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Competencies and Imitability in the Pharmaceutical Industry: An Analysis of Their Relationship with Firm Performance

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Two research questions are addressed in this article. First, does technological competence enhance firm performance. Second, does competitor imitation of firm knowledge hurt performance. The relationships between technological competence, imitability and performance are basic premises in the resource-based view, yet there has been little empirical testing of them. Measures of technological competence and imitability are developed. These variables, together with measures of marketing and regulatory competence, are tested for their impact on firm performance in the pharmaceutical industry. Imitability has a negative and significant impact on accounting and market-based performance measures. Contrary to expectations, technological competence is inversely related to market-based performance measures and positively related to accounting measures. Research and managerial implications for the findings are discussed.

When it comes to core competencies, it is difficult to get off the train, walk to the next station, and then reboard.

–Prahalad and Hamel (1990: 85)

This quote from the article by Prahalad and Hamel succinctly allegorizes the relationship between organizational knowledge and core competencies. Core competencies are the embodiment of organizational knowledge, built up over time and not easily imitated (Leonard-Barton, 1995; Prahalad & Hamel, 1990) that yield a competitive advantage. Core competencies represent an accumulation of knowledge as organizations learn, actualize that learning in competencies, and deploy those competencies in their product–market

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strategies. Competencies are typically so embedded in an organization that to acquire a different "bundle" of competencies entails a significant investment in terms of resources, such as capital, people, and managerial vision—hence, the virtual impossibility of "boarding the next train."

This is particularly true with respect to firms whose competencies are technologically based, competing on the basis of a technological advantage as opposed to competing on the basis of marketing adeptness, distribution access or ownership of natural resources. Developing and sustaining technological competencies is important to continuous innovation in these firms. Many recent perspectives of firm behavior such as the resource-based view (Barney, 1991; Wernerfelt, 1984), dynamics capabilities (Teece, Pisano & Shuen, 1997) and knowledge-based view (Kogut & Zander, 1992) suggest that firm competencies are stocks of knowledge (De Carolis & Deeds, 1999; Dierickx & Cool, 1989; Lev & Sougiannis, 1999) accumulated over time, difficult for competitors to replicate, and are the source of competitive advantage (Barney, 1991; Dierickx & Cool, 1989; Reed & DeFillippi, 1990; Wernerfelt, 1984).

A related stream of literature proposes that core competencies can become core rigidities (Leonard-Barton, 1995). Core rigidities are the opposite of core competencies; they are strengths that evolve into weaknesses. A technological competence may become a liability if it prevents the firm from expanding outside a particular knowledge trajectory to sustain competitive advantage. Core rigidities prevent new competencies from being developed or from maintaining the right balance of competencies.

For core competencies to yield a competitive advantage, they must be inimitable—costly or difficult for competitors to imitate. Barney (2001) stresses that imitability is the most important concept to emerge from the resource-based view. Imitability explains competitive advantage in equilibrium and this is what is most new about the resource-based view. Barney (2001) further claims that the empirical assertions derived from this concept are ". . . likely to be among the most important to come out of resource-based theory" (Barney, 2001: 45). However, there has been little empirical research on the construct of imitability.

This article investigates two related research questions motivated by the resource-based view. First, do technological competencies make a difference in firm performance and, second, does competitor imitation of technological competencies hurt a given firm's performance. A firm's performance, even in technologically intensive industries, does not rely solely on technological expertise. Competencies in areas such as marketing, general management, human resource management, and dealing effectively with external stakeholders and government entities may be critical to competitive advantage (Prahalad & Hamel, 1990).

To address these questions, hypotheses are developed, based on the resource-based view of the firm, about the relationship between competencies, imitability and performance and tested in the pharmaceutical industry.

This article makes several contributions to the growing literature on competencies and the resource-based view of the firm. First, addressing a gap in previous studies, this article investigates the impact of three different types of competencies on firm performance. This extension of previous empirical work was recently suggested by Lev and Sougiannis (1999) who call for examination of the performance implications of various assets such as marketing related competencies. Second, this paper develops a measure of technological competence that captures building on prior knowledge. This adds to the growing literature

on measuring stocks of knowledge (see for example Cockburn & Griliches, 1988; Hall, Jaffe & Trajtenberg, 2000; Lev & Sougiannis, 1999). Third, although the concept of imitability is central to the resource-based perspective, again, a review of the empirical literature in this area reveals that this construct has not been operationalized nor has its relationship with firm performance been assessed. Fourth, I empirically examine the impact of competencies on accounting and market-based measures of firm performance, again addressing a gap in the resource-based literature. Finally, the empirical analysis is based on longitudinal data and this type of dynamic research wherein the conditions under which competencies are developed under one period have implications for subsequent periods is appropriate for examining resource-based theory (Barney, 2001).

The article begins with a brief exposition of the role of competencies and imitability in the context of the pharmaceutical industry. This is followed by the development of the model and hypothesis. The following sections describe the methodology, the data, and the construction of the variables. The paper then turns to a description of the results and closes with a discussion of their strategic implications for managers and suggestions for future research.

Competencies and Competitive Advantage

The term "competence" as used in the management literature generally conveys the notion that a firm possesses a degree of expertise and excellence in one or more particular areas compared to its competitors that results in a competitive advantage. In the numerous articles on competencies that have appeared in the past 20 years or so, the particular nomenclature for the "resources that yield competitive advantage" has varied greatly. Probably the term used most frequently is "core competence," popularized by Prahalad and Hamel (1990). A review of the literature reveals that several concepts have emerged in lieu of or in addition to the term core competence or competence. The most commonly used terms are: resources, strategic assets, competencies, core competencies, capabilities, and core capabilities. Table 1 outlines these terms and the various authors that have used them.

This table reveals that early definitions of competence were somewhat general in nature. The term has evolved into a richer concept that explains "how" firms do things better. The table also illustrates how some of the same terms are used to describe different ideas. I use the term competence as distinct from capabilities, concurring with the differences noted by Henderson and Cockburn (1994) and Leonard-Barton (1992). In this article the term competence is used to denote the local abilities, knowledge and skills and technical systems of a firm that may yield a competitive advantage.

A review of the empirical studies in the competence literature reveal two gaps in the literature that are addressed in this article. First, competence is measured in various ways by different researchers. Competence has been operationalized by survey instruments of excellence in functional areas (Hitt & Ireland, 1985; Hitt, Ireland & Palia, 1982; Hitt, Ireland & Stadter, 1982; Snow & Hrebiniak, 1980); by using financial measures of intensity such as the ratio of research and development to sales, advertising to sales and administrative intensity (Chatterjee & Wernerfelt, 1991; Harrison, Hitt, Hoskisson & Ireland, 1991); by relatedness among business units (Markides & Williamson, 1996; Robins & Wiersema, 1995);

Table 1
Overview of definitions relating to competencies in the management literature

Author(s)	Resources	Strategic assets	Competencies	Core competences	Capabilities	Core capabilities
Selznick (1957)			[Distinctive] those things that an organization does well in comparison to competitors			
Andrews (1971)			[Distinctive] the set of things an organization does especially well in comparison to its competitors			
Snow and Hrebiniak (1980)			[Distinctive] "... an aggregate of numerous specific activities that the organization tends to perform better than other organizations ... " (p. 317)			
Wernerfelt (1984)	"... anything which could be thought of as a strength or weakness of the firm." (p. 172)					
Dierickx and Cool (1989)		"Critical or strategic asset stocks are those assets which are nontradeable ... nonimitable and nonsubstitutable." (p. 1507)				
Prahalad and Hamel (1990)				"... the collective learning in the organization ... how to coordinate diverse production skills & integrate multiple streams of technology." (p. 82)		
Barney (1991)	"... all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by the firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness." (p. 101)					
Grant (1991)	"... inputs into the production process ... on their own, few resources are productive." (p. 119)				"... the capacity for a team of resources to perform some task or activity ... the main source of [a firm's] competitive advantage." (p. 119)	

Leonard-Barton (1992)						"... the knowledge set that distinguishes and provides a competitive advantage ... embodied in (1) knowledge & skills (2) technical systems (3) managerial systems (4) values"
Amit and Schoemaker (1993)	"... stocks of available factors that are owned or controlled by the firm." (p. 35)	"... the set of difficult to trade and imitate, scarce, appropriable and specialized resources and capabilities that bestow the firm's competitive advantage." (p. 36)			"... a firm's capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end." (p. 35)	
Henderson and Cockburn (1994)			"... component competence or the local abilities and knowledge that are fundamental to day-to-day problem solving ..." (p. 65)			
Henderson and Cockburn (1994)			"... architectural competence or the ability to use these component competencies ..." (p. 65)			
Teece et al. (1997)	"... the firm specific assets that are difficult if not impossible to imitate." (p. 516)		[Organizational routines/competencies] "When firm specific assets are assemble in integrated clusters spanning individuals and groups so that they enable distinctive abilities to be performed ... constitute organizational routines ..." (p. 516)	"... define a firm's fundamental business as core ... derived by looking across the range of a firm's (and its competitors) products and services." (p. 516)		Dynamic capabilities—"the firm's ability to integrate, build & reconfigure internal & external competencies to address rapidly changing environments ..." (p. 516)
Barney (2001)	"... resources are the tangible & intangible assets a firm uses to choose & implement its strategies." (p. 54)					

and by property based vs. knowledge-based resources (Miller & Shamsie, 1996). However, few studies (Henderson & Cockburn, 1994) specifically measure technological competence as building on a firm's stock of knowledge.

Second, relatively few studies have actually tested the relationship between different competencies and financial performance. This is due in large part to definitional and operational issues. There exist many definitions of competence representing different levels of analysis. Moreover, it is difficult to measure competencies on an aggregate level. Some scholars have used the case study approach to document the link between competencies and competitive advantage (Collis, 1991; Leonard-Barton, 1992). Henderson and Cockburn (1994) studied the relationship among competencies and *research productivity*. Chatterjee and Wernerfelt (1991) examined the link between resource profiles and *diversification types*. Thus, there appears a gap in the literature on actually measuring the direct impact of specific competencies such as technological, regulatory and marketing on firm performance. One of the purposes of this investigation is to fill that gap and empirically investigate the impact of specific competencies on firm performance.

Competencies and Imitability in the Pharmaceutical Industry

The context of the pharmaceutical industry provides an appropriate domain for this study since it is a technologically dynamic industry. Discovery of new drugs and their successful commercialization drive performance. Three types of competencies are valuable in this industry: technological, marketing and regulatory (Bogner & Thomas, 1994). The value of a firm's resources is determined by the context of the specific market in which it is operating. This makes the value component of the resource-based view exogenously determined (Barney, 2001; Priem & Butler, 2001). Technological, marketing and regulatory competencies are *valuable* in the context of the pharmaceutical industry (Bogner & Thomas, 1994; Cool & Schendel, 1988; Henderson & Cockburn, 1994, 1988; Hill & Hansen, 1991; Thomas, 1990).

Technological competencies in pharmaceuticals are a function of expertise in scientific discipline and therapeutic area. The traditional scientific knowledge base for pharmaceutical companies has been organic chemistry and pharmacology. However, biotechnology is affecting the technology of drug research and the capabilities of established pharmaceutical companies since its knowledge bases are found in genetics, molecular biology and protein chemistry (Pisano, 1997).

Research skills in pharmaceuticals are interpreted relative to the various therapeutic classes of drugs that exist (Bogner & Thomas, 1994). Pharmaceutical firms have generally pursued capabilities in particular therapeutic areas so as to become experts in certain fields. One of the factors contributing to this drive for competence in specific areas is that the preponderance of relatively "easy" pharmacological discoveries has already been made (Economist, 1997; Langreth, 1995; Tanouye & Langreth, 1997). It is becoming more difficult for pharmaceutical companies to find entirely new drugs. During the 1960s and 1970s there were many breakthrough medicines to treat heart disease, depression, arthritis and other diseases. New Drug Applications to the Food and Drug Administration (FDA) peaked in 1983 to 270 from 120 in 1978. Subsequently, new discoveries became harder to find

as evidenced by the decline in New Drug Applications—86 in 1993 (Economist, 1997; Langreth, 1995; Tanouye & Langreth, 1997).

On the other hand, pursing new products in one therapeutic area can enhance learning in *other* areas. Allen, Lee and Tushman (1980) and Katz (1988) suggest that in technology-driven environments intra-organizational learning enhances research performance. Henderson and Cockburn (1994) also find that a flow of information across the boundaries of the firm is related to research productivity. Moreover, a strategy of strictly pursing certain therapeutic classes could be too limiting and most firms look into other therapeutic areas to develop competencies and broader pipelines or portfolios of potential drugs.

The durability of a firm's competitive advantage is partly a function of how successfully other firms are able to imitate the focal firm's technological competence. Unsuccessful imitation does not erode the focal firm's competitive advantage. However, when a firm's technological competencies are being imitated, then competitive advantage will not last long. This is certainly true in many industries and perhaps is even more critical in the pharmaceutical industry. Research and development costs in this industry are somewhere between US$400 and US$500 million dollars and it takes approximately 10 years to bring a drug to market (MedAd News, 1999). Pharmaceutical companies patent a new chemical entity at the time of discovery affording them some protection. By the time the development process is completed and FDA approval is achieved, a significant portion of the patent protection is gone. This has important implications for innovation in this industry. Once a patent is granted, the knowledge contained in that patent is public. This reinforces the fact that learning must be ongoing, as imitation will eventually erode firm specific innovation. Therefore, new learning even in the same areas is critical for survival.

Effectively dealing with the FDA is another valuable resource. The approval process for new drugs is costly and lengthy. The final submission of the New Drug Application (NDA) averages about 50,000 pages. The review process can take anywhere from several months to several years. (There is an exception in the case of "high priority drugs" such as cancer or AIDS treatments that are usually approved/disapproved within 12 or so months.)

Finally, pharmaceutical companies need to effectively market their new products. The success of some drugs, particularly those in the same category such as high blood pressure drugs, depends on how well a company can differentiate that drug particularly to physicians. The market share and revenues of a particular drug depend in large part on a strong and educated marketing and sales team. Thus, the context of pharmaceuticals provides a rich arena in which to examine the effect of technological, marketing and regulatory competencies on firm performance.

Theoretical Model and Hypotheses

Technological Competence and Firm Performance

The premise that unique firm capabilities are critical to firm performance has been addressed in many streams of literature: resource-based models of firm behavior (Barney, 1991; Wernerfelt, 1984) organizational learning theories (Cohen & Levinthal, 1990; Fiol & Lyles, 1985); knowledge-based perspectives of the firm; (Kogut & Zander, 1992) evolutionary

economics (Nelson & Winter, 1982) and the dynamic capabilities perspective (Teece et al., 1997).

A natural trajectory of knowledge is embedded in a firm's competencies. Knowledge has been defined as the creation and organization of information, based on the commitments and beliefs of its holder (Nonaka, 1994). This explanation of knowledge is consistent with the notion that firms operate within certain technological paradigms (Dosi, 1982). Most innovations are not radical or discontinuous in the sense that they make obsolete existing organizational capabilities (Tushman & Anderson, 1986). Radical innovations are based on new science and create new markets. Most innovations are incremental in nature, building on already existing firm knowledge. Incremental innovations involve the adaptation, refinement and enhancement of existing products, services and/or production processes. Firms typically compete with incremental innovations and will increase their learning and knowledge in that particular technological dominant design.

Technological competencies consist of knowledge and skills embedded in people and knowledge embedded in technical systems (Leonard-Barton, 1995). Technical systems are the manifestations of years of accumulating, codifying and structuring the tacit knowledge embodied in people. These competencies can become institutionalized. That is, they are part of organizational assumptions that guide strategic decision-making. Technology embedded in technical systems and people skills typically can be traced back to the firm's first products or services. Dominant logic (Bettis & Prahalad, 1986) refers to the general management mindset that pervades the firm by producing a world-view governing decision-making processes and strategies. This dominant logic is also applicable to organizational knowledge as defined above.

In the pharmaceutical industry, firms usually develop an expertise in both scientific and therapeutic areas. Advances and learning in both areas are critical in new drug discovery and development (Henderson & Cockburn, 1994). Specialized learning over time reinforces the competencies and patterns of interactions that bear successful solutions.

Firms may learn and develop technological competencies in many ways. As firms work in a particular technological regime, they innovate in the sense that knowledge is combined to create improvements in a product or incorporate new functions into a product. These incremental improvements may duplicate a competence or re-combine internal knowledge or incorporate either new internally developed knowledge or newly acquired external knowledge into the existing product. A firm's absorptive capacity, the learning that occurs through absorption of external knowledge (Cohen & Levinthal, 1990) is a critical concept in understanding competence building. Firms may acquire external knowledge and apply this knowledge to their own understanding. Cohen and Levinthal (1990) also emphasize that firms absorb and incorporate new knowledge that is related to their existing knowledge bases. The re-combining of internal capabilities to produce new knowledge is a central focus in the knowledge-based theory of the firm (Kogut & Zander, 1992).

The creation of technological competencies is theoretically linked to competitive advantage (Barney, 2001; Prahalad & Hamel, 1990; Leonard-Barton, 1995). In particular, many studies address the importance of unique technological competencies to be strategically significant in science and technology-driven industries (Dierickx & Cool, 1989; Henderson & Cockburn, 1994).

There does exist a downside to building on firm knowledge, what Leonard-Barton (1992) calls "core rigidities." Core rigidities may result from the institutionalization of knowledge and routines so that new concepts and technologies are not taken seriously. Firms see only their competencies as being valuable and do not consider alternative innovations as having commercialization possibility. Yet, accumulated firm knowledge is the prime ingredient in technological competence as firms operate in particular technological paradigms. The manifestation of technological competencies is the ability of firms to become "experts" in what they do through the enhancement over time of organizational knowledge. The building of stocks of knowledge leads to the development of competencies.

Hypothesis 1: There will be a positive relationship between technological competence and firm performance.

Imitability and Firm Performance

Imitability refers to the extent to which rivals can imitate a competence. The construct of imitability has received the most theoretical attention by scholars (Dierickx & Cool, 1989; Reed & DeFillippi, 1990) and the empirical assertions derived from this concept (Barney, 2001) are likely to be among the most important emanating from the resource-based view. This is due to its theoretical relationship with sustained competitive advantage. Of course, competitive advantage can be sustained in many ways and under different conditions (Reed & DeFillippi, 1990). Such a theoretical and empirical undertaking is beyond the scope of this paper. Yet, the discussion of the role of imitability in competitive advantage is well delineated in the literature and, as such, is central to the discussion of competitive advantage.

A firm's technological competencies may be inimitable (Barney, 1991; Prahalad & Hamel, 1990; Wernerfelt, 1984) and may be disseminated in a variety of ways. Levin et al. (1984) identified several methods of spillover: patent disclosures, publications, technical meetings, conversations between employees of competing firms, hiring of employees from rival firms, and reverse engineering of products. With respect to patents, there are numerous articles that support the notion that the value of the knowledge contained in patents does spill over to other firms who cite those patents. The theoretical and empirical literature in the innovation area suggests that patent citations are in fact a form of knowledge spillover (Trajtenberg, 1990). This literature also suggests that highly cited patents are the most innovative as other firms are vying to imitate their ideas (Carpenter & Narin, 1983; Narin, Rose & Olivastro, 1989; Trajtenberg, 1990).

However, there is little literature on the effect of this imitation on the "cited" firm. In other words, if the originator of a valuable innovation is being imitated (in the case of patents, "cited"), then there should be a detrimental effect on the firm's competitive advantage. Rival firms are appropriating their knowledge and their commercial success from that knowledge.

In the pharmaceutical industry, knowledge spillovers may be beneficial to research productivity. Henderson and Cockburn (1996) suggest that knowledge spillovers produce a positive effect on research productivity if the knowledge is complementary. However, when rival research efforts are substitutes, there would be a negative effect on research produc-

tivity. Moreover, even though pharmaceutical companies can license their patents to other firms, they receive no income when other firms cite their patents in subsequent patents.

Appropriability—the ability of a firm to capture the profits generated by an innovation—is influenced by legal mechanisms such as patents, copyrights and trade secrets and also by the nature of the underlying technology, that is, the extent to which knowledge is tacit or codified (Teece, 1986). If an innovation is easily imitated, then a firm may not be able to appropriate the returns from that innovation. A weak appropriability regime (Teece, 1986) lessens the chances that an innovator will profit from an innovation.

In pharmaceuticals the long lead-time between the patenting of a new molecular entity and its final commercialization can result in patent expiration before the commercialization (Pisano, 1997). Moreover, this lead-time may be even shorter in that once a patent is issued, the information becomes public knowledge. Rival firms have the opportunity to circumvent issued patents and imitate the knowledge generated in those innovations. Thus, it should be true that if a firm's knowledge is imitated, its performance will diminish.

Hypothesis 2: Imitability of firm knowledge has an inverse relationship with firm performance.

Marketing Competencies and Firm Performance

As mentioned above, firms may possess several types of competencies. Conceptually, a marketing competence refers to a firm's ability to develop and maintain relationships with customers, the ability to use market intelligence about external factors that might influence current and future customer needs and also the quality of channel relationships (Mooreman & Slotegraaf, 1999). Marketing competencies are proposed to be just as important to firm performance (Cool & Schendel, 1987). Current marketing literature, based on resource-based theory, suggests that a firm's marketing competency will have a direct influence on performance (Day, 1994; Hunt & Morgan, 1995; Mooreman & Slotegraaf, 1999).

In the pharmaceutical industry, the deployment of strong marketing capabilities impacts the success of new drugs. Pharmaceutical companies rely on highly trained sales forces to represent their products to doctors, health care systems and managed care networks. Pharmaceutical representatives are intensely trained so as to be knowledgeable about the drugs being promoted to their various customers. Pharmaceutical companies track the prescribing habits of individual physicians through pharmacies to obtain data on which physicians are prescribing particular drugs. A strong marketing competence can make a tremendous difference in market share for drugs of the same type. Several studies have empirically linked the positive effects of advertising on firm performance (Chauvin & Hirschey, 1993; Jose, Nichols & Stevens, 1986; Lustgarten & Thomadkis, 1987; Morck, Shleifer & Vishny, 1988). In the management literature, the importance of resources such as marketing and innovative skills is closely linked to firm performance (Bettis, 1981; Chatterjee & Wernerfelt, 1991).

Hypothesis 3: Marketing competencies have a positive relationship with firm performance.

Regulatory Competencies and Firm Performance

Barney (1986) suggests that assets required to implement a strategy might be bought and sold in factor markets. As Dierickx and Cool (1989) point out, however, this is not true of all assets. Consider for example, the instance of corporate reputation, dealer loyalty or the ability to deal proficiently with governmental agencies. Dierickx and Cool (1989) suggest that assets such as these are nonappropriable. Their nonappropriability derives from many sources such as the absence of defined property rights, loyalty or trust. These assets are built or accumulated over time. Firms will engage in a consistent pattern of activities over long periods of time to accumulate such competencies.

As mentioned previously, throughout the drug development process, a pharmaceutical company must maintain constant communication with the FDA, which has oversight authority over the clinical trials, final approval and manufacturing of any drugs. Pharmaceutical companies are required to file an Investigational New Drug (IND) Application with the FDA that must be approved prior to the commencement of clinical trials. They also need to prepare and file a (NDA) with the FDA for final approval to manufacture and market a new drug. Pharmaceutical companies have entire staffs devoted to dealing with the FDA. Developing an expertise in the preparation and completion of the required documentation for the drug approval process and establishing a relationship with the FDA, is critical to product commercialization in the pharmaceutical industry (Cool & Schendel, 1988).

These relationships and expertise in communicating with the FDA are attributable to the accumulation of expertise in this area, to time compression diseconomies (Dierickx & Cool, 1989), to tacit knowledge, to complexity and to asset specificity (Reed & DeFillippi, 1990). There exists a tremendous human component in maintaining a successful relationship with an external agency. It involves a degree of tacitness, that is, development by experience and practice that is hard to codify. It is characterized by complexity—consisting of large numbers of organizational routines and individual or team based experiences. A regulatory competence is necessary to maintain harmonious relationships with governmental agencies (Hitt & Ireland, 1985). Thus, in addition to technological knowledge and marketing competencies, a proficiency in documentation and filing for the FDA and a working relationship with this agency is an important competency in the pharmaceutical industry.

Hypothesis 4: Regulatory competencies have a positive relationship with firm performance.

Measuring Technological Competence and Imitability

Technological competence involves building a *stock* of knowledge. Most of the previous research that has attempted to measure technological competence has been case study or anecdotal evidence (Bogner & Thomas, 1994; Collis, 1991; Grant, 1991; Leonard-Barton, 1992; Prahalad & Hamel, 1990). New measures of technological competence and imitability are advanced using a variation of patent citation analysis. Before the actual measure used is described, the general technique of patent citation analysis is explained.

Patent citations are references delineated on the front page of every patent that refer to prior patents. Every new patent relies on knowledge developed in past patents, much in the same way that advances in management literature cites previous research. When firms develop new inventions and patent these inventions, they will cite prior "state of the art." The front page of a patent contains demographic information as well as a section titled "References Cited." In this section, prior patents that provided the knowledge relied on for the current patent are listed. Citation analysis involves the selection of certain patents and then scrutinizing subsequent patents to assess how many times they are cited.

Patent citations are worthy indicators of technological competence for two reasons. First, they are objective. Patent citations are not quoted at the whim of the inventor. The patent examiner, together with the inventor and the inventor's attorney, arrive at a final list of citations for every patent and this list limits the scope of property rights of the patent owner and is protected by law. Thus, there is an incentive for all parties to cite the relevant state of the art (Campbell & Nieves, 1979; Trajtenberg, 1990).

Second, patent citations are indicators of valuable technological knowledge. A patent that is highly cited is one that is regarded as having greater than average impact. Clearly, patent citation analysis is an improvement over simple patent counts that do not capture the quality of a patent. Other studies (Carpenter & Narin, 1983; Narin et al., 1989; Trajtenberg, 1990) empirically establish the validity of patent citation analysis as indicators of technological competence. In a recent study, Hall et al. (2000) find that citation weighted patent stocks are more highly correlated with market value than stocks of patents themselves.

Self-citation Analysis

Earlier works have measured stocks of knowledge and have operationalized the stock of knowledge with patent data (De Carolis & Deeds, 1999; Henderson & Cockburn, 1994, 1996). Patents are one manifestation of firm knowledge. The learning that occurs to produce the innovation contained in the patent—whether that learning be acquired through combining existing internal knowledge or combining existing internal knowledge with new internal knowledge—is represented on that patent. Patents embody stocks of accumulated knowledge—not just from 1 or 2 years but also from many years.

Extending these prior empirical applications, this study suggests that a firm's ability to build on its knowledge is manifested by the frequency with which it cites its own inventive activities on its issued patents. In the present study, this is measured using a variation of patent citation analysis that is identified as "self-citation analysis." That is, a firm's references to its prior patents on its subsequent patents are representative of building knowledge stocks. This approach is analogous to bibliographic author counts that are indicators of how frequently researchers in the natural and social sciences are quoted. Researchers who cite their past work, build knowledge within particular areas and become experts in those areas. This same reasoning is applied to patent references. Thus, the method used in this study to represent a firm's stock of knowledge is patent self-citation analysis. Similarly, imitability may be measured by assessing how frequently other companies cite a particular firm's knowledge, again obtained from patent data. It is expected that the value of a firm's knowledge is diluted as more and more companies try to mimic that knowledge.

Methodology

In addition to the reasons discussed above for choosing the pharmaceutical industry as the domain of this study, testing the model is tested in a single industry over multiple points in time rather than in multiple industries controls for industry effects. Patent data was obtained from Computer Horizons Inc. (CHI) and the sample consists of 14 pharmaceutical companies that represent major global firms, were in the top 40 of annual US pharmaceutical sales in at least one of the sampled years and have been used extensively in previous research. These companies are: Abbott Labs, American Home Products, Bristol Myers Squibb, Eli Lilly, Glaxo, Johnson and Johnson, Merck, Monsanto, Pfizer, Schering-Plough, Smith Kline Beecham, Syntex, Upjohn and Warner Lambert.

Measures

Descriptions of the measures used for the independent and dependent variables are given below. Measures for technological competence and imitability, are derived from a patent database developed by CHI. The database obtained by this author included selected information on patents and patent citations for each of the pharmaceutical companies for the years 1985–1991.

Technological competence (Techcomp). This variable is calculated as follows: Company A had issued "*N*" number of patents during a given year. Within 2 years of their issue date, "*M*" patents had cited these "*N*" patents. Of these "*M*" citations, "*X*" patents belonged to Company A—self-citing. The ratio of *X/N* is the measure used for *technological competence*.

Imitability (Imitability). Similar to the self-cite measure, this was calculated as follows: Company A had issued "*N*" number of patents during a given year. Within 2 years of their issue date, "*M*" patents had cited these "*N*" patents. Of these "*M*" citations, "*Y*" patents were by other companies. The ratio of *Y/N* is the measure used for *Imitability*.

Marketing competence (Ad/Sales). Relative advertising expenditures is used measured as the total advertising expenditures divided by total sales for a given year. This information was obtained from Compustat. Previous studies have utilized levels of spending intensity as proxies for marketing skills (Bettis, 1981; Chatterjee & Wernerfelt, 1991; Lecraw, 1984).

Regulatory competency (Approval). This construct is operationalized as the number of new drugs per year per firm. Pharmaceutical companies may develop a reputation for dealing effectively with the FDA. This expertise should be reflected in the amount of new drug approvals per year. New drugs categorized as Type A drugs or high priority drugs were used as the basis for this measure. Type A drugs as defined by the FDA Pink Sheets, represent totally new chemical entities; thus they embody the culmination of the firm's developing knowledge.

Research and development expenditures (RD/Sales). Research and development expenditures have been used as a proxy for innovation, competence or technological strength

(Hill & Snell, 1988; Jensen, 1987). The assumption is that more funds committed to R&D the more chances a firm has to be innovative. An alternative view (Grabowski & Vernon, 1990; Graves & Langowitz, 1993; McClean & Round, 1978; Scherer, 1965) suggests that increased R&D expenditures in fact lead to a decline in innovation. Given the inconsistent results of prior research on the effects of research and development on firm performance (Henderson & Cockburn, 1996) it is included as a control variable here. It is measured as the ratio of research and development expenditures to total sales and data was obtained from Compustat.

Size (Assets). The size of the pharmaceutical company measured as total assets is included as a control variable. All data was obtained from Compustat.

Total number of patents (Patents). This variable, measured, as the total number of patents granted to a pharmaceutical company per year, is included as a control variable. Single patent counts have correlated with innovativeness in prior empirical studies.

Firm age (Age). Sorensen and Stuart (2000) found that age had implications for innovative activities for firms. Specifically, they found that the tendency of a firm to cite their own patents increases with firm age. In this study, confined to one industry, most of the firms will be of relatively similar age. However, firm age is included as a control variable here, acknowledging the effect found by Sorensen and Stuart (2000).

Performance (ROA & MKBK). Performance is measured using return on assets (*ROA*) and market to book value (*MB*). There are several reasons for using both measures. First, profitability measures are frequently used in the strategy literature. Previous research in the resource-based view has also empirically examined profitability measures as a function of competencies (Bierly & Chakrabarati, 1996; Harrison et al., 1991; Markides & Williamson, 1994, 1996).

This investigation is also part of the patents-performance literature that spans the disciplines of strategy, economics and finance. Within these streams, many studies have explored the relationship between innovation and market value using patent data (Deng, Lev & Narin, 1999; Hausman, Hall & Griliches, 1984; Hall, 1998; Hall et al., 2000). In the tradition of these literatures, market to book value is also used a performance measure. Market to book values captures the market valuation of a firm's total assets, both tangible and intangible, relative to an accounting valuation—the book value of assets. Market to book captures future economic returns whereas return on assets captures current returns (Mueller, 1990). Compustat is the source for both performance measures.

Analysis

Since the data covers 7 years, this study employs a time-series cross sectional regression analysis. The particular technique used is TSCS REG found in SAS. The model under investigation consists of observations of the same units several times and the observations may not be statistically independent. The biases associated with this specification are serial and contemporaneous correlation of the residuals and heteroskedasticity. The modified GLS

estimation technique by Parks (1967) takes into account three sources of bias under these assumptions. The first is serial correlation which assumes that the error terms within cross sections are more highly correlated in years 1 and 2 than in years 1 and 7. The second bias is heteroskedasticity that occurs when the residuals do not have a common variance. The third is contemporaneous correlation. The Parks method corrects for all of these biases. This particular type of time-series cross sectional analysis has been performed in other management studies (Mizruchi & Stearns, 1988; Stearns & Mizruchi, 1993).

The analysis is performed using models with no lag between the independent and dependent variables and with a 1-year lag to account for any lagged effects of specific competencies and imitation activity on firm performance. Conceptually, the independent variables represent a firm's stock of competencies and similarly, the variable imitability is capturing the cumulative imitation of technological competence. On the other hand, there may also be lagged effects so that accumulated competencies affect performance in future periods. Other studies in this area have shown lagged effects (Deng et al., 1999; Hausman et al., 1984).

Results

Concerning the patent citation analysis, Table 2 shows the breakdown of the citations into within sample and outside of the sample. The sample includes a total of 4198 patents. One thousand six hundred and eight of those patents are self-cites within the group. Two thousand two hundred and fifty-three are cites from outside the sample. The average patent activity for the sample is 97 patents.

Descriptive statistics and the correlation analysis are presented in Table 3. *Techncomp* and *Imitability* were standardized. A *t*-test was performed to check for differences of the means between technological competence and imitability. The test was significant at the .001 level. It should be noted that citations begin to decline during the last year because in some cases, citations are made to these patents after 1991. This should be kept in mind when interpreting the regression results (Hall, 1998).

The results of the correlation analysis show no problems of multicollinearity among the independent variables. As would be expected there is a significant positive correlation between Assets and Patents suggesting that larger firms engage in more patenting activity. The positive and significant correlation between Age and Assets further implies that older firms are larger in size. Patents are negatively correlated with RD/Sales, suggesting that more research and development dollars do not necessarily result in increased patenting

Table 2
Breakdown of patent citations

	Self-cites	Cites from others	Total
Within sample	1608	337	1945
Outside sample	0	2253	2253
	1608	2590	4198

Table 3
Descriptive statistic and correlation analysis

Variable	*N*	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1. ROA	98	13.634	5.76	1.000									
2. MKBK	98	5.399	3.41	.421***	1.000								
3. Techcomp	98	.000002	.95	.075	−.128	1.000							
4. Imitability	98	−.000001	.97	−.092*	−.218*	.245	1.000						
5. Ad/Sales	98	.069	.06	−.130	−.013	.316**	−.006	1.000					
6. Approval	98	.847	.91	.200	.118	−.171	−.069	−.020	1.000				
7. RD/Sales	98	.096	.03	.200	.150	−.140	−.120	−.363***	.029	1.000			
8. Assets	98	5219.000	2418.00	−.101	.037‘	−.208	−.115	−.343***	.192	−.230	1.000		
9. Patents	98	100.286	50.07	−.117	.007	−.056	−.012	.167	.260*	.414***	.596***	1.00	
10. Age	98	96.571	30.07	−.097	.095	−.072	−.053	−.375***	.025	−.131	.436***	.137	1.00

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 4
Return on asset and market to book regression results

Variable	Model 1 (ROA—no lag)	Model 2 (ROA—lag)	Model 3 (MKBK—no lag)	Model 4 (MKBK—lag)
Techcomp	.685*** (.090)	.470** (.183)	−.089 (.198)	−.510*** (.076)
Imitability	−.519*** (.1655)	−.330*** (.094)	−.395*** (.089)	−.551*** (.097)
AD/Sales	−10.760 (13.38)	−16.580 (11.68)	5.960* (3.37)	19.370*** (5.23)
Approval	.050 (.09)	.560 (.036)***	.139** (.056)	.024** (.093)
RD/Sales	33.160** (13.61)	27.470* (14.26)	37.820*** (6.03)	17.440 (10.584)
Assets	.000** (.000)	.000*** (.000)	.000*** (.000)	.000*** (.000)
Patents	.001 (.0044)	−.004 (.004)	.011** (.004)	−.010*** (.005)
Age	.012	−.073*** (.014)	−.018 (.030)	.021 (.023)

* $p < .05$.
** $p < .01$.
*** $p < .001$.

activity. Ad/Sales has a negative relationship with age, assets and RD/Sales. This implies that older and larger firms spend less on advertising and sales. The inverse relationship among AD/Sales and RD/Sales suggests that firms that spend more on research and development spend less on advertising.

Table 4 shows the regression results for four models. Using ROA as the dependent variable, there are consistent results across both models for *Techcomp* and *Imitability*. Supporting Hypothesis 1, *Techcomp* is positive and significant. *Imitability* is negative and significant supporting Hypothesis 2. Hypothesis 3 is not supported as *Ad/Sales* is not significant. Hypothesis 4 is supported in the lagged model as *Approval* is positive and significant. Of the control variables, *Assets* and *RD/Sales* are positive and significant in Models 1 and 2. *Age* is negative and significant in the lagged model.

Models 3 and 4 show the regression results with *MKBK* as the dependent variable. Contrary to Models 1 and 2, there are different results, particularly with *Techcomp*. In Model 3, there is no relationship between *Techcomp* and *MKBK*. However, in Model 4, there is a negative and significant relationship between *Techcomp* and *MKBK* suggesting that building on firm specific knowledge adversely affects future cash flows. In support of Hypothesis 2 and consistent with the results found in Models 1 and 2, *Imitability* is negative and significant with *MKBK*. *AD/Sales* is positive and significant in both models supporting Hypothesis 3. Hypothesis 4 is also supported as *Approval* is positive and significant. With respect to the control variables, Assets is positive and significant in both Models 3 and 4. *RD/Sales* is directly and significantly related to *MKBK* only in Model 3. Finally, *Patents* is positive and significant in both Models 3 and 4 skills in terms of preventing knowledge appropriation.

Discussion

Despite the theoretical support for a relationship among technological competence and performance, the empirical results in this study are conflicting. Technological competence has a positive impact on return on assets and a negative effect on market to book value in the lagged model. Return on assets is a return on investment measure. These results suggest

that in the short term, building on prior stocks of knowledge may be a superior strategy. However, future cash flows, as evidenced by market to book value, do not benefit from a strategy of building on firm knowledge stocks.

What accounts for this unpredicted finding? Building on firm specific knowledge could indicate the development of core rigidities (Leonard-Barton, 1995) and the market sees this as a shortcoming. The implication is that relying on the same competencies (as well as the self-citations demanded by such reliance) rather than developing new competencies is damaging to firm performance. This could lead to ignoring external developments that may be crucial to future competitive advantage, particularly in environments characterized by rapid scientific and technological advances. These results not only highlight the controversy over appropriate performance measures in the strategy literature but also speak to the challenges facing managers when making strategic decisions. Building on firm specific knowledge may be profitable in the short term but the market views does not view this strategy as the route to competitive advantage. Reliance on the same competencies will not carry the day in the future, as is evidenced by the inverse relationship between technological competence and market to book value. This may also be seen as "active inertia"—that is, the tendency of firm's to persist in a current trajectory and continue established behavior patterns (Sull, 1999). Sull (1999) suggests that companies become stuck in modes of thinking and working that initially brought them success. When the environment changes, firms may be unable or incapable of adapting.

The predicted negative relationship between imitability and firm performance was supported in all models. This is quite a significant result given the magnitude of the imitability concept in the resource-based view. These findings provide strong evidence that a firm's competitive advantage can be diluted quickly as other firms draw from its technological knowledge.

Marketing competence is positively and significantly related to market to book value but not to return on assets. This implies that the development of marketing competencies is a necessary expense that does not immediately contribute to accounting returns but may in fact contribute to the future value of the firm. Regulatory competence is positive and significant in all but one of the regression models affirming the importance of cultivating effective relationships with governmental bodies. In the pharmaceutical industry, a regulatory competence is a valued asset that is developed over time and contributes to firm performance.

The total number of patents is positive and significant only in the market to book regression models. This finding is consistent with recent prior literature (Deng et al., 1999; Hall, 1998) on the relationship between patenting activity and market value.

The field of organizational ecology has addressed the repercussions of aging on organizational innovation, but there is no consensus in that literature as to whether these repercussions are positive or negative in terms of firm performance (Sorensen & Stuart, 2000). This analysis seems to suggest that the market is agnostic as to the age of the firm. Age is negative and significant with ROA, implying that as firms get older, their return on their current investment shrinks.

Finally, research and development intensity is directly related to performance in all but Model 4. As mentioned earlier, prior theoretical and empirical literature is inconsistent about the impact of research investment on organizational performance. To some extent, these results exhibit that same inconsistency.

Overall, these findings seem to suggest that competencies are better predictors of market measures of performance. This seems to square well with previous studies using patent data (Deng et al., 1999) and market measures of performance. It also implies that the market incorporates the affect of stocks of competencies—be it positive or negative—into its evaluation of future performance.

Future Research

In addition to the questions this study addresses, the results suggest several new directions for future research. This article used patent citation data to tease out the extent to which firms built upon their own innovative activity. Future research might seek out other ways of measuring the phenomena of building on firm specific knowledge. For example, competencies could develop from a combination of internal and external learning, or the re-combining of internal knowledge, or from the acquisition of external knowledge. Incorporating measures that represent these different dimensions of technological competence may increase our understanding technological competencies and their impact on firm performance. However, measuring firm knowledge building is a difficult task.

Another avenue of research is to explore the intriguing possibility that firms whose innovations have been imitated may in fact learn from the imitator. In other words, a firm may be able to enhance its knowledge by learning from what others have done in their attempts to imitate them. A scholarly examination of how imitation of knowledge may impact the originator of that knowledge would provide tremendous insights into the strategy, learning and technology areas.

This study proposed a measure for imitability, a central construct in the resource-based view that is at the firm level and not been used before. The findings for the imitability measure are a first step and should spur future research interest in both operationalizing this construct and examining its relationship to firm performance. Related to this, researchers could investigate how firms try to prevent imitation. Protecting knowledge from appropriation is a skill unto itself and examining the ways firms do this would be an interesting avenue of research.

Another avenue for future research in this area is the generation of alternative measures for both marketing competence and regulatory competence. As marketing competence is strategically important not only for pharmaceuticals but for many industries, the creation of more refined measures of this construct would be a great contribution to this area. Similarly, regulatory competence, the ability to deal effectively and successfully with government agencies, is a critical strategic competence in many industries. Through communicating and working with government agencies, companies gain a certain reputation for their adroitness or ineptness in this area. Incorporating the impact of reputation more directly into a measure of regulatory competence might shed more light on the relationship between regulatory competencies and firm performance.

Finally, the fundamental issue of does innovation or day-to-day execution of business processes matter more for firm performance is highlighted in this study. In the market to book models, both execution variables, marketing and regulatory competence are directly related to firm performance, while in the ROA models, technological competence, not the

other competence variables, directly influence performance. Future research could explore this possibility.

Practical Implications

These findings generate some interesting managerial implications. First, the results suggest that accumulation of firm specific knowledge does not always lead to a competitive advantage. In fact, these results actually suggest that reliance on the same competencies harms firm performance in the long run. In technologically dynamic industries, the acquisition and incorporation of new knowledge is critical to both short and long term competitive advantage as evidenced by these findings. Companies are challenged to simultaneously learn how to exploit their current competencies while allocating resources to develop new ones. With respect to the pharmaceutical industry, the rapid advances in biotechnology necessitate quick learning of new competencies for established pharmaceutical firms.

Second, and most challenging for the pharmaceutical industry, is the finding with respect to imitability. Being innovative is a double-edged sword in pharmaceuticals as patenting protects yet reveals knowledge. Despite the fact that knowledge building is critical, the imitation of firm knowledge can be detrimental. Competitors may imitate and approve upon innovations creating new knowledge, techniques and products. These findings underpin the managerial imperatives of (1) monitoring and incorporating technological developments; (2) continually generating innovations and (3) improving their skills in terms of preventing knowledge appropriation.

Limitations

These findings, their interpretation and my subsequent discussion must be considered in the context of the study's limitations. This investigation focused on one industry and, as such, lacks generalizability. However, with a homogeneous sample, any industry disturbances are held constant for all firms. Deeper insight into the effects of competencies and imitability on firm performance would be obtained by examining these variables in different industries.

The data covered only a selected time period. Longer time frames may shed more light on the robustness of the hypothesized relationships. In some cases, citations made to specific patents may decline in later years, as there is not enough time for them to be cited. This limitation should be recognized in interpreting the regression results. Moreover, the patent data used in this study has some limitations. First, I was unable to differentiate between product and process patents and also patent categories and there may exist systematic differences in patent citations among these different types of patents. The second limitation of this particular patent data set is the inability to identify licensed or acquired patents that have implications in terms of firm's building on a stock of knowledge.

Conclusion

This article opened with a quote from Prahalad and Hamel (1990) in which they suggested that developing new competencies is no easy task—rather unlike simply getting off one train and sauntering onto another. Implicit in their analogy is the fact that accumulation

of expertise not only takes time to acquire, but it also takes time to transform. These empirical results highlight the jeopardy inherent in acquiring competencies and the importance of new learning. These empirical findings also provide evidence of the negative relationship between competitor imitation of knowledge and firm performance. Finally, the results suggest that firm performance is affected by other competencies, such as marketing and regulatory.

It is hoped that the results presented here stimulate new resource-based research on the relationship between competencies, imitability and firm performance in other industry contexts.

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References

Allen, T., Lee, D., & Tushman, M. 1980. R&D performance as a function of internal communication, project management and the nature of work. *IEEE Transactions on Engineering Management*, EM-27(1): 2–12.

Amit, R., & Schoemaker, P. J. 1993. Strategic assets and organizational rent. *Strategic Management Journal*, 14(1): 33–46.

Andrews, K. R. 1971. *The concept of corporate strategy*. Homewood: Dow Jones-Irwin.

Barney, J. B. 1986. Organizational culture: Can it be a source of sustained competitive advantage? *Academy of Management Review*, 11(3): 656–665.

Barney, J. 1991. Firm resources and sustained competitive advantage. *Journal of Management*, 17(1): 99–120.

Barney, J. 2001. Is the resource-based "view" a useful perspective for strategic management research? Yes. *Academy of Management Review*, 26(1): 41–56.

Bettis, R. 1981. Performance differences in related and unrelated firms. *Strategic Management Journal*, 2(4): 379–393.

Bettis, R., & Prahalad, C. 1986. The dominant logic: A new linkage between diversity and performance. *Strategic Management Journal*, 7(6): 485–501.

Bierly, P., & Chakrabarti, A. 1996. Generic knowledge strategies in the U.S. pharmaceutical industry. *Strategic Management Journal*, 17: 123–135.

Bogner, W. C., & Thomas H. 1994. Core competence and competitive advantage: A model and illustrative evidence from the pharmaceutical industry. In G. Hamel & A. Heene (Eds.), *Competence based competition*. Chichester: Wiley.

Campbell, R. S., & Nieves, A. L. 1979. *Technology indicators based on patent data: The case of catalytic converters: Phase 1 report: Design and demonstration*. Battelle: Pacific Northwest Laboratories.

Carpenter, M. C., & Narin, F. 1983. Validation study: Patent citations as indicators of science and foreign dependence. *World Patent Information*, 5(3): 180–185.

Chatterjee, S., & Wernerfelt, S. 1991. The link between resources and type of diversification: Theory and evidence. *Strategic Management Journal*, 12: 33–48.

Chauvin, K., & Hirschey, M. 1993. Advertising, R&D expenditures and market value of the firm. *Financial Management*, 22(4): 128–140.

Cockburn, I., & Griliches, Z. 1988. Industry effects and appropriability measures in the stock market's valuation of R&D and patents. *AEA Papers and Proceedings*, 78(2): 419–423.

Cohen, W., & Levinthal, D. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35: 128–152.

Collis, D. 1991. A resource-based analysis of global competition: The case of the ball bearing industry. *Strategic Management Journal*, 12: 49–68.

Cool, K., & Schendel, D. 1987. Strategic group formation and performance: The case of the U.S. pharmaceutical industry. *Management Science*, 33(9): 1102–1124.

Cool, K., & Schendel, D. 1988. Performance differences among strategic group members. *Strategic Management Journal*, 9(3): 207–223.

Day, G. 1994. The capabilities of market-driven organizations. *Journal of Marketing*, 58: 37–52.

De Carolis, D., & Deeds, D. 1999. The impact of stocks and flows of organizational knowledge on firm performance: An empirical investigation of the biotechnology industry. *Strategic Management Journal*, 20(10): 953–968.

Deng, Z., Lev, B., & Narin, F. 1999. Science and technology as predictors of stock performance. *Financial Analysts Journal*, 55(3): 20–32.

Dierickx, I., & Cool, K. 1989. Asset stock accumulation and sustainability of competitive advantage. *Management Science*, 35(12): 1504–1513.

Dosi, G. 1982. Technological paradigms and technological trajectories. *Research Policy*, 11: 147–162.

Economist. 1997. Bulls, pills and patents. *The Economist*, 69.

Fiol, M., & Lyles, M. 1985. Organizational learning. *Academy of Management Review*, 10(4): 803–813.

Grabowski, H. G., & Vernon, A. 1990. A new look at the returns and risks to pharmaceutical R&D. *Management Science*, 36: 804–821.

Grant, R. B. 1991. A resource-based theory of competitive advantage: Implications for strategy formulation. *California Management Review*, 33(3): 114–135.

Graves, S., & Langowitz, N. 1993. Innovative productivity and returns to scale in the pharmaceutical industry. *Strategic Management Journal*, 13: 593–605.

Hall, B. 1998. *Innovation and market value*. Working paper, Oxford University.

Hall, B., Jaffe, A., & Trajtenberg, M. 2000. *Market value and patent citations: A first look*. Working paper, University of California, Berkeley.

Harrison, J., Hitt, M., Hoskisson, R., & Ireland, R. 1991. Synergies and post acquisition performance: Differences versus similarities in resource allocation. *Journal of Management*, 17(1): 173–190.

Hausman, J., Hall, B., & Griliches, Z. 1984. Econometric models for count data with an application to the patents–R&D relationship. *Econometrica*, 52(4): 909–938.

Henderson, R., & Cockburn, I. 1994. Measuring competence? Exploring firm effects in pharmaceutical research. *Strategic Management Journal*, 15: 63–84.

Henderson, R., & Cockburn, I. 1996. Scale, scope and spillovers: The determinants of research productivity on drug discovery. *Rand Journal of Economics*, 27(1): 32–69.

Hill, C., & Hansen, G. 1991. A longitudinal study of the cause and consequences of changes in diversification in the U.S. pharmaceutical industry 1977–1986. *Strategic Management Journal*, 12: 187–199.

Hill, C., & Snell, S. 1988. External control, corporate strategy and firm performance in research intensive industries. *Strategic Management Journal*, 9: 577–590.

Hitt, M., & Ireland, R. 1985. Corporate distinctive competence, strategy, industry and performance. *Strategic Management Journal*, 6: 273–293.

Hitt, M., Ireland, R., & Palia, K. 1982a. Industrial firms' grand strategy and functional importance: Moderating effects of technology and uncertainty. *Academy of Management Journal*, 25(2): 265–298.

Hitt, M., Ireland, R., & Stadter, G. 1982b. Functional importance and company performance: Moderating effects of grand strategy and industry type. *Strategic Management Journal*, 3: 315–330.

Hunt, S., & Morgan, R. 1995. The comparative advantage theory of competition. *Journal of Marketing*, 59: 1–15.

Jensen, E. 1987. Research expenditures and the discovery of new drugs. *The Journal of Industrial Economics*, 36: 83–95.

Jose, M., Nichols, L., & Stevens, J. Winter 1986. Contributions of diversification, promotion and R&D to the value of multiproduct firms. *Financial Management*, 15(4): 33–42.

Katz, R. (Ed.). 1988. *Managing professionals in innovative organizations: A collection of readings*. New York: Harper Business.

Kogut, B., & Zander, U. 1992. Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science*, 3(3): 383–396.

Langreth, R. 1995, September 11. New technique for discovering medicines takes hold. *Wall Street Journal*, B2.

Lecraw, D. J. 1984. Diversification strategy and performance. *Journal of Industrial Economics*, 33: 179–198.

Leonard-Barton, D. 1992. Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal, Summer Special Issue*, 13: 111–126.

Leonard-Barton, D. 1995. *Wellsprings of knowledge*. Boston, MA: Harvard Business School Press.

Lev, B., & Sougiannis, T. 1999. Penetrating the book-to-market black box: The R&D effect. *Journal of Business Finance & Accounting*, 26(3/4): 419–449.

Levin, R., et al. 1984. *Survey research on R&D appropriability and technological opportunity*. Research Paper, Yale University.

Lustgarten, S., & Thomadkis, S. 1987. Mobility barriers and Tobin's Q. *Journal of Business*, 60(4): 519–537.

Markides, C., & Williamson, P. J. 1994. Related diversification, core competences and corporate performance. *Strategic Management Journal*, 15: 149–165.

Markides, C., & Williamson, P. 1996. Corporate diversification and organizational structure: A resource-based view. *Academy of Management Journal*, 39(2): 340–367.

McClean, I. W., & Round, D. K. 1978. Research and product innovation in Australian manufacturing industries. *Journal of Industrial Economics*, 27: 1–12.

MedAd News. 1999, September. *Greater expense, fewer rewards*: 10.

Miller, D., & Shamsie, J. 1996. The resource-based view of the firm in two environments: The Hollywood film studios from 1936–1965. *Academy of Management Journal*, 39(3): 519–543.

Mooreman, C., & Slotegraaf, R. 1999. The contingency value of complementary capabilities in product development. *Journal of Marketing Research*, 36: 239–257.

Morck, R., Shleifer, A., & Vishny, R. 1988. Management ownership and market valuation: An empirical analysis. *Journal of Financial Economics*, 20: 293–315.

Mizruchi, M., & Stearns, L. 1988. A longitudinal study of the formation of interlocking directorates. *Administrative Science Quarterly*, 33: 194–210.

Mueller, D. 1990. *The dynamics of company profits: An international comparison*. Cambridge: Cambridge University Press.

Narin, F., Rose, M., & Olivastro, D. 1989. Patent citation analysis: New validation studies and linkage statistics. In A. F. J. van Raan, A. J. Nederof, & H. F. Moed (Eds.), *Proceedings of Leiden workshop in science and technology indicators: Their use in science policy and their role in science studies*: 35–47.

Nelson, R., & Winter, S. 1982. *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.

Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. *Organizational Science*, 5(1): 14–37.

Parks, R. W. 1967. Efficient estimation of a system of regression equations when disturbances are both serially and contemporaneously correlated. *Journal of The American Statistical Association*, 62: 500–509.

Pisano, G. 1997. *The development factory: Unlocking the potential of process innovation*. Boston: Harvard Business School Press.

Prahalad, C. K., & Hamel, G. 1990. The core competence of the corporation. *Harvard Business Review*, 68(3): 79–91.

Priem, R., & Butler, J. 2001. Is the resource-based view a useful perspective for strategic management research? *Academy of Management Review*, 26(1): 22–40.

Reed, R., & DeFillippi, R. J. 1990. Causal ambiguity, barriers to imitation and sustainable competitive advantage. *Academy of Management Review*, 15: 88–112.

Robins, J., & Wiersema, M. F. 1995. A resource-based approach to the multibusiness firm: Empirical analysis of portfolio interrelationships and corporate financial performance. *Strategic Management Journal*, 16(4): 277–299.

Scherer, F. M. 1965. Firm size, market structure, opportunity and the output of patented inventions. *American Economic Review*, 55: 1097–1125.

Selznick, P. 1957. *Leadership in administration*. New York: Harper.

Snow, C. C., & Hrebiniak, L. G. 1980. Strategy, distinctive competence, and organizational performance. *Administrative Science Quarterly*, 25(2): 317.

Sorensen, J. B., & Stuart, T. E. 2000. Aging, obsolescence, and organizational innovation. *Administrative Science Quarterly*, 45(1): 81–112.

Stearns, L., & Mizruchi, M. 1993. Board composition and corporate financing: The impact of financial institution representation on borrowing. *Academy of Management Journal*, 36: 603–618.
Sull, D. 1999. Why good companies go bad. *Harvard Business Review*, 77(4): 42–56.
Tanouye, E., & Langreth, R. 1997. With patents expiring on big prescriptions, drug industry quakes. *Wall Street Journal*, 8/4/97: A1–A6.
Teece, D. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15: 285–305.
Teece, D., Pisano, G., & Shuen, A. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7): 509–533.
Thomas, L. G. 1990. Regulation and firm size: FDA impacts on innovation. *Rand Journal of Economics*, 21(4): 497–517.
Trajtenberg, M. 1990. A penny for your Quotes: Patent citations and the time value of innovations. *Rand Journal of Economics*, 21: 172–187.
Tushman, M., & Anderson, P. 1986. Technological discontinuities and organizational environments. *Administrative Science Quarterly*, 31: 439–465.
Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal*, 5: 171–180.

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