, 1993: 35), and capabilities, or the 'firm's capacity to deploy *Resources*' (Amit and Schoemaker, 1993: 35, emphasis in original), are both heterogeneously distributed among firms and imperfectly mobile. These assumptions allow not only for the existence of differences in firm resource endowments, but also for these differences to persist over time (Barney, 1991). Based on these assumptions, RBV scholars hypothesize that (1) if a firm possesses and exploits resources and capabilities that are both valuable and rare, it will attain a competitive advantage, (2) if these resources and capabilities are also both inimitable and non-substitutable, the firm will sustain this advantage, and (3) the attainment of such advantages will enable the firm to improve its short-term and long-term performance (Amit and Schoemaker, 1993; Barney, 1991, 1997; Eisenhardt and Martin, 2000; Henderson and Cockburn, 1994; Powell, 2001; Teece, Pisano, and Shuen, 1997).

In order to test these hypotheses, most scholars have employed a 'resource heterogeneity approach,' whereby a specific resource or capability is argued to be valuable, rare, inimitable, and/or non-substitutable, and then the amount of that resource or capability possessed by a firm is correlated with its competitive advantage or performance (Newbert, 2007). Clearly, evidence that a specific resource or capability may enable a firm to attain a competitive advantage in a particular industry setting is important given that it provides managers operating in that context the incentive and justification to obtain and exploit it. Yet, it is precisely this degree of specificity that is this

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methodological design's greatest limitation. Consider, for example, that all firms in an industry do not (both by ability and by choice) compete on the same bases. Rolex and Timex have both achieved tremendous success making timepieces while employing entirely different business models. Whereas Rolex competes on quality, status, and marketing, Timex competes primarily on scale (Barney, 1997: 148). Therefore, although a specific resource or capability may be found to exhibit a strong correlation with competitive advantage and/or performance in a particular context, that resource or capability may simply not *fit* with the enterprise-level strategies of all firms operating in that context. For managers of those firms who endeavor to compete on alternative bases, there is little to be gleaned from findings of this sort.

What might be more useful to these managers would be findings that allowed them to autonomously identify, and in turn seek out and exploit, resources and capabilities that might not only contribute to their firms' competitive position, but also fit with their idiosyncratic business models. One way to arrive at such findings is by eschewing the tendency to predetermine *which resources and capabilities* ought to be correlated with competitive advantage and/or performance, and instead identify *which characteristics of resources and capabilities* are related to these ends. Scholars employing such a methodological design, referred to as a 'conceptual-level approach,' typically operationalize the independent variable not in terms of specific resources or capabilities, but rather in terms of their value, rareness, inimitability, and/or non-substitutability (Newbert, 2007). Findings from conceptual-level studies are important as they provide insight into the characteristics that resources and capabilities *in general* must possess in order to improve a firm's competitive position.

To illustrate the importance that findings of this sort might offer, consider, for example, Henderson and Cockburn's (1994) seminal study of pharmaceutical firms. Employing a resource heterogeneity approach, Henderson and Cockburn (1994) argue that organizational competence (operationalized as the total number of patents generated by and the importance of publications for promotion within the firm) is a valuable, rare resource and find that it is significantly related to competitive advantage. Although the results of this study clearly demonstrate the significance of patents and publications to success in the pharmaceutical industry, because the independent variable is operationalized as a specific resource rather than as that resource's value and rareness, Henderson and Cockburn's (1994) study is not informative with respect to precisely *why* patents and publications are important. While one might speculate that they owe their significance to their inherent value and rareness, such cannot be concluded with any degree of certainty. In fact, it may be that the significance of patents and publications to a firm's competitive advantage is a function of some other characteristic not addressed by Henderson and Cockburn (1994).

Indeed, Collis and Montgomery (1995) argue that a firm's competitive advantage is a function not only of the value, inimitability, and non-substitutability of its resources and capabilities (indicative of traditional RBV logic), but also of their durability, appropriability, and superiority. When applied to Henderson and Cockburn's (1994) findings, Collis and Montgomery's (1995) framework suggests that the reason patents, for example, may enable pharmaceutical firms to attain a competitive advantage is because they are durable (they offer protection for up to 20 years), appropriable (they are legally bound to the firm), and superior (they offer greater security than other forms of intellectual property protection).

Therefore, to conclude that organizational competence is valuable and rare simply because it is related to competitive advantage is to assume that the RBV hypotheses linking value and rareness to competitive advantage are factual and require no empirical confirmation. These hypotheses, however, are purely theoretical, or synthetic, and can only be known to be true *after* empirical investigation (Priem and Butler, 2001a). In order to truly understand why a resource or capability contributes to a firm's competitive position, its underlying characteristics must be examined. Without such conceptual-level investigation, advice to practitioners to seek out and exploit valuable, rare, inimitable, and/or non-substitutable resources and capabilities may be unfounded. For example, Markman, Espina, and Phan (2004), in their conceptual-level study, find that competitive advantage in the pharmaceutical industry is related to the inimitability but *not* the substitutability of patents. Such results suggest that the RBV hypothesis relating non-substitutability and competitive

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advantage may be invalid and hints at the possibility that the criteria by which managers should evaluate resources and capabilities may need revision.

Given the insights to be gleaned from conceptual-level studies, it is unfortunate that there is a paucity of research employing this methodological approach, particularly with respect to the characteristics of value and rareness (Newbert, 2007). In response to this gap, this study will employ a conceptual-level approach in testing the RBV hypotheses relating value and rareness to competitive advantage and performance. It is hoped that the subsequent empirical results will add to our understanding regarding whether and to what degree resources and capabilities possessing these characteristics actually improve a firm's competitive position.

In testing these hypotheses, this study seeks to adhere more closely to RBV theory than prior studies in two important ways. First, given that resources and capabilities have long been argued to be effective only when deployed in combination (Penrose, 1959), this study will operationalize the independent variable as the value and rareness of resource-capability *combinations* rather than of individual resources or capabilities as is typical of research in this area (Newbert, 2007). Second, given that competitive advantage is hypothesized to mediate the resource/capability-performance relationship, this study will avoid the tendency to test the direct effect of resources and capabilities on performance (Powell, 2001), and instead explore the intervening effect of competitive advantage.

THE RBV

Though the RBV is the result of the efforts of many scholars (cf. Amit and Schoemaker, 1993; Barney, 1991; Eisenhardt and Martin, 2000; Henderson and Cockburn, 1994; Penrose, 1959; Peteraf, 1993; Rubin, 1973; Teece *et al*., 1997; Wernerfelt, 1984), Barney is generally acknowledged as the first to formalize the resource-based literature into a comprehensive theoretical framework. In his 1991 article, Barney argued that firms that possess and exploit resources and capabilities that are valuable and rare will attain a competitive advantage. Barney further reasoned that these advantages will ultimately manifest in improved performance in the short term (see Figure 1). Today, the RBV is considered to be one of the most widely accepted theories of strategic management (Powell, 2001; Priem and Butler, 2001a). However, because the relationships depicted in Figure 1 have received only limited attention in the empirical literature, the RBV's acceptance appears to be grounded more on the basis of logic and intuition than on empirical evidence. In light of this condition, the fundamental logic underlying the RBV will be discussed and empirically tested herein.

Value

According to Barney (1991), if a resource or capability yields the potential to enable a firm to reduce costs and/or respond to environmental opportunities and threats, it is valuable, and to the extent that a firm is able to effectively deploy such a resource or capability, it will attain a competitive advantage. Given this argument, it follows that the magnitude of a firm's competitive advantage will be a function of the value of its resources and capabilities. In other words, firms whose resources and capabilities are of marginal value will at best attain only minor competitive advantages. On the other hand, firms whose resources and capabilities are of great value will likely attain sizable competitive advantages. While such logic is straightforward, it nevertheless assumes that the firm is actually capable of exploiting its resources and capabilities; for, only once potentially valuable resources and capabilities are effectively deployed can a firm attain whatever competitive advantages those resources

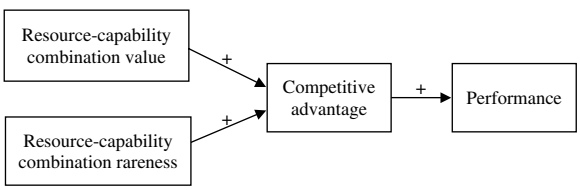

Figure 1. Conceptual model

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and capabilities might suggest are available. In order to understand how resources and capabilities must be exploited, the symbiotic relationship that exists among them must be acknowledged.

According to Penrose, 'resources consist of a bundle of potential services ... [T]he services yielded by resources are a function of the way in which they are used' (Penrose, 1959: 25). In order to effectively use, or exploit, a resource, Amit and Schoemaker argue that a firm must have access to the appropriate capabilities, which 'refer to a firm's capacity to deploy *Resources*' (Amit and Schoemaker, 1993: 35, emphasis in original). In other words, while a given resource may have the potential to yield a valuable service, that service will remain latent until deployed via a relevant capability.

Clearly, resources and capabilities are inextricably bound together in the attainment of a competitive advantage. As Penrose suggests, '[no] resources [or capabilities]... are of much use by themselves; any efficient use for them is always viewed in terms of possible combinations with other resources [or capabilities]' (Penrose, 1959: 86). In support, Rubin avers that 'firms must process raw resources to make them useful' (Rubin, 1973: 937). Like Penrose (1959), he argues that in order to effectively process resources, a firm must use them in some effective combination. More recently, Makadok (2001) contends that firms may create rents not only by picking better resources than competing firms, but also by exploiting them more effectively with the proper capabilities. He continues by suggesting that '[n]o matter how great a firm's capabilities might be, they do not generate economic profit if the firm fails to acquire the resources whose productivity would be enhanced by its capabilities' (Makadok, 2001: 389).

In summary, it seems that while a resource (or capability) may have tremendous *potential* value, its value can only be realized when it is combined with a corresponding capability (or resource). Given that resources and capabilities are essentially unproductive in isolation, the key to attaining a competitive advantage is not simply the exploitation of a valuable resource or a valuable capability, but rather the exploitation of a valuable resource-capability combination. Moreover, the more valuable the firm's resource-capability combinations, the greater the advantage it will enjoy as a result of their exploitation.

Hypothesis 1: The value of the resource-capability combinations that a firm exploits will be positively related to its competitive advantage.

Rareness

As noted above, to attain a competitive advantage, firms must achieve a cost level, exploit a market opportunity, and/or neutralize a threat that their competitors cannot. Given the novelty associated with such accomplishments, Barney (1991) reasons that firms are unlikely to achieve these ends if the resources and capabilities they exploit are widely held. Instead, competitive advantage likely derives from the exploitation of resources and capabilities that are rare, or possessed by some number of firms in an industry that is small enough to prohibit perfect competition (Barney, 1991). Along this vein, it is important to note that because resources and capabilities must be exploited in combination, to the extent that rareness contributes to competitive advantage, it likely does so not at the level of individual resources and capabilities but rather at the level of resource-capability combinations. In support, Barney (1991) acknowledges that the criterion of rareness applies to 'resource bundles,' suggesting that if a particular bundle of resources (and capabilities) is common, then large numbers of firms will be able to implement the resulting strategy, thereby reducing the advantage to be gleaned from it by each firm.

Given this logic, it seems that firms need not necessarily possess rare resources *and* rare capabilities in order to attain a competitive advantage. If, for example, a firm possesses a capability that no other firm does (such as a patented chemical process), it is not necessary for it to possess equally rare resources in order to translate that capability's latent value into a competitive advantage. To the extent that this patented process is designed to manipulate widely available raw materials (such as naturally occurring chemical compounds), the firm may still enjoy a competitive advantage over its competitors given that its rare capability allows it to exploit common resources differently than other firms. Thus, common resources (or capabilities) can be essential to the attainment of a competitive advantage provided they are paired with other capabilities (or resources) in such a way that the resulting combination in which they are exploited is rare.

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In summary, if the resource-capability combinations a firm exploits are rare, then it ought to attain a competitive advantage. Moreover, the rarer these combinations are, the greater the firm's advantages will be.

Hypothesis 2: The rareness of the resource-capability combinations that a firm exploits will be positively related to its competitive advantage.

Competitive advantage

Though the terms *competitive advantage* and *performance* are often used interchangeably (see Porter [1985: 11] for example), the two constructs are acknowledged to be conceptually distinct (Powell, 2001). Whereas a competitive advantage is generally conceptualized as the implementation of a strategy not currently being implemented by other firms that facilitates the reduction of costs, the exploitation of market opportunities, and/or the neutralization of competitive threats (Barney, 1991), performance is generally conceptualized as the rents a firm accrues as a result of the implementation of its strategies (Rumelt, Schendel, and Teece, 1994).

According to Peteraf and Barney (2003), a firm that has attained a competitive advantage has created more *economic value* (the difference between the perceived benefits of a resource-capability combination and the economic cost to exploit them) than its competitors. The authors continue by suggesting that economic value is generally created by producing products and/or services with either greater benefits at the same cost compared to competitors (i.e., differentiation-based competitive advantage) or the same benefits at lower cost compared to competitors (i.e., efficiency-based competitive advantage). Because superior benefits tend to enhance customer loyalty and perceived quality (Zou, Fang, and Zhao, 2003), a firm that can exploit its resource-capability combinations to effectively attain a differentiation-based competitive advantage should be able to improve its performance compared to competitors by selling more units at the same margin (i.e., parity price) or by selling the same number of units at a greater margin (i.e., premium price). Furthermore, because a superior cost structure enables greater pricing flexibility as well as the ability to increase available surplus (Barua *et al*., 2004; Porter and Millar, 1985; Zou *et al*., 2003), a firm that can exploit its resource-capability combinations to effectively attain an efficiency-based competitive advantage should be able to improve its performance compared to competitors by selling more units at the same margin (i.e., low price) or by selling the same number of units at a greater margin (i.e., parity price). In either case, it is logical to assume that a firm that attains a competitive advantage, whether in the form of greater benefits at the same cost or the same benefits at lower cost, will be able to improve its performance in ways that its competitors cannot.

This assumption, however, should not imply that competitive advantage and performance will necessarily be equivalent from an empirical standpoint for at least two reasons. First, although a competitive advantage may be a sufficient condition for improved performance, it may often be unnecessary (Durand, 2002). Indeed, the implementation of a resource-based strategy is simply one of many means by which a firm might earn rents. In support, there is a wealth of empirical evidence suggesting that many factors exogenous to the firm significantly affect performance (Brush, Bromiley, and Hendrickx, 1999; Datta, Guthrie, and Wright, 2005; McGahan and Porter, 1997; Rumelt, 1991; Schmalensee, 1985; Spanos and Lioukas, 2001). Thus, a firm's performance may increase even in the absence of a well-executed resource-based strategy.

Second, even when a firm *does* effectively implement a resource-based strategy, it may often find itself unable to recover the resulting economic value at a cost lower than that required to create it (Coff, 1999; Peteraf and Barney, 2003). Teece (1987) argues that a firm's ability to appropriate economic value is primarily a function of the nature of the technologies upon which the associated products and services are based and the effectiveness of the available forms of legal protection. Given these constraints on value appropriation, any improvement in performance a firm experiences is unlikely to correlate perfectly with its competitive advantage.

In summary, while it is expected that competitive advantage and performance will be correlated, the two constructs are clearly theoretically and empirically distinct. Whereas competitive advantage refers to the economic value that has been created from the exploitation of a firm's resource-capability combinations, performance refers to the

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economic value that the firm has captured from their commercialization. Although a firm's performance is influenced by a host of exogenous effects, the competitive advantages a firm attains are no doubt an important antecedent toward this end. Thus, it is expected that the performance of firms that are able to attain competitive advantages will be greater than the performance of those firms that are not.

Hypothesis 3: A firm's competitive advantage will be positively related to its performance.

According to Barney, 'firms are able to improve their performance only when their [resource-based] strategies exploit opportunities or neutralize threats' (Barney, 1991: 106). In other words, the best performing firms will not necessarily be those that simply exploit the most valuable and rare resource-capability combinations, but rather those firms that exploit their combinations most effectively. In support, Castanias and Helfat (2001) argue that rents derive not from random and/or misguided initiatives, but rather from properly motivated and well-directed strategic effort. Thus, in order to improve performance, firms (or more specifically, firm actors) must first identify and implement resource-based strategies that actually result in the creation of economic value. Unfortunately, the 'human limitations in crafting firm strategy' (Amit and Schoemaker, 1993: 34) are likely to result in considerable variation in the degree of skillfulness with which resource-capability combinations are exploited. For example, Prahalad and Bettis (1986) observe that individuals often make decisions based on the most readily available (rather than the most accurate) information, a heuristic that invariably leads to the selection of strategies that have proven effective in the past. The authors contend that such cognitive biases manifest in tremendous variance in the effectiveness of decisions regarding resource utilization. In other words, because decisions tend to be based on idiosyncratic and often erroneous information, firms may often implement resource-based strategies that do not result in improved performance.

It seems then that while some firms will be able to gain access to potentially valuable resources and capabilities that other firms will not (Barney, 1986; Dierickx and Cool, 1989), their mere exploitation cannot ensure the appropriation of positive economic rents. In order to reap any performance benefits from its valuable, rare resources and capabilities, the firm must deploy them in combinations that actually result in the reduction of costs, the exploitation of market opportunities, and/or the neutralization of environmental threats. It is precisely because of the fact that a firm may not necessarily succeed in attaining these ends that its performance is ultimately a function of the effectiveness with which it exploits its resource-capability combinations, as opposed to their underlying value and rareness.

The above discussion is not intended to suggest that the value and rareness of the resource-capability combinations a firm exploits play *no* role in determining its performance. Indeed, in order to deliver a product or service with unique features and/or at lower cost than competitors, a firm must exploit valuable resource-capability combinations in ways that its competitors do not. At the same time, however, no matter how valuable and rare these combinations are, they will not directly predict a firm's performance. In order to earn rents from its resource-capability combinations, a firm must successfully attain the competitive advantages that result from their exploitation. Thus, while a firm may find itself unable to improve its performance in the absence of valuable, rare resource-capability combinations, it is the competitive advantages that derive from their exploitation that will ultimately determine the firm's level of performance.

Hypothesis 4: A firm's competitive advantage will mediate the relationship between the value of the resource-capability combinations that the firm exploits and its performance.

Hypothesis 5: A firm's competitive advantage will mediate the relationship between the rareness of the resource-capability combinations that the firm exploits and its performance.

METHODOLOGY

Sample

In their assessment of what has been learned from the RBV literature, Barney and Mackey argue that 'the best resource-based empirical work will involve collecting primary data from firms in a carefully drawn sample' (Barney and Mackey,

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2005: 5). In response to this call, a sample of micro- and nanotechnology firms was surveyed from the fall of 2003 through the spring of 2004. Micro- and nanotechnology firms were chosen for two reasons. First, scholars have argued that competitive advantages are exceedingly difficult, if not impossible, to sustain in dynamic markets (Brown and Eisenhardt, 1998; D'Aveni, 1994; Lei, Hitt, and Bettis, 1996; Teece *et al*., 1997). In such cases, scholars argue that the best a firm can hope for is to attain 'a series of temporary advantages' (Eisenhardt and Martin, 2000: 1118). Given that this study seeks to understand how firms may attain (as opposed to sustain) competitive advantages, firms competing in a dynamic environment that are continuously seeking to do so makes for an appropriate sample.

Second, because of the infancy of micro- and nanotechnologies, they have yet to gain the legitimacy necessary to stimulate widespread adoption by potential customers (Aldrich and Fiol, 1994). Due to the absence of a known demand, the attainment of a competitive advantage in this sector may not always translate into improved performance. Therefore, the present sample may offer insights with regard to the important mediating role competitive advantage plays in the resource/capability-performance relationship.

Because a sizable proportion of U.S. firms are privately held, analyzing a sample of publicly traded micro- and nanotechnology firms would only produce biased results. In order to identify a more representative sample of firms, the mailing list for the Micro and Nanotechnology Commercialization Education Foundation (MANCEF), a trade organization designed to facilitate the commercialization of micro- and nano-based technologies, was obtained. This list consisted of senior-level executives at MANCEF member firms, 30.8 percent of which were found to be privately held. Of these names, those with valid mailing addresses working at firms directly involved in micro- and nanotechnology sectors at for-profit firms were selected, yielding a usable sample size of 664. These 664 firms were found to compete in a variety of industries, of which semiconductors, chemicals, electronics, computer equipment, communications, and aerospace were the most commonly represented. Because many of the public firms in the sample were known to be multidivisional, each respondent was asked to consider only the division that competes directly in the micro- and nanotechnology sector when responding to the survey.

Variables

Competitive advantage, value, and rareness

Given that firms are widely acknowledged to be bundles of resources and capabilities (Barney, 1991; Penrose, 1959; Rubin, 1973; Wernerfelt, 1984), it is unlikely that a firm's competitive position is solely attributable to any one specific resource or capability. Therefore, unlike prior conceptual-level studies (i.e., Markman *et al*., 2004), a focus on specific resources or capabilities was avoided. Instead, this study focuses on the value and rareness of as well as the competitive advantages attained from the exploitation of the firm's entire resource/capability base. In so doing, it is hoped that any subsequent findings will be generalizable to all resources and capabilities exploited by all firms in the context.

Because respondents would likely be unable to assess the value and rareness of each individual resource and capability controlled by the firm due to bounded rationality (Simon, 1957), it was decided that the entire resource/capability base might be best assessed by asking respondents to comment on several broad categories of resources and capabilities. Due to its widespread use, Barney's (1997) typology (financial, human, organizational, and physical resources and capabilities) was identified by a team of two academics as an appropriate starting point. After consulting with five senior-level executives at five different technology firms, the category 'intellectual resources and capabilities' was added to the typology to make it more comprehensive and relevant to micro- and nanotechnology firms (see Appendix).

Items were then constructed with careful attention to the fact that each firm competes with a unique set of competitors, maintains an idiosyncratic set of strategic objectives, and is subject to different environmental contingencies. Therefore, respondents were asked to assess the resources and capabilities their firms exploited for the purposes of reducing costs to a 'competitive' level, exploiting 'targeted' opportunities, and defending against 'known' threats. By positioning the items in this fashion, any *a priori* assumptions on the part of the researcher regarding what ought to constitute an appropriate cost structure, what opportunities

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ought to be exploited, and what threats ought to warrant a response were avoided (see Appendix).

Competitive advantage. Barney (1991) defines competitive advantage as the degree to which a firm has reduced costs, exploited opportunities, and neutralized threats. To measure competitive advantage, items were initially developed by the academic team in accord with this operational definition as suggested by Kerlinger and Lee (2000: chap. 3). These items were then reviewed by the practitioner panel in order to ensure their clarity and relevance to non-academics. Through an iterative ratification process between the academic team and practitioner panel, a set of three items emerged (see Appendix, items CA1–CA3). These items are positively coded, such that the higher the response, the greater the firm's competitive advantage.

In operationalizing this variable, responses to these three items were summed for each resource/capability category, resulting in five scores that reflected the competitive advantages the firm had attained from the exploitation of its financial, human, intellectual, organizational, or physical resource-capability combinations. For example, the competitive advantage attained from a firm's financial resource-capability combinations was calculated as: CA1a + CA2a + CA3a. Finally, a composite score reflecting the average level of competitive advantage across all resource/capability categories was created by averaging these five scores.

Value. Harrison, McLaughlin, and Coalter (1996) note that when the constructs under empirical examination are similar conceptually, the potential for highly correlated responses is increased. Because the definitions of value and competitive advantage have been argued to be tautological (Priem and Butler, 2001a, 2001b), respondent bias of this nature was a concern. To mitigate this issue, two steps were taken in the construction of the value items.

First, a multi-item scale was used given evidence that response bias decreases as the number of items measuring each construct increases (Harrison *et al.*, 1996). Second, respondents were asked to comment *indirectly* about the value of their firm's resources and capabilities. Indirect framing was used to reduce the likelihood that respondents would seek to rationalize responses describing the level of competitive advantage their firms had attained with the value of the underlying resources and capabilities. Specifically, items were developed that asked respondents to consider, regardless of whether or to what degree their firms had attained a competitive advantage, if access to other (i.e., more valuable) resources or capabilities might enable their firms to *improve* any such advantages. By assessing value in this manner, the potential for response bias is reduced as prior responses regarding the firm's competitive advantage need no justification.

Relying on this logic, six items measuring value emerged from the iterative ratification process discussed above (see Appendix, items V1–V6). In their raw form these items are negatively coded such that the higher the response, the more effectively the firm could reduce costs, exploit opportunities, and/or neutralize threats with access to resources and capabilities that are currently beyond the firm's control. In other words, the higher the response, the less valuable those resources and capabilities that the firm does control. Once the surveys were returned, responses to these items were recoded (i.e., positively coded) such that the higher the response, the more valuable the resources and capabilities to which the firm has access.

As argued above, a resource is exponentially more valuable when combined with the appropriate capability. Therefore, the value of a resource-capability combination ought to be a multiplicative (as opposed to additive) function of the value of the individual resources and capabilities that comprise it. Given this logic, responses to each of the capability value items (V1, V3, V5) were multiplied by the corresponding resource value items (V2, V4, V6, respectively), resulting in three preliminary value scores reflecting the firm's ability to reduce costs to a competitive level, exploit targeted opportunities, and neutralize known threats with the resources and capabilities to which it has access. These preliminary scores were computed for each resource/capability category and then summed, resulting in five scores reflecting the overall value of each firm's financial, human, intellectual, organizational, or physical resource-capability combinations. For example, the value of a firm's financial resource-capability combinations was calculated as: V1a × V2a + V3a × V4a + V5a × V6a. Finally, a composite score reflecting the average

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value of all of the firm's resource-capability combinations was computed by averaging these five scores.

Rareness. In order to confer a competitive advantage, a given resource-capability combination must be exploited by a small number of firms. However, as noted above, common resources and capabilities often play an important role in the attainment of a competitive advantage. Therefore, items measuring rareness must account for the degree to which a firm exploits unique resource-capability combinations as well as the degree to which it exploits common resources (or capabilities) with unique capabilities (or resources). Following this logic, three items measuring rareness were developed conjointly by the academic team and practitioner panel (see Appendix, items R1–R3). These items are positively coded such that the higher the response, the rarer the firm's resource-capability combinations. In operationalizing this construct, responses to these three items were summed for each resource/capability category, resulting in five scores that reflected the rareness of each firm's financial, human, intellectual, organizational, or physical resource-capability combinations. For example, the rareness of a firm's financial resource-capability combinations was calculated as: R1a + R2a + R3a. Finally, a composite score reflecting the average rareness of all of the firm's resource-capability combinations was computed by averaging these five scores.

Illustrative example. To illustrate how the above scales measure the constructs at issue, consider a simplified example in which a population of two firms produce oil from separate but identical deposits of bitumen, or 'oil sand,' a highly viscous form of petroleum (a physical resource). Suppose that Firm A possesses high-quality surface mining capabilities (a conventional technology whereby the land is strip-mined to extract bitumen at shallow depths) and steam injection capabilities (a conventional technology whereby steam is pumped into the bitumen reservoir to extract bitumen deep underground). Further suppose that Firm B possesses high-quality surface mining capabilities and fireflood capabilities (an experimental and significantly more energy efficient technology than steam injection, whereby the bitumen reservoir is ignited to extract bitumen deep underground).

Because both firms are producing oil, each has successfully exploited a targeted opportunity and, thus, each has attained a competitive advantage. Yet, because Firm A lacks fireflood capabilities, it has not exploited the opportunity as efficiently as Firm B, rendering Firm B's competitive advantage greater than Firm A's. Furthermore, because no additional capabilities would enable Firm B to better exploit the resource, its capabilities can be considered to be extremely valuable. Conversely, because gaining access to fireflood capabilities would enable Firm A to exploit the resource more efficiently, its current set of capabilities can be considered to be less valuable than Firm B's. Lastly, because each firm combines a common resource with one common and one unique capability, the resource-capability combinations exploited by each firm can be considered to be moderately rare.

Performance

Three types of performance measures are used regularly in the strategy literature: objective financial performance (Combs and Ketchen, 1999; Knott, 2003; Maijoor and Van Witteloostuijn, 1996; Makadok, 1999; Miller and Shamsie, 1996; Robins and Wiersema, 1995; Russo and Fouts, 1997), subjective financial performance (Powell, 1992a, 1992b; 1995; Powell and Dent-Micallef, 1997), and subjective nonfinancial performance (Combs and Ketchen, 1999; Henderson and Cockburn, 1994; Markman *et al.*, 2004; Powell and Dent-Micallef, 1997; Yeoh and Roth, 1999). Due to the prevalence of private firms in the sample, data on objective financial performance were not available. Thus, performance was measured via Delaney and Huselid's (1996) widely used market performance scale (Perry-Smith and Blum, 2000; Richard, 2000), a subjective scale that includes both financial (sales, profitability) and nonfinancial (marketing, market share) indicators and has a well-documented reliability of 0.86 (see Appendix, items P1–P4). These items are positively coded such that the higher the response, the greater the firm's performance. This variable is operationalized by summing the responses to the four items. Given that research suggests that perceptual measures of performance correlate well with objective measures (Powell, 1992a), coupled with the ubiquity of accounting irregularities in today's marketplace, it is believed that this scale will serve as a rigorous indicator of firm performance.

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Control variables

Authors engaging in RBV research typically control for firm size and the environment. In this study, firm size is operationalized as the firm's total number of employees. This variable was highly skewed in its raw form; thus, its log was taken in order to normalize the distribution. In so doing, because several respondents indicated having no employees, a value of one was added to this item prior to taking its log.

In light of the fact that micro- and nanotechnology firms do not operate in a single industry, and because industry information on many of the private firms in the sample were unobtainable, Khandwalla's (1976) environmental hostility scale (see Appendix, items EH1–EH3) is used to control for environmental effects in lieu of Standard Industrial Classification-based measures. This scale is designed to measure the degree to which the respondent perceives that the firm's environment is characterized by competition and risk and has a well-documented reliability of 0.73. This variable is operationalized by summing the responses to the three items.

Pilot study

In an attempt to assess the reliability and validity of the newly developed scales (value, rareness, and competitive advantage), a pilot survey was administered to 153 of the 664 respondents following the Dillman (1978) Total Design Method.[1] Surveys and various accompaniments were sent out in a series of three mailings and three e-mails from November 2003 to December 2003, from which 25 completed surveys were received, reflecting a response rate of 16.3 percent. Cronbach alphas computed on all scales were found to be above or approaching 0.700, suggesting that the scales are internally consistent (Nunnally, 1978). The results of an exploratory factor analysis of these scales show that all items converge with items measuring the same construct and discriminate from items measuring other constructs. While such results would ordinarily provide strong evidence in support of the scales' validity, because the sample-to-variable ratio of 1.5 : 1 is lower than that which is regarded as adequate to derive stable factors (Cattell, 1978; Conway and Huffcutt, 2003; Everitt, 1975; Fabrigar *et al*., 1999), no compelling conclusions regarding validity could be drawn at this stage.

Full study

Also following the Dillman (1978) Total Design Method, the complete survey along with accompaniments were sent out in a series of four mailings and five e-mails from January 2004 to March 2004 to the remaining 511 respondents in the sample who were not sent a pilot survey. From these 511 respondents, 117 completed surveys were received, reflecting a response rate of 22.9 percent, a response rate that compares favorably with similar studies in the field (Alreck and Settle, 1985). Of these 117 respondents, 73 provided data regarding their job title indicating that 24 (33%) are president, general manager, partner, and/or chief officer, 23 (32%) are senior-level directors or managers, 16 (22%) are engineers/scientists, and 10 (14%) are vice presidents. Because those responding to the survey are all senior-level executives or scientists at their respective firms, it is assumed that they are all highly qualified to provide accurate responses to the survey items.

In order to test for the presence of bias among respondents, several tests were conducted.[2] First, chi-square tests were conducted to determine if respondents differed from nonrespondents based on their gender or the geographic location of their firm. All statistics were insignificant, suggesting that respondents and nonrespondents do not differ on these dimensions.

Second, ANOVA tests were then conducted for each survey item to determine if the answers given by early responders (those whose survey was received prior to the third mailing, $n = 60$) differed significantly from late responders (those whose survey was received after the third mailing, $n = 57$). Of the 68 items on the survey, significant differences existed between these two groups for only four (5.88%). Because five percent of the mean responses are expected to be significantly different at the $p = 0.05$ level by chance alone, the fact that significant differences were found to exist for only 5.88 percent of the items is not entirely unexpected. Thus, it is assumed that any bias that

[1] Results pertaining to the reliability and validity of pilot study data are not reported herein but are available upon request.

[2] Results of tests of response bias are not reported herein but are available upon request.

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may exist with respect to the time of response is due largely to chance and will not substantively impact any subsequent analyses.

Lastly, a Harman's single-factor test was conducted to assess the degree to which the data is subject to common method bias, an approach that is routinely used in the literature (Christmann, 2004; Kirkman and Shapiro, 2001; Steensma *et al*., 2005). The unrotated factor solution produced five factors that account for 23.1 percent, 18.3 percent, 11.4 percent, 7.6 percent, and 6.9 percent of the variance, respectively. Because a single factor did not emerge from the analysis and because no single factor accounted for a substantial majority of the variance, artificial response bias is not assumed to exist in the data (Podsakoff and Organ, 1986).

In order to assess the reliability of the data, Cronbach alphas were computed for each scale used in the full study (see Appendix for reliability coefficients). Alphas for all scales are above or approaching 0.700, suggesting that the scales are internally consistent (Nunnally, 1978). In order to assess the validity of these scales, an exploratory factor analysis was conducted on the 19 items comprising these constructs (see Table 1 for results). With a usable sample size of 96, this analysis yields a sample-to-variable ratio of 5.1 : 1. Scholars have traditionally relied on anecdotal evidence when proposing appropriate sample-to-variance ratios (MacCallum *et al*., 1999), resulting in wide-ranging recommendations, from a low of 3 : 1 (Cattell, 1978) to a high of 10 : 1 (Everitt, 1975). More recently, however, rigorous statistical studies of exploratory factor analysis find that a ratio of 4 : 1 is adequate to produce stable factors (Conway and Huffcutt, 2003; Fabrigar *et al*., 1999). In light of such evidence, it is concluded that the factors reported in Table 1 are stable. Furthermore, given that the items in Table 1 converge with items measuring the same construct and discriminate from items measuring other constructs (reaffirming the inconclusive pilot study results),

Table 1. Exploratory factor analysis: full study

	Value	Rareness	Competitive advantage	Performance	Environmental hostility
Survey Item[1,2]					
Capabilities enable threat response (V5)	**0.794**	0.025	−0.013	−0.042	0.021
Resources enable threat response (V6)	**0.777**	−0.148	0.180	−0.113	−0.016
Capabilities enable opportunity exploitation (V3)	**0.767**	0.176	−0.277	−0.014	−0.107
Resources enable opportunity exploitation (V4)	**0.741**	−0.197	0.296	−0.011	−0.090
Capabilities enable cost reduction (V1)	**0.720**	0.054	−0.070	0.250	0.124
Resources enable cost reduction (V2)	**0.649**	−0.149	0.122	0.025	0.263
Combine resources with novel capabilities (R2)	−0.017	**0.874**	0.066	0.189	−0.097
Combine novel resources and capabilities (R3)	−0.126	**0.845**	0.106	0.074	0.077
Combine capabilities with novel resources (R1)	−0.077	**0.783**	0.325	0.123	−0.001
Threats responded to (CA3)	0.047	0.177	**0.835**	0.165	−0.113
Opportunities capitalized on (CA2)	0.140	0.315	**0.759**	0.175	0.060
Costs highly competitive (CA1)	0.054	0.469	**0.424**	0.379	0.023
Growth in sales (P2)	0.060	0.078	0.120	**0.888**	−0.188
Profitability (P3)	0.029	0.138	0.189	**0.807**	−0.155
Market share (P4)	−0.133	0.007	0.354	**0.717**	−0.096
Marketing (P1)	0.051	0.203	−0.089	**0.689**	0.055
Safety of environment (EH2)	0.084	−0.093	0.020	0.037	**0.831**
Richness of opportunities (EH3)	−0.033	−0.083	0.009	−0.174	**0.725**
Control over environment (EH1)	0.083	0.304	−0.127	−0.164	**0.658**
Statistics					
Eigenvalue	4.391	2.168	1.450	3.481	1.307
Variance explained	17.878	14.382	10.475	14.849	9.772

[1] Note that the statistics reported for the value, rareness and competitive advantage items reflect the factor weights for the average resource/capability category. Exploratory factor analyses for each of the individual resource/capability categories are similar, though they are not reported herein.
[2] Item number in parentheses (see Appendix).
N = 96
67.4% of the variance explained.

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it is also concluded that the scales used in this study are indeed valid indicators of the constructs they were developed to measure.

ANALYSIS AND RESULTS

Descriptives and correlations

Descriptive statistics and correlations were computed for the model variables (see Table 2). Two sets of statistics are worthy of note in Table 2. First, of the correlations among variables that will appear conjointly in subsequent regression analyses (bolded statistics), those that are significant are all below 0.500 with the exception of that between rareness (organizational resources and capabilities) and competitive advantage (organizational resources and capabilities). However, because the variance inflation factor (VIF) for these two terms is 1.452, well below the VIF of 10 that Kennedy suggests is indicative of 'harmful collinearity' (Kennedy, 1992: 183), it is assumed that this correlation will not confound the results of any subsequent statistical tests.[3] Second, the correlations among the value and competitive advantage items are relatively low (the maximum r across the five resource/capability categories is 0.358). Such evidence suggests that efforts to mitigate bias in the form of highly correlated responses for these two constructs were successful.

Determinants of competitive advantage

Hypotheses 1 and 2 were tested using six hierarchical ordinary least squares (OLS) regression models, one pertaining to each of the five individual resource/capability categories (financial, human, intellectual, organizational, and physical, respectively) and one pertaining to the average for these categories. As can be seen from the results of these analyses reported in Table 3, the F-statistics and the changes in the F-statistics for all six regression models are significant, suggesting not only that the full models fit the data well, but also that the addition of the independent variables produces models that fit the data significantly better than the control variables models. The results also show that the full models explain a considerable amount of the variance in competitive advantage (11.9% to 32.6% across the six models), which in each case reflects a substantial increase from the control variable model.

The parameters for the control variables show that firm size is insignificant in all six models and that environmental hostility is significant in the financial resources and capabilities model only, suggesting that these variables have little or no effect on competitive advantage. With respect to the hypotheses at issue, the parameter estimate for value is positive and significant in five of the six models (all but the physical resources and capabilities model). This finding offers support for Hypothesis 1, that the value of the resource-capability combinations that a firm exploits is positively related to its competitive advantage. Additionally, the parameter estimate for rareness is significant and positive in all six models. This finding suggests that the rarer a firm's resource-capability combinations, the greater the competitive advantages it will attain from their exploitation. Thus, support is also concluded for Hypothesis 2.

Determinants of performance

Hypotheses 3, 4, and 5 were tested using six hierarchical OLS regression models similar to those discussed above. As can be seen from the results of these analyses reported in Table 4, all six F-statistics and five of the six changes in the F-statistics are significant suggesting that the full model not only fits the data well, but also that the addition of competitive advantage to the model significantly improves the fit of the data for all but the physical resources and capabilities model. The results also show that the full models explain a considerable amount of the explained variance in performance (11.8% to 18.6% across the six models for which the inclusion of competitive advantage improves the model's fit), which in each case reflects a substantial increase from the control variable model.

The parameter estimates for the control variables show that environmental hostility is significantly and negatively related to performance in all six regression models. This finding, which is consistent with prior research (Dess *et al.*, 2003), suggests that the less hostile a firm's environment, the greater its performance. Firm size, on the other hand, is insignificant in all models, suggesting that this variable is unrelated to performance. The results also show that the parameter estimate for

[3] The VIF is calculated as $1/(1 - r^2)$.

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Table 2. Descriptives and correlations[1]

Variable[2]	Mean	Std. dev.	N	1	2	3	4	5	6	7	8	9
1 Environmental hostility	11.938	3.120	112									
2 Firm size (log)	4.911	3.004	105	**−0.177**								
3 Value (financial)	21.872	12.500	109	**−0.104**	**0.294****							
4 Value (human)	22.055	10.683	109	**0.189**	**0.129**	0.425***						
5 Value (intellectual)	22.798	11.480	109	**0.117**	**0.086**	0.314***	0.624***					
6 Value (organizational)	22.500	11.245	108	**0.150**	**0.159**	0.384***	0.660***	0.729***				
7 Value (physical)	24.560	11.069	109	**0.012**	**0.242***	0.696***	0.667***	0.469***	0.450***			
8 Value (average)	22.347	9.026	109	**0.107**	**0.219***	0.704***	0.845***	0.797***	0.813***	0.798***		
9 Rareness (financial)	9.860	2.221	107	**0.049**	**−0.143**	**0.021**	0.021	−0.165	−0.121	0.013	−0.051	
10 Rareness (human)	10.300	2.224	107	**0.020**	**−0.360*****	−0.339***	**0.026**	−0.002	−0.040	−0.182	−0.118	0.356***
11 Rareness (intellectual)	10.590	2.525	107	**0.023**	**−0.302****	−0.432***	−0.078	**−0.024**	−0.045	−0.375***	−0.216*	0.353***
12 Rareness (organizational)	9.910	2.255	107	**0.082**	**−0.096**	−0.119	0.089	0.043	**0.164**	−0.077	0.041	0.412***
13 Rareness (physical)	9.900	2.172	107	**−0.059**	**−0.287****	−0.099	0.145	−0.041	−0.024	**0.041**	−0.006	0.470***
14 Rareness (average)	10.110	1.748	107	**0.031**	**−0.314****	−0.261**	0.049	−0.049	−0.018	−0.161	**−0.096**	0.670***
15 Competitive advantage (financial)	8.722	2.531	108	**−0.158**	**0.044**	**0.358*****	0.038	−0.095	0.054	0.130	0.115	**0.472*****
16 Competitive advantage (human)	9.110	2.417	109	**0.007**	**−0.050**	0.038	**0.236***	0.157	0.221*	0.008	0.172	0.146
17 Competitive advantage (intellectual)	9.472	2.578	108	**0.006**	**−0.243***	−0.098	0.024	**0.234***	0.189	−0.169	0.062	0.141
18 Competitive advantage (organizational)	8.899	2.337	109	**0.022**	**0.003**	0.053	0.084	0.166	**0.285****	−0.114	0.138	0.256**
19 Competitive advantage (physical)	9.284	2.232	109	**−0.056**	**−0.055**	0.165	0.226*	0.114	0.086	**0.235**	0.201*	0.292**
20 Competitive advantage (average)	9.099	1.966	109	**−0.042**	**−0.077**	0.127	0.147	0.141	0.205*	0.017	**0.167**	0.321***
21 Performance	9.955	2.976	112	**−0.243***	**0.074**	**0.089**	**0.084**	**0.054**	**0.100**	**0.023**	**0.088**	**0.144**

Table 2. (*Continued*)

Variable[2]	10	11	12	13	14	15	16	17	18	19	20
1 Environmental hostility											
2 Firm size (log)											
3 Value (financial)											
4 Value (human)											
5 Value (intellectual)											
6 Value (organizational)											
7 Value (physical)											
8 Value (average)											
9 Rareness (financial)											
10 Rareness (human)											
11 Rareness (intellectual)	0.754***										
12 Rareness (organizational)	0.596***	0.538***									
13 Rareness (physical)	0.516***	0.455***	0.374***								
14 Rareness (average)	0.845***	0.822***	0.763***	0.727***							
15 Competitive advantage (financial)	0.001	0.050	0.329***	0.212**	0.273**						
16 Competitive advantage (human)	**0.334*****	0.246*	0.454***	0.336***	0.393***	0.407***					
17 Competitive advantage (intellectual)	0.364***	**0.422*****	0.385***	0.286**	0.420***	0.385***	0.765***				
18 Competitive advantage (organizational)	0.237*	0.271**	**0.558*****	0.141	0.382***	0.554***	0.695***	0.748***			
19 Competitive advantage (physical)	0.159	0.137	0.312***	**0.497*****	0.358***	0.585***	0.653***	0.516***	0.474***		
20 Competitive advantage (average)	0.270**	0.279**	0.500***	0.356***	**0.448*****	0.723***	0.864***	0.842***	0.853***	0.785***	
21 Performance	**0.024**	**0.052**	**0.289****	**0.096**	**0.156**	**0.373*****	**0.299****	**0.309*****	**0.383*****	**0.258****	**0.399*****

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[1] Bolded coefficients indicate those correlations among variables that will appear together in subsequent OLS regressions

[2] Resource/capability type in parentheses (see Appendix)

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Table 3. Determinants of competitive advantage

	Financial resources and capabilities[1]		Human resources and capabilities[2]		Intellectual resources and capabilities[1]		Organizational resources and capabilities[1]		Physical Resources and Capabilities[2]		Average Resources and Capabilities[2]	
Environmental hostility	−0.191	−0.178*	−0.007	−0.040	−0.046	−0.059	−0.009	−0.059	−0.101	−0.052	−0.082	−0.093
Firm size	0.011	−0.016	−0.044	0.033	−0.252*	−0.175+	0.000	0.008	−0.054	0.056	−0.085	0.010
Value		0.311***		0.215*		0.256**		0.194*		0.145		0.187+
Rareness		0.449***		0.332**		0.383***		0.538***		0.487***		0.460***
Adjusted R^2	0.017	0.312	−0.019	0.119	0.041	0.231	−0.021	0.326	−0.010	0.229	−0.009	0.195
F-Statistic	1.800	11.773***	0.088	4.252**	3.036+	8.143***	0.004	12.482***	0.533	8.120***	0.550	6.813***
F Change		20.972***		8.402***		12.500***		24.958***		15.541***		12.936***

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Standardized coefficients reported
[1] N = 96
[2] N = 97

Table 4. Determinants of performance

	Financial resources and capabilities[1]		Human resources and capabilities[2]		Intellectual resources and capabilities[1]		Organizational resources and capabilities[1]		Physical Resources and Capabilities[2]		Average Resources and Capabilities[2]	
Environmental hostility	−0.240*	−0.176+	−0.252*	−0.239*	−0.232*	−0.206*	−0.261**	−0.238*	−0.225*	−0.212*	−0.239*	−0.203*
Firm size	0.075	0.080	0.068	0.057	0.083	0.146	0.052	0.048	0.095	0.081	0.102	0.097
Value	−0.029	−0.139	0.072	0.004	0.018	−0.079	0.046	−0.019	−0.077	−0.112	0.045	−0.025
Rareness	0.180+	0.022	0.112	0.007	0.118	−0.021	0.316**	0.147	0.098	−0.019	0.229*	0.062
Competitive advantage		0.354**		0.316**		0.365**		0.312**		0.240*		0.361***
Adjusted R^2	0.053	0.130	0.040	0.118	0.034	0.126	0.130	0.186	0.034	0.068	0.072	0.168
F-Statistic	2.311+	3.802**	1.985	3.543**	1.819	3.719**	4.526**	5.306***	1.845	2.397*	2.842*	4.823***
F Change		4.124**		3.653*		3.988**		6.435***		1.862		11.446***

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Standardized coefficients reported
[1] N = 95
[2] N = 96

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competitive advantage is significant and positive in all six regression models, thereby suggesting that a firm's competitive advantage is indeed an important antecedent to its performance. Thus, support is concluded for Hypothesis 3.

It was argued above that the moderately high correlation between rareness and competitive advantage would not confound the results for the organizational resources and capabilities model presented in Table 4 given the relatively low VIF for these constructs. In order to confirm this assumption, this model was rerun twice, once without rareness and once without competitive advantage, in order to assess whether the reported results might have been affected by this correlation. These additional regressions show that the significance, signs, and relative effect sizes of the parameter estimates for the remaining variables are virtually identical to those presented in Table 4, confirming that this correlation does not confound the relationships under examination.[4]

Mediating effect of competitive advantage

Following Baron and Kenny's (1986) analytic considerations for mediation, the following four conditions must be met in order to conclude support for Hypotheses 4 and 5: (1) value and rareness must be related to competitive advantage, (2) competitive advantage must be related to performance, (3) value and rareness must be related to performance in the absence of competitive advantage, and (4) the effects of value and rareness on performance must be reduced or eliminated upon the inclusion of competitive advantage to the model. The results highlighted above show that the first two of these conditions are met, namely that value and rareness are related to competitive advantage (see Table 3) and that competitive advantage is related to performance (see Table 4). Unfortunately, Baron and Kenny's (1986) third condition is not satisfied with respect to value. As can be seen in Table 4, the parameter estimate for value is insignificant in stage one of each of the six models. Because no relationship exists between value and performance, there is no relationship for competitive advantage to mediate; thus, Hypothesis 4 is not supported.

The results for rareness, on the other hand, are more promising. As seen in Table 4, the parameter estimates for rareness in the first stage of the financial, organizational, and average resources and capabilities models are significant, thereby satisfying Baron and Kenny's (1986) third condition. Table 4 also shows that the significance of each of these parameter estimates is eliminated upon the inclusion of competitive advantage to the model, thereby satisfying Baron and Kenny's (1986) fourth condition. Taken together, these findings suggest that competitive advantage fully mediates the rareness-performance relationship for these three resource/capability categories.

In order to more rigorously assess the mediating effect of competitive advantage on the rareness-performance relationship, Sobel, Aroian, and Goodman tests, which are designed to determine whether the influence that a mediating variable has on the relationship between an independent and dependent variable is statistically significant, were conducted. As the results in Table 5 show, each of these test statistics is significant, suggesting that the mediating effect of competitive advantage is indeed significant. Because this effect was found for only three of the six models tested, Hypothesis 5 is only partial supported. It is important to note, however, that this mediating effect was found to exist for the average resources and capabilities model (suggesting that this effect is significant on average), thereby strengthening the partial support for this hypothesis.

DISCUSSION

This study was conducted in order to test the RBV hypotheses that the value and rareness of a firm's resource-capability combinations contribute to its competitive advantage and that such an advantage, in turn, contribute to its performance. In finding support for Hypotheses 1 and 2—that the more valuable and rare a firm's resource-capability combinations, the more likely it will attain a competitive advantage—this is one of only a small number of studies that finds empirical evidence of direct relationships between the value and rareness of a firm's resource-capability combinations and its competitive advantage. Such findings may be of interest to both academics and practitioners for several reasons.

[4] Results of these regressions not included herein but are available upon request.

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From an academic standpoint, by examining these fundamental RBV hypotheses at the conceptual level, this study fills an important gap in the empirical literature. The finding that value and rareness, rather than specific resources and capabilities, determine a firm's competitive advantage provides support for hypotheses that have until now been accepted almost entirely on the basis of logic and intuition. Thus, the present findings should help strengthen the RBV's acceptance as a rigorous theory of strategic management. Additionally, by framing the independent variables in terms of resource-capability combinations (as opposed to individual resources or capabilities), the present study more accurately captures the dynamics by which resources and capabilities have long been argued to contribute to competitive advantage than has the majority of prior research in this area.

From a practitioner standpoint, the finding that a competitive advantage stems from the combination of valuable, rare resources and capabilities may inform the way in which managers make decisions to alter their firms' resource/capability bases. Consider, for example, that prior research has suggested that resources and capabilities may be valuated in isolation. Such findings imply that if the exploitation of a given resource has not resulted in the attainment of a competitive advantage, then the resource is not valuable. However, the present findings suggest that the resource may indeed be highly valuable, but that it must simply be exploited via a different capability. Thus, before jettisoning or acquiring a given resource (or capability), managers may wish to first assess the value of the capabilities (or resources) with which it has been or could be combined.

Similarly, prior evidence that only rare resources and capabilities will enable the attainment of a competitive advantage suggests that managers ought to gain access to resources and capabilities that no or few other firms possess. Yet, because rare resources are difficult if not impossible to attain, Miller (2003) theorizes that firms may instead be able to build a competitive advantage from the resources and capabilities they already possess. The results reported herein support this argument. Indeed, the finding that it is the uniqueness with which valuable, though perhaps common, resources and capabilities are combined that enables a firm to attain a competitive advantage suggests that managers need not necessarily seek out novel resources and capabilities, but rather develop novel ways in which to combine those resources and capabilities to which they do have access.

In concluding support for Hypothesis 3, this study finds evidence in support of the notion that a competitive advantage via the implementation of a resource-based strategy is an important means by which a firm can improve its performance. When viewed in the context of the results for the mediation hypotheses (Hypotheses 4 and 5), the current findings seem to indicate that although valuable, rare resource-capability combinations are important in determining a firm's level of performance, their effect on performance is neither direct nor inevitable. Because (1) value and rareness were found to be significantly related to competitive advantage, (2) value was found to be unrelated to performance, and (3) competitive advantage was found to fully mediate the rareness-performance relationship, it seems that in order to reap any performance gains from its resources and capabilities, a firm must first attain the competitive advantages that result from their combined exploitation. In other words, the value and rareness that might characterize a firm's resources and capabilities may not necessarily confer improved performance. Such an end can only be attained if the firm is able

Table 5. Mediating effect of competitive advantage

Mediated relationship[1]	Sobel	Aroian	Goodman
Resource-capability combination rareness (financial) → performance	2.593**	2.556**	2.630**
Resource-capability combination rareness (organizational) → performance	2.465*	2.439*	2.492*
Resource-capability combination rareness (average) → performance	2.758**	2.718**	2.799**

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[1] Resource/capability type in parentheses (see Appendix).

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to exploit these valuable, rare resources and capabilities in combinations that enable it to effectively reduce costs, exploit market opportunities, and/or neutralize competitive threats. These findings may also be informative to both academics and practitioners.

From an academic standpoint, these finding are important for two reasons. First, by adhering more closely to theory, they respond to calls to acknowledge the conceptual differences between competitive advantage and performance in empirical research (Powell, 2001). Second, by demonstrating that competitive advantage plays a significant role in the resource/capability exploitation process, they suggest that studies that test the direct relationship between resources/capabilities and performance may be incomplete.

Taken together with the finding that firm size is insignificant in all but one of the 12 regression models, these findings may also be of interest to practitioners. To the extent that improving performance is not directly a function of the value or rareness of a firm's resource-capability combinations but rather of the advantages it creates from their exploitation, all firms (both those that have access to a wide array of resources and capabilities and those that do not) seem to have an equal opportunity to succeed. Firms seeking to improve their performance need not necessarily exploit only those resources and capabilities that have become the accepted as bases of competition in their respective industry as the results of resource heterogeneity studies might otherwise suggest. Instead, firms need only deploy those resources and capabilities to which they do have access in novel combinations such that they are able to reduce costs and/or respond to environmental conditions. Such findings ought to give hope to owners and managers of new and small firms as well as those of older firms looking to diversify into new markets that may have access to resources and capabilities that are different from those to which established competitors do.

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Though the present analysis may provide some insight into the resource/capability-competitive advantage-performance relationship, it is not entirely beyond reproach. A concern of any study that collects self-report data is that it may be subject to common method bias. It is important to note that survey research was undertaken in light of Barney and Mackey's (2005) call to conduct primary research on the RBV as well as the fact that the context chosen for analysis (the micro- and nanotechnology sector) contains a high percentage of privately held firms for which secondary data is not available. Although the statistical analyses described above suggest that response bias is not present in the data, scholars wishing to replicate this study may nevertheless wish to examine publicly held firms for which secondary data may be more readily obtainable.

Along this vein, it is important to note that the data were provided by single respondents. Although the use of single as opposed to multiple respondents has been argued to increase the likelihood that the data will be biased, single respondents were used for two reasons. First, because the MANCEF mailing list was used to identify a generalizable sample of firms, the list of potential respondents was limited. Second, because the respondents are senior-level executives or scientists at their respective firms, they are arguably better positioned than anyone else in the firm to assess the firm's internal operations and competitive environment. As such, the data collected are believed to be accurate. Nevertheless, scholars conducting research in this area in the future may wish to corroborate their data by surveying multiple respondents within the firm.

Lastly, one of the most serious critiques of the RBV, and one to which this study may not be entirely immune, is that of the tautological nature of value and competitive advantage. Given the tautology inherent in their operational definitions, an empirical test of the relationship between them is admittedly difficult. Therefore, multi-item scales were diligently created in consultation with practitioners with this potential confound in mind in an attempt to avoid unduly correlated responses. Based on evidence that these measures are both reliable and valid, that respondent bias is not present in the data, and that the correlations among these two variables are reasonably low, attempts to accurately measure these constructs were arguably successful.

Nevertheless, because the measurement of value, like that of all unobservable constructs, is inherently complicated (Godfrey and Hill, 1995), it

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cannot be concluded with certainty that no error exists in the measurement of this construct. Indeed, the decision to measure value indirectly may have resulted in data that reflects the subjective shadow price of a firm's existing resources and capabilities as opposed to their true, objective value.[5] To the degree that any such slippage does exist, the results pertaining to value should be accepted guardedly. Additionally, future scholars may wish to measure value via alternative metrics in an attempt to further reduce the potential confounding effects of this tautology while at the same time capturing the essence of this important construct.

Ultimately, this study has endeavored to explore relationships that underpin many of the fundamental hypotheses of the RBV that have until now been largely ignored in the empirical literature. In finding support for the majority of these hypotheses, this study may help strengthen the RBV's perception as a rigorous theory of strategic management. Of course, due to the lack of research in this area, the findings presented herein beckon replication; thus, future scholars are encouraged to continue to conduct conceptual-level tests of the RBV. In so doing, we as a scholarly community will have more rigorous evidence by which to confirm, refine, supplement, and/or refute the RBV's fundamental hypotheses, thereby enriching our understanding of the role that resources and capabilities play in an organization's success and survival.

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APPENDIX: SURVEY INSTRUCTIONS AND SCALES

Instructions

Below are some questions that will help us learn how you use your Capabilities and Resources for the purposes of reducing costs to a competitive level, exploiting targeted market opportunities, and/or defending against known competitive threats. When responding to these questions, please select your answer based on the following definitions:

Resources: the tangible or intangible *assets* a firm possesses or has access to. Important classes of Resources are as follows:

1. Financial Resources: capital, cash, equity, retained earnings, etc.
2. Human Resources: training, experience, judgment, intelligence, relationships, etc. of individual employees.
3. Intellectual Resources: patents, copyrights, trademarks, trade secrets, etc.
4. Organizational Resources: relationships with other firms (such as partners, suppliers, buyers, creditors), channels of distribution, corporate culture, etc.
5. Physical Resources: physical technology, plant and equipment, geographic location, raw materials, etc.

Capabilities: the intangible *processes* (such as skills, abilities, know-how, expertise, designs, management, etc.) with which a firm exploits Resources in the execution of its day-to-day operations.

Performance (Delaney and Huselid, 1996)

Four-point Likert-type scale ranging from much worse to much better.

Compared to other organizations that do the same kind of work, how would you compare the organization's performance over the past 3 years in terms of . . .

P1. Marketing?
P2. Growth in sales?
P3. Profitability?
P4. Market share?

$\alpha = 0.821$

Competitive advantage

Five-point Likert-type scale ranging from strongly disagree to strongly agree.

CA1. The manner in which my firm combines Resources and Capabilities enables it to reduce its costs to a highly competitive level.

a. Financial Resources and Capabilities
b. Physical Resources and Capabilities
c. Human Resources and Capabilities
d. Intellectual Resources and Capabilities
e. Organizational Resources and Capabilities

CA2. The manner in which my firm combines Resources and Capabilities enables it to fully exploit all targeted market opportunities.

a. Financial Resources and Capabilities
b. Physical Resources and Capabilities
c. Human Resources and Capabilities
d. Intellectual Resources and Capabilities
e. Organizational Resources and Capabilities

CA3. The manner in which my firm combines Resources and Capabilities enables it to defend against all known competitive threats.

a. Financial Resources and Capabilities
b. Physical Resources and Capabilities
c. Human Resources and Capabilities
d. Intellectual Resources and Capabilities
e. Organizational Resources and Capabilities

$\alpha = 0.737$, 0.691, 0.755, 0.717, and 0.690 for financial, human, intellectual, organizational, and physical resources/capabilities, respectively

Value

Five-point Likert-type scale ranging from strongly disagree to strongly agree.

V1. Given the Resources my firm possesses and has access to, if my firm possessed other Capabilities it could reduce its costs further.

a. Capabilities to exploit Financial Resources
b. Capabilities to exploit Human Resources

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c. Capabilities to exploit Intellectual Resources
d. Capabilities to exploit Organizational Resources
e. Capabilities to exploit Physical Resources

V2. Given my firm's Capabilities, if my firm possessed or had access to other Resources it could reduce its costs further.

a. Financial Resources
b. Human Resources
c. Intellectual Resources
d. Organizational Resources
e. Physical Resources

V3. Given the Resources my firm possesses and has access to, if my firm had access to other Capabilities it could better exploit targeted market opportunities.

a. Capabilities to exploit Financial Resources
b. Capabilities to exploit Human Resources
c. Capabilities to exploit Intellectual Resources
d. Capabilities to exploit Organizational Resources
e. Capabilities to exploit Physical Resources

V4. Given my firm's Capabilities, if my firm possessed or had access to other Resources it could better exploit targeted market opportunities.

a. Financial Resources
b. Human Resources
c. Intellectual Resources
d. Organizational Resources
e. Physical Resources

V5. Given the Resources my firm possesses and has access to, if my firm had access to other Capabilities it could better defend against known competitive threats.

a. Capabilities to exploit Financial Resources
b. Capabilities to exploit Human Resources
c. Capabilities to exploit Intellectual Resources
d. Capabilities to exploit Organizational Resources
e. Capabilities to exploit Physical Resources

V6. Given my firm's Capabilities, if my firm possessed or had access to other Resources it could better defend against known competitive threats.

a. Financial Resources
b. Human Resources
c. Intellectual Resources
d. Organizational Resources
e. Physical Resources

$\alpha = 0.812$, 0.784, 0.818, 0.833, and 0.812 for financial, human, intellectual, organizational, and physical resources/capabilities, respectively

Rareness

Five-point Likert-type scale ranging from strongly disagree to strongly agree.

R1. Compared to companies with similar Capabilities, my firm uses them to exploit very different Resources when attempting to reduce costs, exploit market opportunities, and/or defend against competitive threats.

a. Financial Resources
b. Human Resources
c. Intellectual Resources
d. Organizational Resources
e. Physical Resources

R2. Compared to companies that possess or have access to similar Resources, my firm exploits them with very different Capabilities when attempting to reduce costs, exploit market opportunities, and/or defend against competitive threats.

a. Capabilities to exploit Financial Resources
b. Capabilities to exploit Human Resources
c. Capabilities to exploit Intellectual Resources
d. Capabilities to exploit Organizational Resources
e. Capabilities to exploit Physical Resources

R3. Compared to my firm's competitors, my firm exploits very unique combinations of Resources and Capabilities when attempting to reduce costs, exploit market opportunities, and/or defend against competitive threats.

a. Financial Resources and Capabilities
b. Physical Resources and Capabilities
c. Human Resources and Capabilities
d. Intellectual Resources and Capabilities
e. Organizational Resources and Capabilities

$\alpha = 0.778$, 0.806, 0.848, 0.811, and 0.819 for financial, human, intellectual, organizational, and physical resources/capabilities, respectively

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Environmental hostility (Khandwalla, 1976)

Seven-point scale reflecting agreement with one of two opposing statements about the firm's environment.

EH1. Very safe, little threat to the survival and well-being of my firm—Very risky, a false step can mean my firm's undoing.

EH2. Rich in investments and marketing opportunities—Very stressful, exacting, hostile; very hard to keep afloat.

EH3. An environment that my firm can control and manipulate to its own advantage, such as a dominant firm has in an industry with little competition and few hindrances—A dominating environment in which my firm's initiatives count for very little against the tremendous competitive, political, or technological forces.

$\alpha = 0.622$

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