TO HAVE AND TO HOLD: PROTECTION, DEPLOYMENT, AND THE IMITATION OF CRITICAL RESOURCES

by

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(Under the Direction of Gideon D. Markman)

ABSTRACT

This study makes the following contributions to strategic management theory. First, it identifies specific actions firms take to protect critical resources such as technological discoveries. Second, it examines the extent to which these actions expedite or impede resource imitation by competitors. It provides greater theoretical clarity on the link between resource attributes, resource deployment, and their imitation. Thirdly, it proposes that the interaction between resource attributes and how firms deploy these resources predict the probability and timing of resource imitation. Lastly, it begins to explicate how particular resources are susceptible to imitation. The findings of this study provide mixed support for the theory, as the analysis did not confirm some of the hypotheses. The study's most interesting finding concerns how resource deployment, as measured by its level of visibility by external parties, moderates the negative relationship between a resource's innovativeness and the timing of its imitation. Overall, the findings suggest that both resource attributes and firm deployment decisions impact the probability and timing of resource imitation.

INDEX WORDS: Resource-based theory, Imperfectly imitable resources, Isolating mechanisms, Resource protection and deployment, Patents

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A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2007

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May 2007

ACKNOWLEDGEMENTS

First, I would like to thank my wife Stacy who has been my greatest supporter. It has been an interesting ride so far, I look forward to the future. You mean more to me than you will ever know.

Next, I would like to thank my three beautiful children. Costa my buddy, you are the inquisitive one who understood the importance of what dad was trying to accomplish; Baze, with her sweet and timely comic relief, you always bring a smile to my face; and Brahm, who came on board late in the game, you are the determined one who gave me the energy right until the end. You all make me so proud.

To Gideon Markman, I could not have asked for a more devoted, conscientious and tenacious mentor and chair. Thank you for constantly raising the bar to make this the best possible dissertation. You have been a sage advisor, and I have learned numerous and invaluable lessons from you. I look forward to our future collaborations.

To my committee members, Allen Amason and Ann Buchholtz, who provided frank and sound advice throughout my studies.

To my fellow doctoral students who shared the joys and the frustrations along the way. A special thanks to Jill Brown, who was able to make the past four years entertaining and enjoyable.

Lastly, I want to thank my parents, Gus and Barbara Gianiodis, who without your guidance and love I would not have started on this path nor strived so high.

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CHAPTER 1: INTRODUCTION

The goal of this dissertation is to further advance our understanding of how firms protect, and deploy critical resources[1]. The focus on firm processes of resource protection and deployment originates from themes in strategic management, organizational theory, and economics (McEvily, Eisenhardt, & Prescott, 2004). Protecting resources from imitation is a key component of innovation and strongly relates to firm outcomes including financial performance and organizational change (Barney, 1991; Teece, 2000). Although the process of invention is critical to the success of any innovation, of equal importance is protecting and leveraging critical resources; it is here where a substantial value of resource acquisition and development is garnered (McEvily et al., 2004). Firms create isolating mechansims and barriers to imitation in order to protect critical resources. In the case of knowledge-based resources such as technological discoveries, protection may be derived from organizational capabilities and processes. It is through the development of these capabilities and processes that firms protect critical resources from imitation (Lieberskind, 1996).

This dissertation offers a framework to explain and predict why, when, and how firms deploy resources while reducing the risk of imitation. It starts with a broad question: what isolating mechanisms do firms employ to reduce resource imitation by competitors? Developing a framework that explains how firms erect barriers to resource imitation—as opposed to product imitation—is important because it provides a link between processes of resource exploration and

[1] This dissertation adopts resource-based theory's (RBT) definition of critical resources – ones that are simultaneously valuable, rare, inimitable and non-substitutable (VRIN). Thus, the term critical resources represents VRIN resources.

resource exploitation (Ahuja & Katila, 2004; McEvily et al., 2004). Firms exploit resources under their control, but how they deploy their resources can influence how quickly these rent-generating resources erode through competitor imitation (Reed & DeFillippi, 1990). A framework explicating the actions firms take to protect resources against competitor imitation adds specificity and conceptual nuances to research on causal ambiguity, complexity, and tacitness (McEvily et al., 2004). In fact, a theory of resource deployment and imitation has implications for resource-based theory (RBT), and how it conceptualizes firm heterogeneity and sustainable competitive advantage (Barney, 2001).

Holding product imitation constant, this dissertation redirects attention to the role of firm purposeful action to protect resources; how firms deploy their resources, and the interaction between resource attributes and how firms deploy said resources. The motivation for this dissertation centers on the following research questions: to what extent do resource attributes *and* firm actions act as isolating mechanisms from competitor imitation, and how do these isolating mechanisms interact to predict the probability and timing of resource imitation? This dissertation identifies four endogenous resource attributes which are particularly salient in explaining the likelihood and timing of imitation. 1) Scope describes a resource's breadth and depth of use (Pil & Cohen, 2006). 2) Innovativeness is the extent of radicalness (or newness) of an invention or resource (Rosenkopf & Nerkar, 2001). 3) Internal linkages describe how a resource is bundled within a firm's existing network of resources (Black & Boal, 1994). 4) External linkages describe the extent to which external resources or knowledge bases complement a resource (Lavie, 2006). Further, the model posits the direct effects of resource deployment, specifically the extent resources are visible to external parties, and how deployment interacts with the four endogenous resource attributes to predict the likelihood and timing of

imitation. In so doing this dissertation explicates a central tenet of strategic management theory; can firms use isolating mechanisms to erect "resource barriers" (Wernerfelt, 1984), or is imitation a function of resource attributes and thus largely disconnected from firms' action or influence?

The model acknowledges the importance of RBT's conceptualization of valuable, rare, and non-substitutable (VRN) resource qualities in explaining resource-based advantages; however, this dissertation focuses wholly on imitation because it is the most important factor in determining competitive advantage. Imitation is the fastest method for closing any advantage deficits, especially within research-intensive markets and industries where R&D plays a critical role (Mansfield, Schwartz, & Wagner, 1981). In addition, imitation compresses time, and reduces the expense associated with searching for and experimenting with new technologies (McEvily & Chakravarthy, 2002). Lastly, firms are limited in identifying equally effective alternatives for closing major performance gaps, especially when firms face a great deal of environmental uncertainty (Cyert & March, 1963; Haunschild & Minor, 1997).

Theoretical Contributions

RBT suggests that when firms manage their resource endowments effectively they can create and sustain a competitive advantage (Barney, 1991, 2001; Eisenhardt & Martin, 2000; Helfat & Peteraf, 2003; Liebeskind, 1996; McEvily et al., 2004; Newbert, 2007; Teece, Pisano, & Shuen, 1997). RBT has made substantial contributions to the strategic management literature; however it does not fully specify the link between resource deployment and the risk of competitor imitation (Lieberman & Asaba, 2006). Two major criticisms are prevalent in the literature to explain this shortcoming: first, RBT uses broad and varied definitions of critical resources (Barney, 1991; Wernerfelt, 1984), and second, RBT treats resource positions as

relatively static (Helfat & Peteraf, 2003; Eisenhardt & Martin, 2000). RBT defines firm resources as anything which denotes a strength or a weakness (Wernerfelt, 1984); RBT research generally employs this broad definition to describe resources (Priem & Butler, 2001). When researchers view virtually any resource as critical to the firm, it is exceedingly difficult to discern imitation because modeling resources in this way obscures the mechanisms firms employ to protect against resource-based imitation. Research also tends to model firm resource positions as static, which under specifies firm processes of resource bundling, reconfiguration, and deployment (Eisenhardt & Martin, 2000).

Because RBT assumes a broad definition of resources, and empirical research has employed mostly static models, it under specifies the role of firm mechanisms to protect the controlling rights to critical resources (Foss & Foss, 2005). This is especially true when describing the relationship between the presence or absence of critical resources and competitive advantage (Kim & Mahoney, 2002). According to this view, firms derive competitive advantage from intrinsic resource attributes. Thus, although RBT recognizes that firms protect their resources by embedding them in other resources, processes or routines, the theory devotes little attention to specific actions firms take to create isolating mechanisms (Teece et al., 1997). Determining imperfectly imitable resources has become a function of somewhat under-specified and difficult to operationalize constructs—social complexity, causal ambiguity, unique historical conditions, or path dependence (Barney, 1991; Peteraf, 1993; Reed & DeFillippi, 1990). In contrast, this dissertation redirects attention to isolating mechanisms firms purposefully use to reduce the threat of value erosion due to competitor imitation. Only limited research acknowledges that how firms utilize their resources can and does influence the probability and the pace at which such resources get imitated (Teece et al., 1997). Thus, prevailing theory

suggests that because resources are inherently inimitable, firms can easily and inconsequentially deploy and exploit said resources

The dissertation addresses these deficiencies by providing greater theoretical clarity on the link between resource attributes, how firms deploy resources, and their imitation. It challenges the implicit assumption that resources are inherently imitable or inimitable, implying that imitation is, to a large extent, beyond the control of firms. Put differently, because RBT assumes imitation is largely an endogenous attribute of the resource itself, it suggests that firms have limited latitude in influencing resource imitation. This assumption ignores firms' choices in deploying their critical resources (Teece, 2000). This dissertation suggests that resource imitation is a function of endogenous resource attributes, *and* exogenous actions firms undertake to create isolating mechanisms (Lippman & Rumelt, 2003). Firm isolating mechanisms interact with specific resource attributes to either impede or accelerate the probability and timing of resource imitation. Thus, this dissertation surfaces the contingent relationships between resource attributes, deployment, and the likelihood and timing of imitation.

Research supports the view that in certain contexts sharing technological discoveries is a prudent strategy (Spencer, 2003). However, RBT suggests that preventing imitation of discoveries is a necessary condition for gaining competitive advantage and earning above average returns (Berman, Down & Hill, 2002; De Carolis, 2003; Markman, Espina & Phan, 2004; Ray, Barney & Muhanna; 2004). This contrast implies that greater theoretical precision is needed to better understand the relationship between resource deployment, imitability, and performance. For example, what sort of technological discoveries are best deployed via proprietary mechanisms, and what types of mechanisms are more likely to impede imitation. To better comprehend these contingent relationships, this dissertation examines specific mechanisms

firms employ to protect their technological discoveries. This will advance theory by specifying how firms embed resources in routines and processes to make resource-based imitation more difficult.

Although the concept of competitor imitation is a central tenet of RBT and other strategic management theories (Lieberman & Asaba, 2006; Peteraf, 1993), there exists only limited systematic theoretical and empirical research on resource-based imitation. This is due in part to the literature's focus on product-market competition, where firms clearly define their rivals because they are more easily discerned (Markman, Gianiodis, & Buchholtz, 2006). This research confines competitive engagement to product markets, and assumes that all resource-based competitive actions naturally carry forward to competitive behavior over product markets. In contrast, this dissertation suggests that the protection of critical resources, such as the exploitation of technological discoveries, is a function of how firms deploy them. How firms deploy their discoveries will affect the likelihood and timing of their imitation. For this reason, a broader theory, which includes the conditions for and outcomes of resource-based imitation, is important to extending existing theories of competitive dynamics (Ketchen, Snow, & Hoover, 2004).

To summarize, this dissertation seeks to make several contributions. First, it identifies specific actions firms take to protect critical resources such as technological discoveries. Second, it examines the extent to which these actions hinder or delay resource imitation by competitors. It provides greater theoretical clarity on the link between resource attributes, resource deployment, and their imitation. Thirdly, it proposes that the interaction between resource attributes and resource deployment predict the probability and timing of resource imitation. Lastly, it begins to explicate how particular resources are susceptible to imitation; firm

choices of resource deployment either facilitate or hinder resource imitation. Below, I present an overview of the dissertation including a brief outline of the methodology, the key findings of the study and the order and content of each chapter to follow.

Overview

This dissertation reviews the pertinent literatures and develops the theoretical model to address the following research questions: to what extent do resource attributes and firm actions of resource deployment act as isolating mechanisms from competitor imitation, and how do these isolating mechanisms interact to predict the probability and timing of resource imitation? To answer these questions, this dissertation examines a narrow set of resources – technological discoveries in the financial services industry (i.e. financial innovation). Specifically, it tests a model of resource-based imitation through the analysis of patents in the financial industry. Patents in this space encompass financial instruments, technologies, financial methods, business methods, or other finance-based processes (Frame & White, 2003; Lerner, 2002; Merges, 2003). Modeling financial patents as critical resources is consistent with research on entrepreneurial and technological discoveries (De Carolis, 2003; Markman, et al., 2004; Shane, 2001). In order to focus on the mechanisms that delay imitation, the unit of analysis is the *resource* (i.e. the financial patent). The level of analysis is appropriate given the dissertation's ultimate objective to better understand interfirm resource imitation.

In developing the theoretical model and testing the hypotheses, I employ a two phase research design. Phase I identifies and develops the key constructs. Because this dissertation aims to provide not only a conceptual but also an empirical assessment on how firms erect barriers to imitation, it is necessary to use parameterized and measurable constructs. To this end, the dissertation employs only quantifiable resources - patented financial innovations. The

dissertation relies on six subject matter experts (SME) to assist in developing the key constructs. The SMEs included: a patent attorney, an entrepreneur who started a new venture based upon a patented financial technology, three executives at a leading financial services firm, who helped commercialized financial patents, and a finance professor. Phase II, the final phase, consisted of a full test of the data set – 1911 financial patents issued from 1980-2004. The final count used in the study is consistent with previous research (cf. Lerner 2002, 2003), and is more fully defined in chapter 4. Lastly, the data analysis occurred through various diagnostic and validation tests.

Briefly, the study provided mixed support for the role of resource attributes, resource deployment, and their interaction in determining the likelihood and timing of resource imitation. Specifically, two resource attributes – scope and external linkages – are significant predictors of the probability and timing of imitation. Likewise, the resource deployment mechanism – visibility or the extent to which a resource is observable in practice – is a strong predictor of the probability, but not the timing of imitation. The crux of this study is in determining the role of resource deployment as a moderator of the relationship between resource attributes and imitation. In fact, several interactions garner significant support. Specifically, the deployment mechanism visibility intensifies the relationship between resource scope and the probability of imitation. In addition, visibility significantly moderates the relationship between a resource's innovativeness and the timing of its imitation. Stated differently, the model predicts highly innovative resources to take longer to imitate, but when these resources are deployed in highly visible processes or products, imitation is accelerated. The overall findings suggest that inherent resources attributes, *in addition to* resource deployment and the interaction between attributes and deployment influences the likelihood and timing of imitation.

This dissertation is composed of six chapters including the introduction. Chapter two consists of a review of the pertinent literature to ground the study. To inform the theoretical model, it examines the emerging resource-based theory (RBT), as well as contemporary studies employing resource-based logic.

In Chapter three I present the research model, including a definition of the key constructs and the attendant hypotheses. Chapter four describes the methodology (i.e. the two phase approach) used to test the hypotheses. The chapter includes a description of the sample, the operationalization of the key constructs, and the approaches of data collection and analyses. In Chapter five I present the results obtained from the hypotheses testing through the analyses of the research model. Lastly, chapter six discusses the implications of the research findings and the limitations of the dissertation. It concludes with a brief overview of future research directions and how to translate the findings into actionable knowledge for managers.

CHAPTER 2: LITERATURE REVIEW

Prior work shows that firms achieve and sustain a competitive advantage when they employ isolating mechanisms to protect their most critical resources (Dierickx & Cool, 1989; Lippman & Rumelt, 1982). Isolating mechanisms are important because they undermine competitors' imitative efforts, which tend to erode the profit margins generated by the protected resources (Peteraf, 1993). Hence, an effective use of isolating mechanisms to ward off rivals' effort to imitate critical resources impacts a focal firm's long-term performance. In contrast to earlier work, which tends to conceptualize the imitation construct as an attribute endogenous to resources, this dissertation focuses on the tactical actions firms take to further isolate their resources from erosion due to imitation. That is, over and above the qualitative nature of resources, this dissertation redirects attention to purposeful actions firms take to actively protect their rent-generating resources. Because Penrose (1959), Barney (1986, 1991), Hunt (1995, 2000), Teece, (1986, 1997, 2000), and other scholars emphasize the importance of resource heterogeneity in securing and sustaining competitive advantage (Connor, 1991), their work provides the theoretical platform for this dissertation.

As alluded to in the introduction chapter, earlier work regards resource-based theory's (RBT) four tenets—valuable, rare, inimitable (imperfectly imitable), non-substitutable (VRIN) resources—as equally important. This dissertation certainly appreciates the significance of these four resource attributes and their synergistic effect, but the focus here is on the imperfectly

imitable construct, because of its critical role in fighting rivals in factor markets (Markman, et al., 2006) and fending off new entrants from establishing footholds in product markets (Lieberman & Asaba, 2006; Porter, 1980). Attributing greater attention to the imperfectly imitable construct is justified because strategic management theories seek to explain and predict how firms sustain their advantages. Yet when firms leave competitive positions unprotected, the advantages derived form these positions can quickly erode. In addition, current theory assumes firms have limited discretion in enhancing the extent their resources are imperfectly imitable; it under specifies the interaction between resource attributes and firm capabilities.

Thus, the main logic behind this dissertation is that—ceteris paribus—to sustain high returns, firms must not only passively trust that their most valuable resources are inherently imperfectly imitable, but instead should also take action to prevent the their imitation. The extent to which resources are imperfectly imitable is therefore a function of (a) resource's intrinsic attributes and (b) focal firms' action that makes imitation more difficult to accomplish. The extant conceptual and empirical work has validated the former; the goal of this dissertation is to contribute to the latter.

The dissertation tests underlying assumptions inherent in RBT as they apply to theories of resource protection and appropriation (Liebeskind, 1996; Teece, 2000), and competitor imitation (Lieberman & Asaba, 2006). Specifically, I investigate the effects of critical resource attributes, firm protection and deployment processes on the probability and timing of imitation. I elaborate on the inter-play between resource attributes and firm action. This finer-grained approach addresses calls for theoretical extensions and greater conceptual precision regarding processes associated with resource protection, deployment and imitation (Foss & Foss, 2005; Godfrey & Hill., 1995; Newbert, 2007; Lippman & Rumelt, 2003; Sirmon, et al., 2007).

This chapter is organized as follows. First, it reviews resource-based theory, including the key constructs, empirical findings, and most importantly the prevailing assumptions and boundary conditions underpinning imitation. Emphasis is placed on how RBT describes resource heterogeneity and imperfect mobility as necessary conditions for developing competitive advantage. The next section reviews the key factors preventing imitation. Central to this review are the following constructs: *causal ambiguity*, *social complexity*, *unique historical conditions*, *time compression diseconomies*, *asset mass efficiencies*, and the *interconnectedness of resources*. Of note is how each characteristic stresses the importance of intrinsic attributes, rather than purposeful firm action as a means of creating barriers to imitation. The chapter concludes with a preliminary framework for understanding the role of both intrinsic resource attributes, and specific firm protection mechanisms in building barriers to imitation.

Resource-based Theory

In 1959, Edith Penrose argued that a firm's growth is a function of how it acquires and employs its resources to meet opportunities in its markets. The principles underlying Penrose's seminal work lie in the belief that a firm is a bundle of resources acting as antecedent inputs into final offerings in product markets (Lockett & Thompson, 2001). For Penrose, the possession of resources was only one part of the equation; of equal importance was the extent to which firms put their resources to productive use. Thus, an important assumption underlying Penrose's theory is that resources are heterogeneous across firms and this resource heterogeneity is an essential component for determining competitive differentiation (Locket, 2005; Sirmon et al., 2007).

Formalized theories based upon Penrose's initial insights have adopted this foundational assumption (Amit & Schoemaker, 1993; Barney, 1991; Conner, 1991; Hunt, 2000; Peteraf, 1993;

Rumelt, 1984; Wernerfelt, 1984). Building upon Rumelt's (1984) view on the importance of isolating mechanisms and Wernerfelt's (1984) contention regarding the importance of resource-position barriers, Barney (1991) identified an additional precondition for competitive advantage: imperfect resource mobility. Imperfect mobility necessitates resources that are nontradable or have less value to users other than the firm that owns them (Peteraf, 1993). A parallel perspective argued that only those resources that are difficult to imitate, substitute and trade for can provide a competitive advantage (Dierickx and Cool, 1989). By tying the nature of resources to competitive advantage, the heretofore "resource-base view" intimates that certain resources may generate Ricardian rents and quasi-rents (Conner, 1991; Peteraf, 1993).

Because RBT employs a broad definition of resources, and assumes resource heterogeneity and imperfect mobility as preconditions for competitive advantage, its explanatory interests are two-fold: first, how firms secure heterogeneous resources, and second, what are the performance implications resulting from these varying resources. In examining sources of firm heterogeneity, RBT focuses on various stages of a firms evolution–from founding (Stinchcombe, 1965), through growth and diversification stages (Chandler, 1962), and finally to organizational maturity (Aldrich, 1999).

RBT scholars suggest several explanations for how resource heterogeneity emerges, including initial endowments and prior commitments (Eisenhardt & Schoonhoven, 1996), timing of acquisition (Stinchcombe, 1965), varying life-cycles (Helfat & Peteraf, 2003), and managerial capabilities (McEvily et al., 2004; Sirmon et al, 2007). These explanations provide a beneficial starting point for inquiry; however, they remain incomplete. Recent research has adopted a more evolutionary perspective, which suggests that resource heterogeneity results from firm action as a response to idiosyncratic situations (Ahuja & Katila, 2004). For instance, firms search for and

acquire resources based upon opportunities that arise in their environment (Ahuja & Katila, 2004; Cockburn, Henderson & Stern, 2000).

RBT's second line of inquiry has explored how firms gain competitive advantage from their heterogeneous resource positions. Wernerfelt (1984) acknowledges that a firm's financial performance parallels its product offerings, but he stresses that the resource which support such offerings also drives performance. Barney (1991) formalized RBT further by specifying what resource characteristics lead to competitive advantage. That is, RBT stipulates that firms earn superior returns when they deploy resources that are valuable and rare. Although firms can gain temporary advantages when they hold these resources, this does not guarantee an enduring or sustainable competitive advantage. Indeed, Barney (1991) argued that such resources must also be simultaneously imperfectly imitable, and non-substitutable. This conceptualization has become known as the VRIN tenets (Lavie, 2006) or the VRIO framework (Newbert, 2007). In sum, rare and valuable resources are necessary for achieving a competitive advantage, however, in order to sustain this competitive advantage resources must also be imperfectly imitable and non-substitutable (Priem & Butler, 2001). Figure 1 demonstrates a parsimonious representation of Barney's (1991) conceptual model.

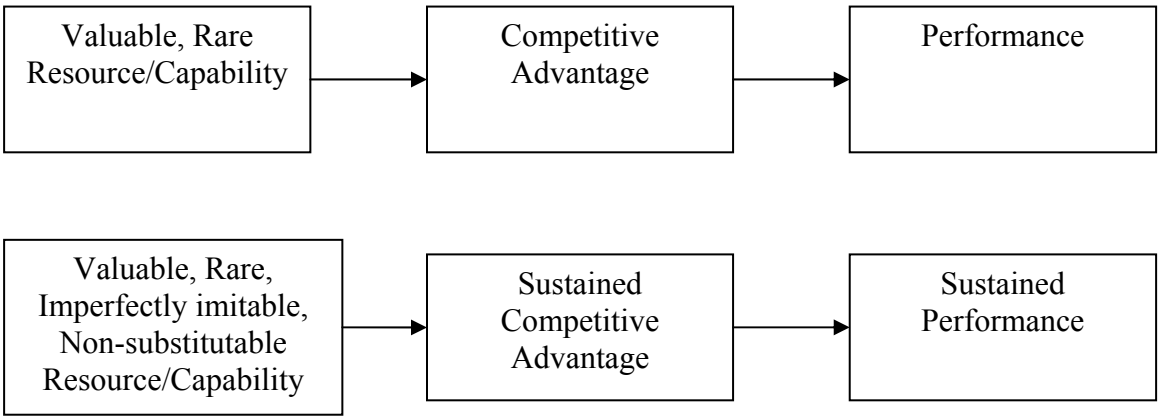


Figure 1. Barney's (1991) Conceptual Model

Despite RBT's prominent position, this conceptual model has not been immune to criticism, generally centering on its static nature (Priem & Butler, 2001). Key concepts and relationships are often underspecified, and the processes through which resources provide competitive advantage tend to remain in a black box (Newbert, 2007). Recent research has advanced a more dynamic view, emphasizing how resources must evolve to remain a source of competitive advantage (Teece at al, 1997). Scholars extended this logic to resource lifecycles (Helfat & Peteraf, 2003), active resource portfolio management (Sirmon et al, 2007); and leveraging resources within and across networks (Lavie, 2006). This dynamic view underscores the need for firm action, moving beyond the notion that competitive advantage is born solely out of the possession of VRIN resources.

Although this theoretical view recognizes the dynamic nature of resource management, the processes firms use to erect barriers to imitation lacks precision (Foss & Foss, 2005; Newbert, 2007). Rather than specifying the interaction between key attributes and firm actions to limit resource imitation, this view stresses resource embeddedness. Firms develop imperfectly imitable dynamic capabilities by embedding their resources in organizational routines, processes or other resources (Eisenhardt & Martin, 2000: Teece at al, 1997). Naturally, when firms deploy their critical resources in an observable fashion, the danger of imitation increases, yet when they embed said resources in internal processes, routines, and capabilities, the threat of imitation decreases. This dissertation identifies purposeful actions firms take to isolate their resources against imitation. Extending this dynamic approach will produce a more robust theory; it will enhance RBT's explanatory power concerning the relationship between the VRIN framework, firm-level processes, and competitive advantage. The critical factors RBT associates with

imperfectly imitable resources necessitate clarification prior to advancing a more robust conceptual model. This next section briefly describes these characteristics.

Characteristics of Imperfectly Imitable Resources

Table 1 summarizes the key characteristics of imperfectly imitable resources. These resource traits primarily come from research on invisible assets (Itami, 1987) human capital (Amit & Schoemaker, 1993; Miller & Shamsie, 1996), knowledge and routines (Grant, 1996; Teece et al., 1997), and intellectual property (Lerner, 1997; Markman et al., 2004). As highlighted in the table, the nature of each characteristic is often derived from an endogenous source; RBT provides only few prescriptions on what firms can actually do to constrain imitation (Foss & Foss, 2005; Zander & Kogut, 1995). For example, in the context of science, tacit knowledge is born in the mind of a research scientist and further developed through each subsequent project. According to RBT, this tacit knowledge is an imperfectly imitable resource. In fact, because firms cannot actively manipulate tacit knowledge, imitating such a resource is somewhat outside their control.

Table 1 Characteristics of Imperfectly Imitable Resources

Construct	Definitions and Key Citations	Nature	Examples
Causal Ambiguity (CA)	CA refers to ambiguous connections between resources and actions that yield favorable outcomes; when the link between the utilization of resources and competitive advantage is not fully understood (Barney, 1991; Lippman & Rumelt, 1982). CA is a particularly strong source of advantage when both a focal firm and imitators have incomplete understanding of the interaction between resources and capabilities (Reed & DeFillippi, 1990).	Advantage gained from neither firm action nor outcomes, but from the complex interactions between resources and capabilities.	Pfizer's processes for commercializing drug therapies developed in their labs
Social Complexity (SC)	SC exists when resources are socially multifaceted and compounded, beyond the ability of firms to systematically manage them (Barney, 1991); resources are not subject to direct management (Black & Boal, 1994). SC is a source of advantage precisely when such complexity constrains imitation (Eisenhardt & Martin, 2000).	Resource management is impractical, hindering firms from preventing imitation of such resources.	GE's culture of leadership and meritocracy not easily replicated even by recruiting key personnel
Unique Historical Conditions or Path Dependence (PD)	PD exists because firms are complex entities, their ability to acquire and exploit resources depends upon their place in time and space as well as past know-how (Barney, 1991).	Past action influences future actions; current action is constrained by earlier knowledge, skills, and competencies.	Microsoft's early relationship with IBM, which garnered it superior market position
Time Compression Diseconomies (TCD)	TCD exists when there is decreasing returns to the fixed factor time, or when the accumulation of resources is constrained by time (Dierickx & Cool, 1989) TCD is a source of advantage when rivals cannot easily "catch-up" to first movers. (Lieberman & Asaba, 2006)	Firm action and resource utility are constrained by time.	Gillette's R&D lead, supported by extensive patent thicket strategy to protect it razorblades
Asset Mass Efficiencies (AMS)	AMS exists when a resource is enhanced to the extent that adding an incremental resource is facilitated by possessing high levels of that existing resource (Dierickx & Cool, 1989) AMS is a source of advantage when previous resource positions facilitate further resource accumulation – when "success breeds success" (Schilling, 1998)	Firm action and resource utility are constrained by prior commitments and prior successes.	Network effects through franchising (e.g. dealerships, fast-food, or direct sellers such as Mary Kay)
Interconnectedness (IC)	IC exists when a resource's effectiveness is influenced by the presence of complementary assets or other resources (Dierickx & Cool, 1989). Source of advantage when resource positions complement each other; service capabilities compliment multi-product branding strategies (Teece, 2000).	Attributes and firm action are tightly coupled	Microsoft's software suite enhances the effectiveness of its operating system

Causal Ambiguity

Causal ambiguity refers to ambiguous connections between resources and actions that yield favorable outcomes. It exists when the link between the utilization of resources and competitive advantage is not fully understood (Barney, 1991; Lippman & Rumelt, 1982). Under conditions of causal ambiguity, firms are able to identify a competitive advantage; however, unable to ascertain the source of this advantage. Causal ambiguity acts as a powerful blocking mechanism to imitation and is a particularly strong source of advantage when both a focal firm and imitators have an incomplete understanding of the interaction between resources and capabilities (Reed & DeFillippi, 1990). For example, Pfizer's processes for commercializing drug therapies developed in its labs are causally ambiguous. The resources underlying these processes are knowledge-based making them more likely to be idiosyncratic to the firm. Replication of these processes is possible as Pfizer has demonstrated through successive launches of blockbuster drugs; however, articulating the causal connections is difficult, hindering outright imitation by competitors.

Research exploring the relationship between causal ambiguity and imperfectly imitable resources has identified three drivers of causal ambiguity: *tacitness*, *complexity*, and *specificity* (Lippman & Rumelt, 1982; Reed & DeFillippi, 1990). *Tacitness* refers to whether a resource such as knowledge is codifiable, particularly when it embodies skills and competencies. Indeed, even skilled operators might be unaware of the causal connections between their actions, resources, and subsequent firm-level outcomes. *Complexity* resides within and between the interactive nature of resources and processes, routines, and capabilities, and thus is beyond the breadth and depth of knowledge of any particular individual. *Specificity* highlights the unique interdependencies between resources and transactions. These characteristics conceptualize

causal ambiguity as an intrinsic resource attribute, beyond the control of firm-specific action. Returning to the example above, the knowledge-based advantages within Pfizer's research labs are not easily codified and therefore difficult to perfectly replicate into other organizational contexts.

While causal ambiguity addresses the limitations imitators face in replicating a competitor's advantage, it does not explain the purposeful actions taken by the focal firm to erect barriers to imitation. The causal ambiguity construct keeps firm-level processes in a black box; it under specifies the interaction between intrinsic attributes and firm protection and deployment mechanisms. This dissertation specifies the role of firm-level protection mechanisms, thus developing a more robust theory and informs RBT to the true nature of the importance of causal ambiguity.

Social Complexity

Resources are socially complex when they are embedded within multifaceted social configurations and are beyond the ability of firms to manage and influence (Barney, 1991;Black & Boal, 1994). Resources that are commonly considered to be socially complex include: organizational culture, reputation for quality, and affinity for effective merger and acquisition integration. Because socially complex resources are unable to be actively managed, they are immune to systematic efforts of replication. Unlike resources which have causal ambiguity characteristics, socially complex resources are identifiable and firms can be fully specify them. The connection between competitive advantage and a socially complex resource, such as organizational culture, is thus discernable. However, identifying this connection does not necessarily make replication possible. In fact, there is no clear path for imitating the "effective" culture locally, even though organizational culture is identified as the source of competitive

advantage. For example, many firms understand the importance of GE's leadership culture on its extraordinary performance, but few if any are able to replicate GE's strong culture, even after recruiting GE executive talent. Thus, advantages are gained form socially complex resources precisely because competing firms' are unable to replicate them.

By definition the social complexity construct is an intrinsic attribute because firms cannot engage in purposeful action to limit resource imitation. As with causal ambiguity, social complexity's focus is on the limitations of would-be imitators, but does not address how owners protect their complex resources. This dissertation extends RBT to identify possible firm manipulation of existing complex resources, and how these specific actions affect barriers to imitation. It acknowledges the importance of possessing socially complex resources, but suggests that purposeful actions by firms to build barriers to imitation are equally important.

Unique Historical Conditions and Path Dependence

Firms are complex entities which makes the context of resource acquisition as significant as the content of the acquired resource. Characteristics of resources are influenced by the unique historical conditions or path dependence because a firm's ability to acquire and exploit resources depends upon their place in time and space as well as past know-how (Barney, 1991). The context through which firms acquire or develop resources is important because firms without this particular historical path will be unable to obtain or replicate the resources necessary to gain the competitive advantage. Thus, once this context passes, imitation of path-dependent resources is imperfectly imitable. For example, Microsoft's dominance in the PC software industry stems from its early relationship with IBM, and IBM's decision not to pursue its own operating system.

As with causal ambiguity and social complexity, firm action to enhance the isolating mechanisms stemming from the resource's original acquisition is perceived as negligible; firms

have little or no discretion in influencing these resource's barriers to imitation. Traditional RBT logic suggests that unique historical conditions or path dependence is a source of sustained competitive advantage, either through a firm's superior expectations of a resource's potential, luck or history (Barney, 1986). However, luck and history cannot be managed, which suggests that a firms' ability to sustain a competitive advantage is related to the unique historical conditions of the resources at the time the firm accumulated them (Liebeskind, 1996). While recognizing the importance of historical context, this dissertation extends RBT by identifying the purposeful actions firms take to enhance the barriers to imitation derived from intrinsic, historical attributes. It suggests firms enact additional protection mechanisms through resource linkage and deployment.

Additional Characteristics of Imperfectly Imitable Resource

Dierickx and Cool (1989) identified three additional characteristics of imperfectly imitable resources: *time compression diseconomies*, *asset mass efficiencies*, and *interconnectedness of resources*. Although not highlighted in Barney's (1991) seminal work and not prominent in recent RBT research, these characteristics are critical in understanding resource protection, barriers to imitation and competitive advantage (Newbert, 2007). The following is a brief overview of each characteristic.

Time Compression Diseconomies: Time compression diseconomies exist when resource acquisition is constrained by time and accumulated knowledge (Dierickx & Cool, 1989). Under conditions of time compression diseconomies, imitators are unable to overcome the knowledge and experience held by first movers. Time compression diseconomies and first mover advantages are two sides of the same coin. Whereas first-mover advantage provides a firm with extra time to capture market share, build the preeminent brand, or develop extensive networks,

time compression diseconomies describes the second-movers inability to "catch-up". Imitation is rarely perfect and replicating a firm's resources may be insufficient to overcome the advantages associated with being the first to adopt (Pil & Cohen, 2006). For example, Gillette's R&D leadership and its experience at building patent thickets to protect its razorblade technology, makes any competitor's attempt to catch-up through "crash" R&D programs nearly impossible. Thus, time compression diseconomies can be a source of sustained competitive advantage when rivals cannot easily "catch-up".

By definition, time compression advantages stem from an intrinsic attribute not subject to ongoing firm action to limit resource imitation. Similar to causal ambiguity and social complexity, time compression diseconomies focuses on impediments to action of would-be imitators, without fully clarifying how owners protect their resources. This dissertation extends RBT by specifying additional actions firms engage in to enhance barriers to imitation, beyond the constraint of time. It recognizes the importance of time compression diseconomies; however it suggests purposeful actions by firms to build barriers to imitation are equally important.

Asset Mass Efficiencies: Asset mass efficiencies occur when the existence of a strong accumulated resource base enhances any incremental resource acquisition (Dierickx & Cool, 1989). As firms acquire resources over time, they accumulate a critical mass, which facilitates retention of greater knowledge and capabilities in related domains. Asset mass efficiencies are an important source of advantage because in general, success breeds success. Attempts by imitators to disrupt this trajectory are constrained by the critical mass of experience of the focal firm. As Dierickx & Cool note; "historical success translates into favorable initial asset stocks (resource positions) which in turn facilitate further accumulation" (1989; 1507). For example, franchising creates network effects, where each additional franchise to the network base

enhances the advantage derived from and to the entire network. In the case of a fast-food franchise, like Subway, the presence of a critical mass of stores magnifies the ease of adding additional franchisees, and with each additional franchisee, the network as a whole creates a barrier to imitation. Likewise, the efficacy of a direct seller business such as Mary Kay is enhanced when each additional "agent" is recruited, creating a stronger barrier to entry for any later imitator.

Whereas time compression diseconomies places the emphasis on the initial endowment of the firm through resource acquisition, asset mass efficiencies stresses the importance of accumulation over time as the isolating mechanism. RBT recognizes how strategic action enhances advantages from asset mass efficiencies; however, it does not identify the specific actions directed at gaining these advantages (Pil & Cohen, 2006). For example, organizational learning is characterized by asset mass efficiencies, yet strategies to improve learning capabilities are often described in generic terms, failing to specify how firms create barriers to imitation (Zahra & George, 2002). This dissertation identifies actions firms perform to enhance barriers to imitation, and specifies which resource attributes and firm actions hinder the imitation of critical resources. It recognizes the importance of asset mass efficiencies; however, it suggests purposeful actions by firms to build barriers to imitation are equally important.

Interconnectedness: Resource interconnectedness occurs when a resource's utility related to the presence of complementary resources. This contingency relationship increases the difficulty of building a barrier to imitation, as it relates to both the extent and position of the primary and complimentary resource. When firms tightly couple their resources, they can act as an effective isolating mechanism. For example, Microsoft's ability to link software development

resources with preexisting product development processes ensures continuous innovation will sustain their competitive advantage.

RBT describes the advantages gained from the interconnectedness of resource positions as endogenous to the resources. The focal resource position can only act as a barrier to imitation and earn economic rent if the attributes of a complimenting resource position act as a catalyst. Research suggests that complimentary or interconnected resources can act simultaneously as a barrier to imitation, and as a means to mute the presence of imperfectly imitable resources. Competitors often leverage complimentary assets to usurp barriers to imitation, while the focal firm may access complimentary resources in order to improve its existing resource barrier (Teece, 2000). Teece's (2000) framework implies that imitation may not be the sole function of inherent resource attributes. This dissertation extends Teece's (2000) logic by specifying the resource linkages which enhance resource barriers. How firms link their resources can moderate the effects specific resource attributes have on the probability and timing of imitation. This more robust view stresses the importance of purposeful actions by firms to build barriers to imitation.

To summarize, the above discussion describes the key characteristics identified in RBT, which make resources imperfectly imitable. Most RBT scholars have followed Barney's (1991) seminal paper focusing on three primary characteristics of imperfectly imitable resources–causal ambiguity, social complexity, and unique historical conditions. Because each of these characteristics derives their ability to limit imitation from endogenous attributes, RBT has not fully explained the purposeful actions firms take to protect their resources. RBT asserts that the ability of firms to prevent imitation of their critical resources lies in the inherent resource traits. Although Dierickx and Cool (1989) identified other characteristics of imperfectly imitable resources-time compression diseconomies, asset mass efficiencies, and interconnectedness of

resources-which allow greater firm discretion, the conceptual link to imitation remains largely underspecified. Stated more bluntly, RBT stipulates that building isolating mechanisms to prevent imitation is necessary for achieving advantage, yet it under specifies the processes or actions firms take to limit imitation.

To this end, the next section moves towards developing a more robust theory of resource-based imitation. The model specifies the key attributes, firm actions, and interactions to predict the probability and timing resource imitation.

Attributes and Actions

Preventing imitation of key resources, processes, routines and capabilities is a fundamental concern investigated across most business disciplines, including neo-classical economics (Arrow, 1971) industrial organization economics (Porter, 1980), accounting (Lev, 2001) finance (Tufano, 1989, 2003) legal studies (Merges, 1996) innovation and technology management (Teece, 2000), and strategic management (Lieberman & Asaba, 2006). What is common across each discipline is the assumption that firms imitate rivals' products and resources to compete in their immediate markets and to augment their current value chain. In the context of resource markets, they simultaneously seek to prevent imitation of their critical resources, while imitating resources they deem important to gain a competitive advantage. To date, RBT has emphasized the inherent attributes of resources in determining their proclivity to imitation by competing firms. This dissertation relaxes RBT's assumption about the nature of resources, and posits that firms take purposeful action to protect their resources, both those which are intrinsically difficult to replicate and those which are more easily imitated.

Figure 2 depicts this more robust model of resource-based imitation and competitive advantage. It expands the more simplified relationship between the VRIN resource conditions

purported in RBT, and their effect on competitive advantage and performance. The solid lines indicate RBT's current logic; imperfectly imitable resources are distinguished by six characteristics, which limit the likelihood, speed, and nature of resource-based imitation. These characteristics support RBT's contention of the need to possess imperfectly imitable resources in order to ensure a sustainable competitive advantage. They work in concert with resource VRN attributes to provide the means for sustainable competitive advantage and financial performance. This much of the theory is clear and has received empirical support, albeit mixed (Newbert, 2007).

As noted, absent from this model are explicit actions firms undertake to raise barriers to imitation; the model aggregates away firm processes of protection and deployment. The broken lines in Figure 2 depict these firm processes. The expanded model suggests that imitation is a function of resource attributes, firm protection mechanisms, and their interaction. I argue that firms deploy the following three protection mechanisms: legal protection via intellectual property, limited resource observability, and network linkages.

Teece and his colleagues (1997) noted the importance of leveraging existing intellectual property in order to determine the appropriability of a resource. Because intellectual property protection is becoming more prevalent, firms have begun to rely more heavily on this system to protect valuable discoveries, knowledge, and other critical resources. A focus of this dissertation is on the actions firms take to protect their critical resources, beyond the decision to use intellectual property systems.

Observability of deployment relates to how and where firms leverage their resources. Conceptually, perfect observability occurs when resources supporting actual products, which makes reverse engineering particularly straightforward. At the other end of the spectrum,

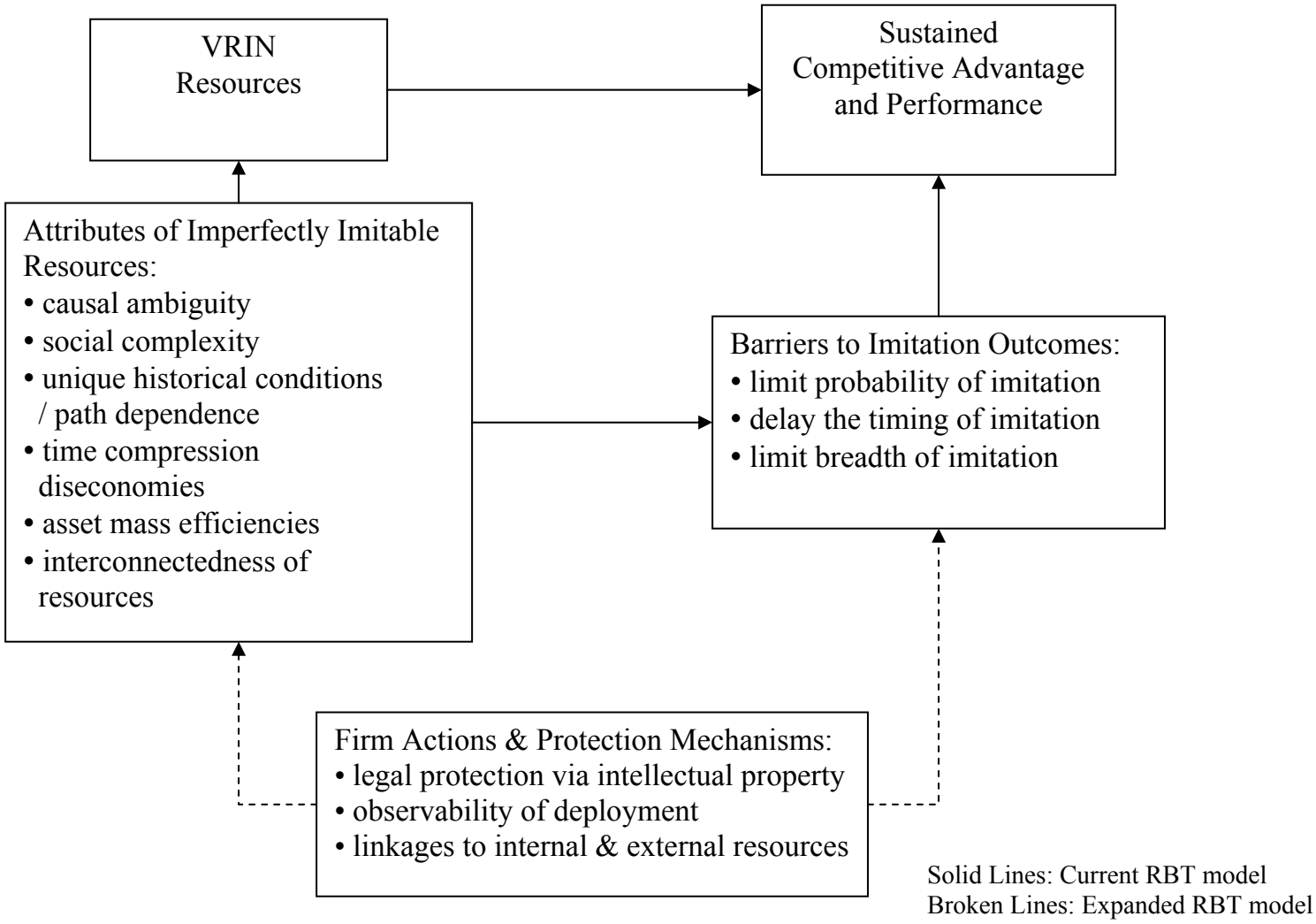
imperfect observability concerns resources supporting processes, routines, or "back-office" activities, which are not well exposed (Teece, 2000). Observability can therefore enhance existing imperfectly imitable attributes, or can mitigate them depending on the breadth of deployment the firm chooses.

Resource linkages concerns how a resource fits within an existing network of resources. Two resource categories are prominent in the literature: contained resources, and system resources. A contained resource is a simple configuration of a network with defined boundaries, which can be valued and traded in factor markets. A system resource exists within a complex network, with no defined boundaries, making it difficult to trade in factors markets. Hence, how firms arrange their resources within an existing system, be it a simple or complex network, may enhance or mitigate existing imperfectly imitable attributes. The next chapter proposes a research model which tests the extent to which resource attributes, firm protection mechanisms concerning and their interaction explain the probability and timing resource imitation.

Summary

To recap, the first section of this chapter reviewed the origins and tenets of resource-based theory. According to this review, at its core RBT makes two fundamental arguments. First, firms holding rare and valuable resources can produce a competitive advantage. Second, when rival firms are unable to imitate, substitute, or transfer such resources for their own use, then these resources may produce a sustainable competitive advantage. The VRIN tenets-rare, valuable, imperfectly imitable, and non-substitutable resources-are necessary for achieving and sustaining a competitive advantage (Priem & Butler, 2001). RBT has enriched strategy research in terms of the "*what"* of theory; it provides a useful framework for examining the determinants of competitive advantage. However, RBT still lacks conceptual precision; its usefulness in

Figure 2. Resource-Base Theory: Imperfectly Imitable Resources, Imitation Barriers, and Sustainable Competitive Advantage



explaining the development, protection, and deployment of VRIN resources is still evolving.

The second section of this chapter provided a review of RBT's conceptualization of imperfectly imitable resources. It identified six characteristics found in the RBT literature: *causal ambiguity*, *social complexity*, *unique historical conditions*, *time compression diseconomies*, *asset mass efficiencies*, and *interconnectedness of resources*. Although these characteristics play an important role in determining whether a resource may in fact be imitated, they lack precision to tell the whole story. These characteristics suggest imitation is inherent in the resource, discounting the role firms play in protecting their resources against imitation. As such, RBT offers little normative guidance for enacting strategies of protection. This section provided a tighter theoretical link between resource attributes and how they are deployed in explaining imitation.

The last section proposed a framework describing a more robust theory of imperfectly imitable resources and competitive advantage. This section concluded with a demonstration of how this framework extends RBT by bringing greater precision to one of its key tenets. The next chapter presents a research model which tests key relationships within this extended theory.

CHAPTER 3: CONCEPTUAL DEVELOPMENT AND HYPOTHESES

As noted in the previous chapter, RBT explains the persistence of firm competitive advantage through the possession and utilization of valuable, rare, imperfectly imitable and non-substitutable (VRIN) resources. RBT's influence on the field of strategic management is illustrated by its rapid diffusion and adoption within the literature (Newbert, 2007; Priem & Butler, 2001). Despite various theories explaining imitation (cf. Lieberman & Asaba, 2006), and the strong link between preventing resource imitation and sustained performance (cf. De Carolis, 2003, Markman et al., 2004), little systematic attention has been given to purposeful or even tactical actions firms take to delay imitation. Moreover, as noted in the previous chapter, RBT's explanations regarding imperfectly imitable resources - *unique historical conditions*, *causal ambiguity*, and *social complexity* – remain under specified. Indeed, these constructs imply that the ability of firms to prevent imitation is largely inherent in the resources they hold. The empirical scrutiny of RBT remains challenging because of its emphasis on attributes that are largely intrinsic or endogenous to resources. Further, RBT offers little normative guidance for firm action or for enacting tactics that would slow the rate of resource imitation (Newbert, 2007). As such, extending RBT helps to explain how particular resource management processes prevent or delay imitation (Helfat & Peteraf, 2003; Sirmon, et al., 2007).

To move RBT forward, in this chapter I develop a more robust theory of actions firms take to reduce the risk of resource imitation. The theory recognizes that imitation is influenced by endogenous attributes of resources, but redirects attention to the role of firm action; how firms

deploy their resources, and to the interaction between resource attributes and how firms deploy said resources. It is a primary thesis of this dissertation that how firms use their resources plays an important role in either facilitating or hindering resource imitation. As RBT suggest, I recognize that resource-based imitation is determined by how resources are acquired or accumulated, but I call attention to the fact that how firms bundle and deploy these resources also influences imitation. To reiterate, RBT's ultimate goal is to explain how heterogeneous resource ownership determines sustainable competitive advantage. This dissertation's focus is on building a midrange theory of resource protection—it aims to explain and predict the extent to which resource imitation is a function of firm action. Thus, while with traditional RBT the primary independent variables (IVs) are VRIN resources and the dependent variable (DV) is usually performance, here the IVs are resource attributes and firm action and the DV focuses on the timing and probability of resource imitation. Providing greater conceptual precision as to *how* firms protect their resources to avert imitation will deepen RBT's explanatory power in understanding the relationship between resource ownership and competitive advantage.

This chapter is organized as follows. First, I describe the key constructs of the research model, I emphasize the distinction between attributes endogenous to resources and how firms deploy their resources. Next, I develop a theory of firm action to delay resource imitation, from which I derive the hypotheses for this study. Central to the theory is the role endogenous resource attributes, how firms deploy resources, and the interaction between resource attributes and how firms deploy their resources. The chapter concludes with a summary of the theory and a brief description of how I test the theory in the forthcoming chapters.

Endogenous Resource Attributes

Scope. Scope describes the extent to which a resource is fungible or its breadth and depth of usability. Resource scope varies based upon usability across different functions within a firm's value chain. Following previous research, scope is the extent to which firms apply a resource through internal processes and products, and through alliances with strategic partners (Lavie, 2006). The scope of a technological resource such as a patent describes its capacity as well as the technological territory where it is applied. Further, patent scope, like other forms of technological intellectual property, distinguishes the inventor's intellectual property from all contiguous technological domains (Markman et al.,2005; Merges & Nelson, 1990; Wu, Levitas, & Priem, 2005). Firms deploy resources with broad scope such as modular design capabilities across several products and processes, whereas resources with more narrow scope such as firm-specific human capital have somewhat more limited function (Pil & Cohen 2006). For example, nanotechnology—the science of manipulating matter on the atomic level—is a broadly scoped resource because it enables molecular manufacturing of matter needed to make products in many industries such as medicine, automobiles, microprocessors, aircrafts, law enforcement (Markman, et al., 2006). Thus, resource scope describes the breadth of its usability within firms' capabilities and supporting activities.

Innovativeness. Following prior research, innovativeness is the extent of radicalness (or newness) of an invention (Rosenkopf & Nerkar, 2001). Researchers generally conceptualized the innovativeness construct along an incremental-radical continuum; some discoveries add incrementally to existing knowledge base, whereas others bring about radical transformation. Unlike technological dynamism, which describes the rate of change in a given technological domain, innovativeness describes the degree to which a resource is different than current resource endowments. Here innovativeness mirrors Schumpeter's (1950) conceptualization of

creative destruction, which describes the process through which new technologies transform industries and product markets. For example, the means through which humans can enjoy music has changed over time, starting from the invention of the phonograph, to subsequent radical inventions of the 8-track, compact disc, and most recently digital technology of the MP3 player. Innovativeness therefore describes a resource's impact on existing resources, including a particular knowledge or technological base.

Linkages. Resource linkages describes the extent to which the resource is integrated; at the extremes an *interdependent resource* is part of a highly complex network of integrated resources, whereas a *stand-alone resource* is highly independent, solely supporting a firm process or product. As I noted in the previous chapter, there are two similar conceptualizations of resource linkages prominent in the literature describing the interdependent/stand-alone dichotomy: 1) contained and system (Black & Boal, 1994), and 2) autonomous and systematic (Teece, 2000). These categorizations diverge based on their level of integration, or the interdependence of the linkages. According to Black and Boal (1994), a contained resource is a simple configuration of a network with defined boundaries; whereas a system resource exists within a complex network, with no defined boundaries. Similarly, Teece (2000) describes autonomous resources as ones with few linkages to existing resource networks; these resources can be deployed without major modifications to the system in which they are embedded. In contrast, systematic resources have many linkages with existing resource networks, and require modification to other sub-systems when deployed. For each conceptualization, linkages signify how tightly or loosely a resource fits into other resource networks, processes, products and contingencies a firm faces when deploying the resource. To illustrate, a biotech firm may accumulate human resources (i.e. scientists) as part of an ongoing stream of research, which is

tightly associated with previous research. Deploying this human resource is contingent upon the resource network in which it belongs. In contrast, the same biotech firm may also possess other human resources, such as accountants and other generalists, who have very tangential linkages to the existing knowledge base or network of resources. Hence, utilizing this human resource is less contingent upon a firm's resource network.

Often interdependent resources (i.e. system or systematic resources) rely upon external resource systems in order for firms leverage them. In contrast, stand-alone resources are generally contained within a specific firm process, and are not beholden to changes in external resource systems. In this study, I make a more nuanced distinction between how a resource is linked with *internal* versus *external* resource systems. This distinction is important because the extent to which resources are linked with internal or external systems affects a firm's ability to protect said resources upon deployment. For example, if a resource is tightly linked with a complex set of external resources, its flexibility of deployment is contingent upon the overall system's flexibility. In contrast, highly autonomous resources, with only limited internal linkages are easier to deploy.

Deployment Mechanism

Firms can deploy their resources in a variety of ways. For instance, firms deploy resources to support the primary activities associated with delivery of products or services to customers. This deployment method refers to front-office processes because they are customer facing. Firms can also choose to deploy resources in functional support activities, such as information technology, accounting or human resource management. These are back-office processes, or production oriented activities because they are concerned with secondary functions of the firm. Stressing the distinction between deploying a resource in front-office versus back-

office processes is important because this deployment decision impacts the resource's level of observability (Teece, 2000). How visible a resource is to external parties affects how well a firm can protect its resources from imitation.

Visibility. Visibility denotes the extent to which external parties can observe the resource in practice. As noted above, resources can support activities throughout a firm's value chain and most resources are observable once firms sell or trade them in markets. For example, resources supporting a new laser printer, microprocessor, or ATM are available for conceptual interpretation and reverse engineering once embedded in products that are brought to the market. Likewise, resources supporting customer-facing functions, such as sales and marketing, can be discerned because of their visibility by external parties. In contrast, resources that support back-office processes are generally less observable (Teece, 2000). For example, external competitors find it difficult or nearly impossible to reverse-engineer proprietary software logarithms that support focal firm's fulfillment or inventory management. Resources supporting back-office processes and routines can be protected if the owners are diligent in applying protection mechanisms, such as trade secrets. Thus, resources supporting back-office processes are inherently less observable than resources supporting product technology (Liebeskind, 1996). As with other resources, patents can support customer-facing offerings and processes or back office processes and activities, and thus vary on their level of visibility, particularly to external observers. The visibility of resources, then, is influenced by how and where said resources are deployed.

Summary of Key Constructs

As noted in the previous chapter, resource imitation is either accelerated or decelerated based on a focal firm's resource management processes. In addition, a resource is susceptible to

imitation when it has certain attractive attributes, or deployment occurs in highly visible processes. For example, resource attributes, such as *scope* and *innovativeness* are likely to attract competitor attention. Likewise, resource deployment supporting highly visible customer-facing activities or products can ease imitation. Other attributes such as resource linkages, may have contradictory effects on the likelihood of imitation. Table 2 and 3 summarize how focal firms and imitators view the attractiveness of particular resource attributes.

Table 2 illustrates the position a focal firm takes to enact its resource management processes and what reactions potential imitators may take given existing conditions. For example, table 2 indicates that focal firms seek out resources that are broader in scope, novel, and have greater internal linkages, while discounting the use of resources that have greater external linkages and that are highly visible. At the same time, imitators pursue a resource that is broad in scope, novel or innovative, and has extensive external linkages. Thus, I suggest that firms enhance barriers to imitation through resource management and deployment. (Wernerfelt, 1984). Further, how and where a focal firm deploys its resources also effects imitation. For example, reducing the visibility of resources also serves as an isolating mechanism. Thus, it is a core thesis of this dissertation that imitation is not triggered solely by the inherent makeup of the resource in question, but also by how firms link or bundle the resource and how and where firms deploy the resource within their value chain (Teece et al., 1997).

Hypotheses

I divide the twelve hypotheses into two sections. The first five hypotheses investigate the effects the key constructs –scope, innovativeness, linkages, and visibility- on the *probability* of imitation. The sixth hypothesis tests the interaction effects between resource attributes (scope, innovativeness, and linkages) and their visibility upon deployment on the probability of

Table 2 Outline of Hypotheses Concerning Probability of Competitor Imitation

Attributes	**Focal Firm Resource Management** Ceteris paribus, what attributes facilitate or hinder the probability of resource imitation?	**Competitor's Actions** Ceteris paribus, what attributes provoke competitors to imitate?
Scope	Focal firms protect and deploy resources with greater *scope to limit the probability of imitation*	Competitor firms are more likely to imitate resources which have greater *scope*
Innovativeness	Focal firms protect and deploy resources with greater *innovativeness to limit the probability of imitation*	Competitor firms are more likely to imitate resources which have greater *innovativeness*
Internal Links	Focal firms protect and deploy resources with greater *internal linkages to limit the probability of imitation*	Competitor firms are less likely to imitate resources which have greater *internal linkages*
External Links	Focal firms protect and deploy resources with fewer *external linkages to limit the probability of imitation*	Competitor firms are more likely to imitate resources which have greater *external linkages*
Deployment Mechanisms	**Focal Firm Resource Management** Ceteris paribus, what deployment mechanisms facilitate or hinder the probability of resource imitation?	**Competitor's Actions** Ceteris paribus, what deployment mechanisms provoke competitors to imitate?
Visibility	Focal firms protect resources with higher *visibility to limit the probability of imitation*	Competitor firms are more likely to imitate resources which have greater *visibility*
Interactions		
Visibility X Scope	Focal firms limit the probability of imitation of resources with greater *scope* and *visibility*	Competitor firms are more likely to imitate resources which have greater *scope and visibility*
Visibility X Innovativeness	Focal firms limit the probability of imitation of resources with greater *innovativeness* and *visibility*	Competitor firms are more likely to imitate resources which have greater *innovativeness & visibility*
Visibility X Internal Links	Focal firms limit the probability of imitation of resources with greater *internal linkages* and *visibility*	Competitor firms are less likely to imitate resources which have greater *internal linkages & visibility*
Visibility X External Links	Focal firms limit the probability of imitation of resources with greater *external linkages* and *visibility*	Competitor firms are more likely to imitate resources which have greater *external linkages & visibility*

Table 3 Outline of Hypotheses Concerning Timing of Competitor Imitation

Attributes	**Focal Firm Resource Management** Ceteris paribus, what attributes facilitate or hinder the timing of resource imitation?	**Competitor's Actions** Ceteris paribus, what attributes provoke competitors to imitate?
Scope	Focal firms protect and deploy resources with greater *scope to impede the timing of imitation*	Competitor firms are *more likely* to imitate *earlier* when they resources have greater *scope*
Innovativeness	Focal firms protect and deploy resources with greater *innovativeness to impede the timing of imitation*	Competitor firms are *more likely* to imitate *later* when resources have greater *innovativeness*
Internal Links	Focal firms protect and deploy resources with greater *internal linkages to impede the timing of imitation*	Competitor firms are *more likely* to imitate *later* when resources have greater *internal linkages*
External Links	Focal firms protect and deploy resources with fewer *external linkages to impede the timing of imitation*	Competitor firms are *more likely* to imitate *earlier* when resources have greater *external linkages*
Deployment Mechanisms	**Focal Firm Resource Management** Ceteris paribus, what deployment mechanisms facilitate or hinder the timing of resource imitation?	**Competitor's Actions** Ceteris paribus, what deployment mechanisms provoke competitors to imitate?
Visibility	Focal firms protect resources with higher *visibility to impede the timing of imitation*	Competitor firms are *more likely* to imitate *earlier* when resources have greater *visibility*
Interactions		
Visibility X Scope	Focal firms impede the timing of imitation of resources with greater *scope* and *visibility*	Competitor firms are *more likely* to imitate *earlier* when resources have greater *scope & visibility*
Visibility X Innovativeness	Focal firms impede the timing of imitation of resources with greater *innovativeness* and *visibility*	Competitor firms are *more likely* to imitate *earlier* when resources have greater *innovativeness & visibility*
Visibility X Internal Links	Focal firms impede the timing of imitation of resources with greater *internal linkages* and *visibility*	Competitor firms are *less likely* to imitate *later* when resources have greater *internal linkages & visibility*
Visibility X External Links	Focal firms impede the timing of imitation of resources with greater *external linkages* and *visibility*	Competitor firms are *more likely* to imitate *earlier* when resources have greater *external linkages & visibility*

imitation. As indicated earlier, research in general, and RBT in particular emphasizes the importance of endogenous resource attributes in preventing imitation, while under specifying the importance of firm actions related to resource protection upon deployment when predicting the likelihood of imitation. In the theoretical model developed in this chapter, I examine the direct effects four endogenous resource attributes-scope, innovativeness, internal linkages, and external linkages-have on the probability of imitation. In addition, the theory examines one attribute of resource deployment mechanism, visibility, and how the visibility of resource deployment moderates the effects of the four attributes listed above. In sum, the first six hypotheses assess the impact of resource attributes and a deployment mechanism on the probability of imitation.

While hypotheses 1-6 focus on the probability of imitation, hypotheses 7-11 examine the effects the same constructs –scope, innovativeness, linkages, and visibility-have on the *timing* of imitation. The twelfth hypothesis investigates the interaction effects between resource attributes-scope, innovativeness, and linkages-and their level of visibility when deployed has on the timing of imitation. The crux of the theory argues that the visibility of resource deployment moderates the effect of the four resource attributes to either facilitate or impede the speed of imitation.

Scope and the Probability of Imitation

Firms deploy resources with broad applications throughout their value chain and across the markets in which they participate. (Prahalad & Hamel, 1990), yet as RBT purports, few resources are effectively deployed in multiple processes or products. Resources with broad applications, such as nanotechnology, can be employed in diverse industries including pharmaceuticals, biotechnology, energy, information technology, and consumer goods. Other resources have very specified uses, such as technological competences supporting a unique manufacturing process (McEvily & Chakravarth, 2002). The latter resource type is termed

'specific' because it is maximally effective in a particular use or when deployed by a particular firm. Theory suggests and empirical research confirms that specified resources proffer the persistence of performance advantages (McEvily & Chakravarth, 2002; Peteraf, 1993).

Resources with broad scope offer performance advantages (Liebeskind, 1996: Teece, 2000); the greater the resource's scope the more likely firms will gain amplification effects over each successive deployment. Amplification effects take the form of knowledge accumulation of how to best leverage the resource, as well as understanding any barriers to imitation (Pil & Cohen, 2006). In addition, a resource with broad functional use may act as a catalyst for more radical innovation. Subjecting a resource to a broad range of contexts increases its adaptability and can create a virtuous cycle of innovation (Steensma & Corley, 2001). Broad usability may improve the performance of the process or product the resource supports with each development cycle. The interplay between extensive deployment of broad resources and further competence accumulation can enhance the efficacy of existing innovation processes (De Carolis, 2003).

The benefits of greater use of broad resources, and the amplification effects which result from each successive deployment, are tempered by the increased risk of imitation. As firms repeatedly apply resources with broad scope across additional domains, they will increasingly garner attention from would-be imitators. For as deployment generates greater and more impactful resources, competitors seek to catch up with leaders through imitation. In addition, greater use brings more opportunities for imitating; this is known as the resource-leveraging paradox (Coff, Coff, & Eastvold, 2006). Coff and his colleagues (2006) argue that as firms scale up their use of knowledge-based resources, especially those embedded with tacit knowledge, they face increasing risks of imitation by potential competitors.

This logic surrounding the connection between scalability and imitation holds especially true for knowledge-based resources such as patents, which often have a broad set of technological claims. In the context of financial services, patents supporting funds processing functions can support ATMs, money counting machines, currency conversion machines, and various other cash handling machines. Owners of these broad resources leverage them in as many domains and functions as possible. Likewise, broad resources supporting financial engineering processes (i.e. mathematical algorithms), can have applications in a variety of client-related application ranging from portfolio management to risk hedging techniques. Competitors can glean much of the pertinent information necessary for imitation directly from patent documentation and from the utilization of said resources (Lerner, 2003). Thus, firms face heightened urgency to protect broad resources and to be more selective concerning their deployment.

To summarize, endogenous attributes of resources furnish imitation barriers. However, firms are also motivated to acquire resources with broader usability in order to take advantage of amplification effects resulting from deployment throughout their value chain. When extensively deployed, broader resources act as a source of knowledge accumulation and trigger increasing levels of innovation. Because of these benefits, resources with broader usability are more vulnerable to imitation. Thus:

H1: The greater the scope of a resource, the more likely it is imitated.

Innovativeness and the Probability of Imitation

According to Schumpeter (1950) firms produce new economic value by introducing radical discoveries. In this process of *creative destruction*, innovations stand to undermine the value of existing technologies or factors of production, shifting dominant market positions and

challenging monopoly rents based on older resource endowments. In models of punctuated equilibrium, Schumpeter's theory focuses more on punctuation than it does on equilibrium; its stresses that each wave of innovation displaces or challenges dominant players from earlier waves. This logic tells a compelling story, yet its focus on the leading edge of innovation while under specifies the pervasiveness of imitation as a means to catch up, compress, and neutralize the advantages already gained from such innovations. In other words, while few winners use innovation to expand the gap of their advantage, many players-incumbents and entrants- destroy said advantage and set competitive parity through imitation. Thus, rapid and widespread imitation undermines the positions gained from innovation, and often motivates parties on the periphery to use imitation as a first step for creating the next wave of innovations (Christensen, 1997).

Past research has focused on the origin of innovations to examine its relationship with first mover advantages (cf. Lieberman & Montgomery, 1988; Makadok, 1998; Tufano, 1989). The emphasis on the acquisition process underscores the importance of understanding where breakthrough innovations come from (Burns & Stalker, 1956). Firms have dual objectives: first, to put in place conditions to foster Schumpeterian rents, and second, to neutralize negative fallout caused by competitors' innovations. Thus, decisions concerning how to first source and then use resources that bring about innovation are vital. For example, Steensma & Corley (2000) found that unique technologies acquired via tightly coupled arrangements (i.e. firm acquisition) had a greater and longer performance impact than unique technologies obtained through more loosely-coupled partnerships (i.e. licensing or joint development). Others focus on organically-driven innovation. Ahuja & Lampert (2001) stress the importance of developing pioneering processes through exploratory learning. Similarly, Sirmon and his colleagues (2007) identify

creativity and the presence of a broad and deep knowledge base as an antecedent of novel resources and new capabilities.

This line of inquiry has yielded interesting extensions of Schumpeter's theory, and has informed RBT on the nature of producing innovations; however it does not address conditions concerning imitation of highly novel resources. For instance, such work does not explain how firms maintain dominant market positions after the introduction of innovations. Although competitors may not understand the underlying knowledge or technologies of novel resources, they do understand the threat it poses to their existing business models, or the dominant logic in the industry (Tushman & Anderson, 1986). Thus, many followers experience strong motivation to imitate innovators. For example, when Netscape developed its web browser, Microsoft, the incumbent firm met it with a strong competitive response. Because Netscape's Navigator™ threatened Microsoft's primary position within the PC-centric business model, the latter imitated some of the technologies underlying the Netscape Navigator. This example illustrates the urgency of imitating highly innovative resources. While imitating generic activities, product offerings, or resources is naturally important, the ability of followers as well as incumbents to accelerate the imitation of innovations is necessary to remain competitive.

To summarize, the introduction of new resources or innovations in factor markets is persistent, albeit somewhat unpredictable. Firms which have a stake in the dominant resource endowments tend to be aware of the threat innovations pose. Even though generic innovations are easier to imitate, firms are more likely to imitate more novel innovations because they are foundational for achieving competitive advantage. Thus, the following hypothesis:

H2: The greater the innovativeness of a resource, the more likely it is imitated.

Resource Linkages and the Probability of Imitation

Resources are bundled or linked[2] together in order to form capabilities. Each capability is a unique combination of resources, which support specific activities within a firm's value chain (Sirmon et al., 2007). How firms bundle a resource depends upon three distinct conditions: the scope of its usability; the level of its innovativeness; and the availability of complementary resources. In addition, firms must determine how to deploy their resources; for example, resources are linked differently when they serve to produce incremental change versus more extensive change. A firm often has limited options in choosing how to bundle their resources because these three conditions are not well synchronized (Teece, 2000). Frequently, for a firm to put a resource into productive use it needs to gain access to complementary resources or a complementary knowledge base, which are often only found *with* external parties (Lavie, 2006; March 1991). The decisions surrounding resource linkages are important because these linkages play a key role in determining potential value and the likelihood of imitation by competitors.

How firms embed their resources has received a great deal of attention in the RBT literature (Eisenhardt & Martin, 2000; McEvily et al., 2004; Teece, et al., 1997). Much of the attention has focused on how firms combine their resources to exploit current capabilities and develop new capabilities. Recent research has complemented the dynamic capabilities perspective with a framework for creating value through dynamic resource management (Sirmon et al., 2007). This framework and other extensions of RBT have offered great insight; however, their emphasis has been on capability building through resource bundling, with scant attention to the important processes of protection and deployment. For example, the dynamic capabilities view suggests firms should embed their resources, but does not adequately specify where and how resources should be embedded, especially when complementary resources are needed from

[2] For ease of interpretation, I use the terms - bundled, linked, and embedded - and any derivations of these words interchangeably.

external parties (Zahra & Nielsen, 2002). The purpose of the next section, then, is to illustrate that where and how firms embed their resources impact the likelihood of imitation.

Internal Linkages. The most expedient method of linking resources is through a firm's existing base of resources. This decision may only grant incremental impact, but it is a way to deepen the base of capabilities, with little cost. This internal linkage method has additional benefits; it allows a firm to pool sources which may aid in maintaining imitation barriers, or in developing new ones. For example, when Gillette obtains an additional patent to enhance its razor technology, its patent is often links the patent to preexisting knowledge stored in earlier patents as well as firm-specific knowledge derived from the capabilities supporting the actual razor. Likewise, in the case of financial patents, Merrill Lynch's ability to gain a dominant position in private banking and wealth management markets is attributable to the barriers to imitation it created with intellectual property and other knowledge-based resources. It fashioned a complex of resources to support its CAP or sweep account[3] (Lerner, 2003; Merges, 2003). In each case, leveraging existing resources to link new discoveries, not only garnered additional capabilities, but ensured the continued efficacy of preexisting barriers to imitation. Barriers to entry derived from internal linkages will naturally subside over time, unless firms can secure additional resource linkages. Given this, the initial deterrence derived from internal linkages projects a strong signal to would-be imitators. This signal discourages imitators because in the final analysis the imitation would be a worthless exercise. Thus, evidence demonstrating the role of resource linkages and the likelihood of imitation suggests the following hypothesis:

[3] A CAP or sweep account is a combination of two or more accounts at a bank or financial service firm. It is useful in managing a stead y cash flow between a cash account where regular payments are made, and an investment account where the cash is able to accrue a higher return. In the late 1970s, Merrill Lynch was one of first investment banks to set up a CAP or sweep account for its clients based on patented innovations and other proprietary processes.

H3: A resource which has greater internal linkages with other firm-specific resources is less likely to be imitated.

External Linkages. Hypothesis 3 specifies the role internal linkages play in deterring imitation; however, as noted above firms are not always able to bundle their resources internally. When this is the case firms must rely upon external resource systems and knowledge to deploy resources, or to fully exploit a new discovery. Given the choice of keeping a resource idle or embedding the resource in an external resource system, firms are apt to seek out external parties to gain access to complementary resources. As Eisenhardt and Schoohoven (1996) note, firms use alliances to gain access to needed resources or to exploit a new discovery within a system of complementary resources. These arrangements allow firms to exchange, share, or embed resources and possibly to co-develop products, services, or technologies (Lavie, 2006). The choice to engage external parties in order to leverage a resource is not risk or cost free, as partners may act opportunistically, regardless of the overall strength of the alliance.

The use of external linkages occurs most often when firms need access to complementary resources in order to better leverage their own resource. Access to complementary resources is often found through strategic alliances; a firm must bring forth additional knowledge and expertise in order to fully leverage the benefits of the alliance (Helfat, 1997). Depending on the context, partners exchange knowledge, skills, and routines, including factors stored in protected mechanisms, such as patents and copyrights. This exchange and transfer of embedded resources is vulnerable to opportunistic behavior of partners. Alliances where complementary resources play a major role often end badly; research indicates that approximately 75% of all alliances fail to meet their original objectives (Ireland, Hitt, & Vaidyanath, 2002). For example, the alliance between Amazon.com and Toy 'R' Us ended in court after Toy 'R' Us accused Amazon of

breach of contract and for improperly using proprietary resources. Under these conditions, the resource-leverage paradox is most acute as the management of shared resources is often beyond the direct control of the partners (Coff et al., 2006). The utilization of resources when linked with partner resources, or as part of a complex external resource system makes imitation a less complicated task. Thus:

> *H4: A resource which has greater external linkages with external resource networks are more likely to be imitated.*

Deployment and the Probability of Imitation

Firms acquire and deploy resources to meet organizational needs or take advantage of an opportunity in the task environment. Through resource acquisition firms broaden their pool of knowledge and capabilities, and use the additional resources to replace outdated ones, or to forge new processes. In fact, theory suggests that resource deployment should stem from actions of acquisition and accumulation (Barney, 1986). RBT argues further that during initial acquisition, the most important resource attributes are fashioned, which later becomes the foundation for how a firm puts them towards productive use. As argued in the previous chapter, deployment decisions should match the evolving environment. RBT discounts the dynamic nature of resource deployment because of its emphasis on endogenous resource qualities and the importance of initial resource acquisition.

However, deployment decisions are more complex than just resource replacement or opportunity matching. Resource deployment is part of an adaptive strategy to better compete in dynamic environments by enhancing the firm's strategic "fitness" (Levinthal, 1997). There are environmental considerations such as rapid change brought on by successive innovations, (Anderson & Tushman, 1990; Tushman & Anderson, 1986), market entrance of non-traditional

competitors (Markman et al., 2006), or structural changes in the industry (Lieberman & Asaba, 2006). Resource deployment also has contingencies related to the attributes of the resources and the availability of complementary resources or stocks of knowledge. Both external and internal contingencies may act to limit or enable how a firm deploys its resources to create value.

Resources support a variety of activities in a firm's value chain. These include products or customer-facing processes and back-office processes or routines, which influence the extent to which rivals can examine resources in action. The variance in the level of observability is important because imitation is predicated—at least to some extent—on how resources are used (Teece, 2000). A thesis of this dissertation is that firms often embed critical resources in back-office processes, which create higher levels of complexity and ambiguity, and thus delay imitation. For example, Walmart's competitive advantage is gained through the deployment of highly sophisticated resources, processes, and routines to support its logistics and inventory management. Because these resource systems support back-office processes, competitor firms have had difficulty trying to imitate Walmart's world-class supply-chain technologies on a similar scale (Lichtenstein, 2005). This illustrates that when firms deploy their resources to support back-office processes, they make said resources more latent than when they support customer facing products and activities (Teece, 2000).

To summarize, effective resource deployment depends on several considerations, including resources' endogenous attributes and the presence (or absence) of complementary resources. Resources supporting products and other customer facing activities are more observable than those supporting back-office processes, making the latter easier to study and imitate. Thus:

H5: Resource imitation is more likely when resource deployment is highly visible (e.g., customer-facing activities and processes).

Visibility as a Moderator of and the Probability of Imitation

An important consideration of resource deployment is its likely observability. Namely, imitation is facilitated when would-be imitators can easily analyze, decompose, and thus reverse engineer the resources because they are deployed in highly visible processes or in products (Teece, 2000)[4]. Thus, exposing resources and making them highly visible augments the likelihood of imitation. A firm's vulnerability to imitation does not end there; highly visible resource deployment can also interact with other important resource attributes to affect their imitation.

Scope and Innovativeness. RBT extols leveraging broadly applicable resources when they are difficult to imitate (McEvily & Chakravarth, 2002; Rivkin, 2001). In the same vain, RBT also encourages the acquisition of pioneering processes to develop or deploy innovative resources to gain first mover advantages (Ketchen, et al., 2004). The advantages often lie in how firms recombine the knowledge which is embedded in resources, and thus rendering the resources difficult to imitate. I argued above that resources with broad usability or that are highly innovative are more vulnerable to imitation. This suggests that any additional resource utilization triggers a resource-leveraging paradox; when scaling up the use of broad and innovative resources, firms must secure additional layers of protection derived from specialized resources or tacit knowledge (Coff et al., 2006). Resources are specialized when they are maximally effective in a particular use or when leveraged by a particular firm (Shane, 2001; Williamson, 1985). The deployment of resources with broad scope requires firms to develop

[4] At the extreme, products and processes which are highly visible can be pirated for nefarious ends. For example, China has developed a reputation as the world's largest market for knock-off (i.e. pirated) goods. In fact, it is believed that about 90% of Microsoft Office software is sold illegal, unauthorized copies.

added layers of protection by embedding the resources in firm processes or routines, which can limit their visibility. Likewise, leveraging highly innovative resources, which are also highly visible, may accelerate resource imitation. This suggests that broad and innovative resources are best deployed in back-office processes and routines, where the threat of visibility limits their imitation (Teece, 2000).

The interplay between resource attributes such as scope and innovativeness, and the visibility after deployment is more acute under conditions where codified knowledge about the resources is easily available for imitators. For example, firms rely on intellectual property (IP) such as patents to support back-office processes because the isolating mechanisms are enhanced when patented technology is deployed within and interlinked with highly contextualized processes (Merges & Nelson, 1990). Similarly, resources such as software supporting financial modeling tools are difficult to imitate because of the complexity, tacitness, and specificity of auxiliary knowledge that is embedded within members who develop and use said resources. The increased visibility of broadly scoped resources deployed to support products or customer-facing processes augments imitators' ability to synthesize the relevant data and develop strategies for imitation without instigating legal wrangling (Lerner, 1995). Thus, the interplay between resource attributes such as scope and innovativeness and visibility can act as a catalyst for imitation, or as a means to erect higher barriers to imitation. The argument above suggests the following hypotheses:

> *H6a: Visibility moderates the relationship between the scope of a resource and its probability of imitation such that greater visibility makes imitation more likely.*
>
> *H6b: Visibility moderates the relationship between the innovativeness of a resource and its probability of imitation such that greater visibility makes imitation more likely.*

Internal and External Linkages. As noted above, how firms combine resources can have differing effects on their probability of imitation. Internal linkages act as buffers, enhancing the efficacy of existing barriers to imitation, while external linkages make resources more observable and thus more vulnerable to imitation. As resources are bundled, a layer of complexity, both social and technical, make imitation that much more difficult. This is illustrated by how building on resource endowments can create path dependencies; adding and interlinking resources and knowledge can amplify the existing barriers to imitation (Lieberman & Asaba, 2006; Somaya, 2003). Resources can be linked to other specialized knowledge residing in human capital or other forms of tacit knowledge, which results in higher levels of causal ambiguity. The effectiveness of Google's technological prowess lies not only with the strength of its intellectual property resources, but also the linkages it creates with internal knowledge, research and development routines. This example illustrates how combining internal resources, both codified and tacit, decreases would-be imitators ability to synthesize the resources' performance effects, making imitation more difficult (Coff et al., 2006; Pil & Cohen, 2006). Similarly, most airlines seeking to emulate Southwest Airlines, JetBlue, or RyanAir face substantial economic and cognitive barriers to imitation. It is easy to rescind airfare prices, but imitating the resource-allocation processes that support operational flexibility and lean organizational structure are not trivial tasks.

Unfortunately, linking resources is not always easy; some novel resources are difficult to bundle with existing internal resources; in fact, many must be linked with complementary resources held by external parties. This makes firms vulnerable to opportunistic behavior of firms with whom they share complementary resources; partners as well as competitors may imitate or misappropriate externally embedded resources. When firms embed their resources

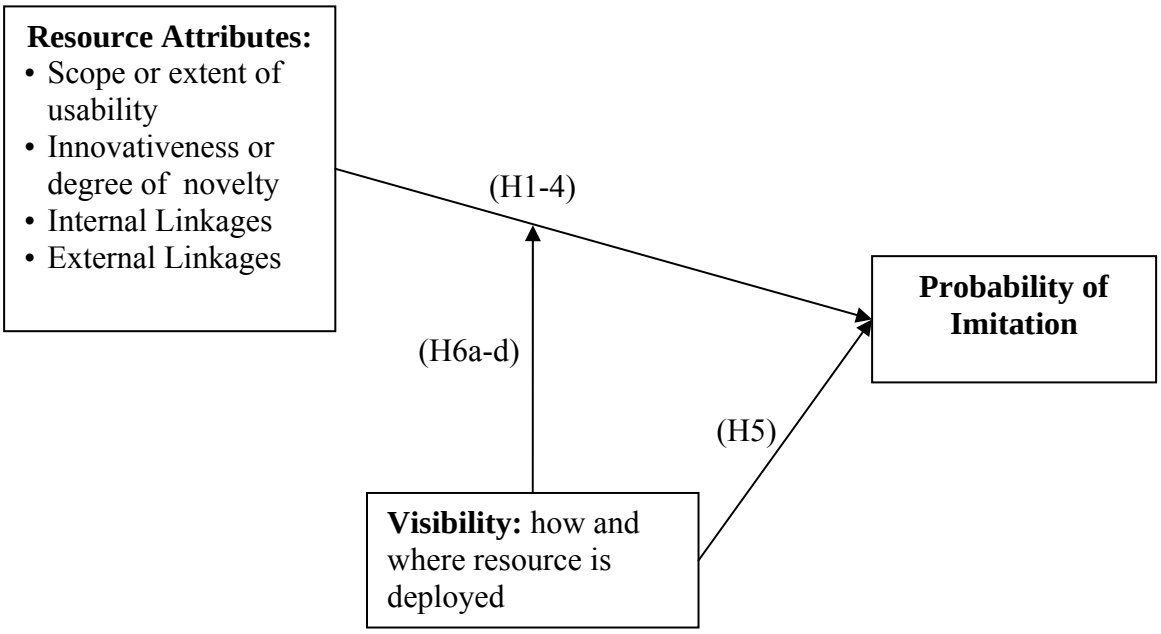
externally, especially with knowledge-based resources, the risk of imitation is heightened (Lavie, 2006). Although trust can be developed in alliances where partners have developed long-term relationships, unintended leakage to third party partners may occur. According to RBT, any gain from the sharing of VRIN resources between strategic partnerships is reliant upon the strength of the relationship, which is subject to change over time. Opportunistic behavior by one or both of the strategic partners in the use of shared resources makes them vulnerable to imitation from third parties. This is one explanation why many joint development programs, where knowledge-based resources such as patents are shared, fail to produce the desired goals and objectives (Ireland, Hitt, & Vaidyanath, 2002).

The benefits gained from leveraging external complementary resources to enhance the efficacy of the focal resource, are diluted when deployed in highly visible processes. The combination of high visibility and the reliance on external linkages make resources more vulnerable to imitation. Likewise, the deployment in highly visible processes mitigates any barriers to imitation derived from internal linkages. Insulating resources in complex internal systems cannot offset the increased scrutiny which comes from customer-facing deployment. It may be true that highly complex and ambiguous processes may be able to withstand the increased vulnerability to imitation which comes with deployment in highly visible processes; however, it does make the completely immune from imitation. In fact, the most effective isolating mechanisms are achieved when linking resources internally, and then deploying them in back-office processes, that are difficult to observe. The argument above suggests the following hypotheses:

> *H6c: Visibility moderates the relationship between the internal linkages of a resource and the probability of its imitation such that greater visibility makes imitation more likely.*

H6d: Visibility moderates the relationship between the external linkages of a resource and the probability of its imitation such that greater visibility makes imitation more likely.

Figure 3. Theoretical Model of the Probability of Imitation



The argument above centered on how three elements, resource attributes, their deployment, and their interactions, ease or impede the likelihood of imitation. This section extends my theory to examine how these effects influence the timing of imitation. The timing of resource imitation is just as important as the likelihood that imitation will occur because timing denotes the window of opportunity firms have to secure first-mover advantages. The efficacy of barriers to imitation lies in the ability of resource holders to limit and delay imitation. The remaining six hypotheses developed below relate specifically to the timing of imitation.

Scope and the Timing of Imitation

As noted above, specialized resources are often imperfectly imitable. Their possession and deployment may allow performance advantages to persist because idiosyncratic features

make reverse engineering and thus imitation very difficult. As a consequence, the likelihood of imitation is rather low. Even when imitation is inevitable, the time needed for perfecting highly contextualized knowledge, processes, and routines complementing specialized resources, can make imitation a lengthy and costly pursuit. Potential competitors are hindered by a lack of contextual experience and inadequate intelligence gathering (McEvily & Chakravarthy, 2002). In addition, because specialized resources are applied in a small number of contexts, there are fewer avenues for which critical knowledge can leak to external parties. Because a discreet group of employees are applying the resources to service a narrow set of customers, potential leaks take more time to translate into actual imitation. All of these factors suggest that highly specialized resources not only will be difficult to imitate, but will take longer to occur (Hunt & Morgan, 1995; Williamson, 1985). For example, Sony applied modular design technology to improve the performance of its video tape players. Although it applied modularity, a broad resource technology, the modular design was deployed in a highly specialized process, causing imitation to occur at a slower rate (Pil & Cohen, 2006).

Firms tend to deploy resources with broader usability in more diverse settings. Greater utilization of broad resources can generate positive externalities such as learning effects. However, when broad resources are deployed widely they are managed by a greater number of employees and interface with more customers, which create opportunities for gleaning insights about the nature of said resources. Broad deployment eases competitor firms' intelligence gathering because they are able to obtain incremental, confirming and disconfirming information upon analyzing the different activities where the resources are applied (Zajac & Bazerman, 1991). In addition, by employing broadly-scoped resources in numerous activities, firms may unintentionally undermine the effectiveness of complementary resources as a means of barriers

to imitation (Teece, 2000). The combination of these 'negative' externalities may allow competitors to imitate the resource more quickly.

This logic can be applied broadly to a variety of resource types, but it appears to be particularly acute to knowledge-based resources. For example, as firms leverage their broadly-scoped resources in more domains, they minimize the effectiveness of embedding complementary resources as imitation barriers. Greater deployment eases interpretation of any codified knowledge, and also any tacit knowledge needed to maximize resource utility.

To summarize, application of resources in a variety of processes allows more opportunities to create value. However, deploying resources in numerous areas or functions is not without risk, as resources are more extensively applied, there are greater opportunities for imitators to uncover important features of the resource (e.g., through reverse engineering). Thus, evidence demonstrating the role of resource scope and the timing of imitation suggests the following hypothesis:

H7: The greater the scope of a resource, the earlier it is imitated.

Innovativeness and the Timing of Imitation

According to RBT, the introduction of innovations grant firms dominant market positions. Dominant market position is often tenuous because of the dual threat of imitation and the introduction of the next wave of innovation. Firms threatened by the "gales of creative destruction" are generally provoked into action, including efforts to imitate the innovations or minimize their effect on dominant business models. For lagging incumbents, imitation is the most likely option because they lack the knowledge base to understand and interpret innovations (Rivkin, 2001). Frequently, incumbents imitate after an innovation becomes an industry standard. Examples are boundless: firms such as Xerox, Kodak, and Sony, were late adopters of

digital technologies; retailers such as Montgomery Ward, Kmart, and Sears were late adopters of supply chain and inventory management technologies; while stodgy manufacturers such as GM, Ford, and Chrysler were late adopters of lean manufacturing technologies. The combination of inertial forces and a dearth of relevant resources and capabilities preclude incumbents from responding quickly to the introduction of new resources, including innovations (Christensen, 1997; Tushman & Anderson, 1986).

This logic suggests that even when firms are aware of impending threat of innovation, and are motivated to respond and match the imminent threat, they may not have the capabilities necessary to meet the challenge (Chen, 1996). This is the "incumbent's dilemma"; how to combat or take action when the most beneficial options – to imitate innovation quickly or produce a next generation innovation – are beyond the firm's existing resource base and capabilities. Firms respond by attempting to develop balanced resource management processes. Although this goal is commendable, it is difficult to consistently generate the pioneering processes needed to create new capabilities (March, 1991; Sirmon et al., 2007). The presence of strong incentives to respond strategically via imitation is offset by the absence of firm resources and capabilities needed to effectively challenge innovations.

The timing of imitation of novel innovations is contingent upon how quickly would-be imitators absorb and then apply the resource (Zahra & George, 2002). When a highly innovative resource is introduced, other players try to analyze the innovation and its underlying technology. This is followed by an elongated digestion period as firms try to incorporate the insights into their existing knowledge base. Because of the complexity of integrating fundamentally different knowledge within a preexisting resource base, imitation takes a more gradual trajectory. The speed of response is tempered by the fundamental challenges of replicating new information with

antiquated processes and firm structures (Eisenhardt & Martin, 2000). Thus, evidence demonstrating the role of resource innovativeness and the timing of imitation suggests the following hypothesis:

H8: The greater the innovativeness of a resource, the later it is imitated.

Resource Linkages and the Timing of Imitation

RBT argues that competitive advantage is often derived from bundled resource systems, rather than a simple resource configuration (Black & Boal, 1994). RBT further suggests that firms develop distinctive processes, ways of coordinating and combining their stocks of resources, in order to unbundle and rebundle them when conditions change in the external environment (Sirmon et al., 2007; Teece et al., 1997). These processes are tools that manipulate resource configurations, and create value when carried out in idiosyncratic situations given external environmental conditions. Thus, capability building through effective resource bundling can secure short term advantages in dynamic markets, and long term advantages is more stable markets (Eisenhardt & Martin, 2000). This dissertation concurs with RBT logic, but I also stress that how firms bundle resources influence their subsequent imitation. For instance, when a resource's utility hinges on its links to other resources or knowledge base (e.g. R&D scientists with prolific research labs), the probability of imitation is lowered. Resources that are combined with external, complementary resources are exposed to imitation due to opportunistic behavior by external partners or through involuntary spillover. Spillover, or the leaking of information derived from knowledge-based resources, is a common risk to firms that use partners or share critical resources with suppliers or even competitors. Following the internal-external dichotomous framework used above, I investigate the effects of resource linkages on the timing of imitation.

I argue that firms take purposeful action to create isolating mechanisms by linking critical resources with a complex internal system. This is done to minimize the probability of imitation, and also to delay imitation. Resource bundling can take the form of layering onto an additional resource base or by leveraging complementary resources held by external parties (Teece, 2000). For example, firms may choose to develop technological resources which are compatible with existing standards, and thus are extensively linked to an external resource system, or they can choose a more autonomous path, developing new technologies to create a new industry standard (Schilling, 1998; Teece, 2000). When Apple developed the software to run its iPods, instead of creating it entirely in-house, it contracted with external firms (i.e. PortalPlayer for software platform and Pixo for user interface software) because these technologies were already becoming industry standards. Regardless of the method, by coordinating and combining with firm-specific resources, firms can render the process of imitation more arduous. Complex resources take longer to reverse engineer because a great number of components, and the relationships among them, must be examined.

Imitation processes such as reverse engineering are especially challenging when applied to knowledge-based resources because they generally have well-defined prior development paths. When firms layer resources with existing knowledge-based technologies and complementary resources they create a highly complex resource system (Black & Boal, 1994). When Microsoft develops its technological resources to support its Vista operating system, the software is composed of prior knowledge based on earlier Window versions, as well as newly developed knowledge supporting the technology. Likewise, Intel's technological resources are deeply embedded in previous knowledge accumulation as well as newly developed resources. Each case represents how firms leverage existing stocks of resources to link incremental

innovations and to preserve existing barriers to imitation. While these isolating mechanisms naturally subside over time, their initial impact delays imitation.

Increased exposure, which accompanies external linkages, plus the reliance on shared knowledge to maximize resource utility, accelerates imitation. For example, firms may cede control of proprietary information when they embed their resources with complementary knowledge from external parties. By relying upon idiosyncratic knowledge from external parties, firms become vulnerable to opportunistic behavior. The result will be less time to synthesize the embedded technological know-how, and thus a shorter window to imitate its content. The argument above suggests the following set of hypotheses:

> *H9: The greater a resource is internally linked with other firm-specific resources, the later it is imitated.*
>
> *H10: The greater a resource is externally linked with interfirm resources, the earlier it is imitated.*

Resource Deployment and the Timing of Imitation

The front-office / back-office dichotomy infers that resource deployment influences the probability of resource imitation. Likewise, it is expected that how resources are deployed affect the speed at which imitation occurs. Teece (2000) notes that product and customer-facing technologies are observable and therefore easier to reverse engineer. In contrast, process or back-office resources are more difficult to observe and hence more difficult to analyze and imitate.

As noted above, resource deployment choices are contingent upon both internal and external conditions. When firms deploy a critical resource in back-office processes they raise its complexity, which is an action that maintains or even enhances barriers to imitation. This is true for all types of resources, but more pronounced in knowledge-based resources. Returning to the

Merrill Lynch example, when launching its CAP account, Merrill Lynch deployed its patents in back-office money management and customer support systems in order to create greater levels of complexity and specificity surrounding the product. Attempts at imitation were slow because Merrill Lynch was able to create high barriers to imitation through the complex deployment of its technology-based knowledge and other tacit knowledge (Merges, 2003). In contrast, Amazon.com's one-click system technology[5] supports a highly visible, customer-facing process. Although it is patent-protected, it was quickly imitated by numerous competitors because the technological resource was easy to detect, analyze and deploy in diverse business models. Resources supporting products and other customer facing activities will in turn be more visible than those supporting back-office processes, making the former easier to study and imitate. Thus, the role of resource visibility and the timing of imitation suggest the following hypothesis:

> *H11: Resource imitation occurs earlier when resource deployment is highly visible (e.g., customer-facing activities and processes).*

Resource Deployment as a Moderating Mechanism of Imitation Timing

Resource deployment decisions greatly impact the likelihood of imitation. Embedding resources in back-office processes creates a barrier to imitation. How long this first-mover advantage lasts depends upon a firm's ability to limit or delay competitors from imitating their critical resources. The theory described below examines how the decision to deploy in front-office or back-office processes moderates the relationships developed in hypotheses 7-11. Applying similar logic from hypotheses 6a-d, the following sections argue that a resource's relative visibility acts to either accelerate or impede the timing of imitation.

[5] In 1999, Amazon.com sued BarnesandNoble.com for patent infringement of its "1-click" patent (US patent No. 5,960.411, *Method and System for Placing Order Via a Communications Network*). The lawsuit was eventually settled out of court in 2002; however, in 2006 the USPTO ordered a reexamination of the 1-click patent based upon a request that it did not cite prior art – an earlier e-commerce patent and Digicash electronic cash machine.

Scope and Innovativeness. This dissertation has argued that resource scope and innovativeness are important resource attributes, which the focal firm seeks to leverage while competing firms seek to imitate. Each attribute affects not only the likelihood of imitation, but also the speed at which imitation takes place. For example, when investigating patents, theory suggests that firms seek to obtain legal entitlement on a broad set of claims in order to enhance the value of the patent and to act as a catalyst for future discovery (Merges & Nelson, 1990). Firms seek to develop highly novel resources because they generally carry greater value when deployed, and can grant their owners competitive advantage (Shane, 2001). As valuable as these resources are to the holding firm, broadly-scoped and innovative resources also carry great value in factor markets, which may prompt competitors to imitate.

The ability of competing firms to imitate these resources is partially determined by how firms deploy said resources. Because knowledge-based resources already have an established technological trajectory, firms seeking to add additional layers of protection must embed them in less visible processes and routines. Highly visible processes can expedite a competitor's attempt to replicate the knowledge within the resource and the processes it supports. There is a fine distinction between the attributes scope and innovativeness, and the effects of deployment decisions. In the case of scope, it is expected that highly visible deployment accelerates imitation, as firms are able to quickly discern how the resource is being used in multiple contexts. Competitor information gathering processes are also enhanced because imitating firms are not constrained by complex or firm-specific internal processes.

The deployment of resources in highly visible processes also accelerates imitation. Above I argued that highly innovative resources were subject to longer periods prior to imitation because competing firms did not have an adequate knowledge base to fully understand the

breakthrough technology. Yet, this deficiency of knowledge can be tempered by the ability to view how the resource's technologies work in practice. For example, because resources developed from nanotechnologies are broad in scope, they are likely to be imitated quicker, unless they are deployed in back-office processes or routines. When broad or innovative resources support highly visible products or customer-facing activities the effectiveness of existing knowledge barriers to imitation is restrained. The argument above suggests the following hypotheses:

> *H12a: Visibility moderates the relationship between the scope of a resource and the timing of its imitation such that greater visibility accelerates imitation.*
>
> *H12b: Visibility moderates the relationship between the innovativeness of a resource and the timing of its imitation such that greater visibility accelerates imitation.*

Internal and External Linkages. Choices firms make regarding deployment and how to embed their resources affect not only whether resources are likely to be imitated, but also how quickly. I argued that internal linkages may act as buffers, or isolating mechanisms preventing imitation. Internal resource bundling creates greater complexity, tacitness and specificity, which make imitation more difficult. In the case of knowledge-based resources, information culled from existing resource system is difficult to discern when combined with highly contextualized knowledge, thus creating high barriers to imitation (Rivkin, 2001). This is especially true of technological discoveries which are codified, but are supported by human capital or tacit knowledge. For example, Goldman Sachs and Merrill Lynch have developed reputations for being innovators in the financial services industry. Their effectiveness is to some extent a function of their ability to coalesce novel resources with the tacit knowledge culled from their vast array of human capital. Their collective knowledge base and their ability to link innovations to existing internal resources aid in erecting salient barriers to imitation (Tufano, 1989; Frame &

White, 2002). While this dissertation has determined the effectiveness of combining resources with existing resource stocks, it has also identified external linkages as sources of imitation vulnerability.

The choice of resource deployment moderates the relationship between linkages and time to imitation. Deployment in highly visible processes affects both internally and externally linked resources providing greater access to competitors to view them in practice. Resources deployed in customer-facing processes offer more sources of potential knowledge leak, since the processes can be observed by a larger set of customers and competitors. Although internal linkages can buffer resources from swift imitation, this barrier is weakened to some degree with highly observable deployment. Visibility has the same effect on resources with greater external linkages, but it is more intensified because externally linked resources are not endowed with strong barriers to entry. The argument above suggests the following complementary hypotheses:

> *H12c: Visibility moderates the relationship between the internal linkages of a resource and the timing of its imitation such that greater visibility accelerates imitation.*
>
> *H12d: Visibility moderates the relationship between the external linkages of a resource and the timing of its imitation such that greater visibility accelerates imitation.*

Summary

RBT has treated resource imitation in simplistic terms; imitation occurs when resources add value and do not possess certain qualities such as causal ambiguity, social complexity and unique historical conditions. The research model presented in this chapter suggests a broader view of resource imitation. The model posits that resource attributes, deployment decisions, and their interaction influence a competitor's ability to imitate, which subsequently affects the

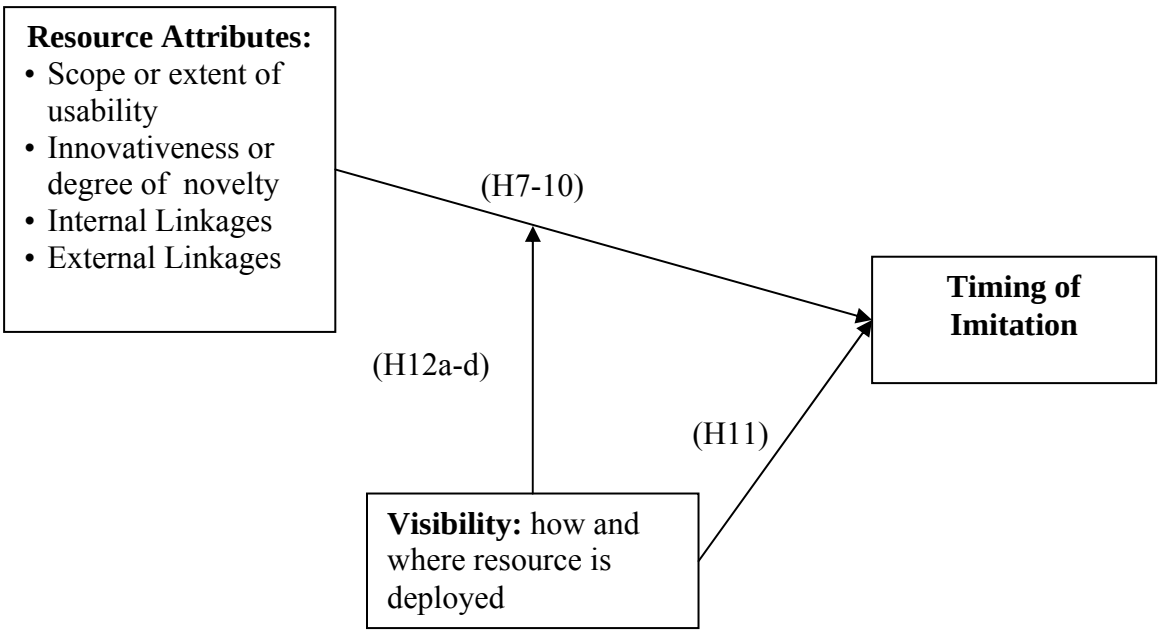


Figure 4. Theoretical Model of the Timing of Imitation

likelihood and timing of imitation. It is important for firms to understand these multiple-layered effects when developing protection and deployment strategies. My framework speculates that instead of simply embedding critical resources in existing processes and routines, firms should combine said resources with highly contextualized internal processes and stocks of knowledge, while limiting exposure of customer-facing processes.

In the next chapter I outline the research design utilized for this study, describe the sample chosen to test the theoretical model, and explain the variables of interest. Lastly, the chapter details the statistical procedures used to test the hypotheses.

CHAPTER 4: RESEARCH METHODOLOGY

Research Design Overview

While the study of imitation is a universal concern across business disciplines, the investigation into the *probability* and *timing* of resource imitation has received a paucity of empirical research. The importance of isolating mechanisms in limiting imitation is well established in the literature; RBT, for example, extols its importance in a firm sustaining a competitive advantage. However, specifying factors which improve the efficacy of isolating mechanisms remains underdeveloped, and is a critical factor in moving theory forward. This dissertation seeks to expand RBT by providing a tighter theoretical link between resource attributes and their deployment and subsequent imitation. By testing the research model proposed in the previous chapter, this dissertation will further broaden RBT's treatment of imperfectly imitable resources and clarify the role of firm purposeful action (i.e. how firms deploy their resources) in sustaining a competitive advantage. The research context for this study is the financial services industry. Specifically, the research model relies on a sample of financial patents, a critical resource used by financial service firms, across various industries.

As outline in table 4 this dissertation employs a two phase research design to test the theoretical model proposed in the previous chapter. In Phase I, an exploratory study is conducted to better understand the development and patenting of financial innovations and subsequent imitation of these innovations. The goals of this phase are 1) conduct a reality test of the initial conceptual model developed through literature review; 2) gain a better understanding of the phenomenon; 3) refine the theoretical constructs and validate measures used to empirically

test the model; and 4) develop testable hypotheses. The exploratory study consisted of a series of interviews with six subject matter experts totaling approximately 35 hours. These six subject matter experts (SMEs) were chosen because of their expertise in one or more of the following areas: 1) financial innovation, 2) financial patenting, 3) financial service marketing and sales, or 4) financial services operations and customer support systems.

Table 4: Two-Phase Research Design

Phase	Activities
I	Eleven total interviews. An in-depth, face-to-face "active interview" with each subject matter expert (SME) and five follow-up interviews via telephone (the sixth SME was unavailable for a follow-up interview).
II	Cross-sectional study consisting of the full sample (1911 financial patents) used to validate the research model and empirically test the attendant hypotheses.

Phase II consists of a cross-sectional study using the full sample of 1911 financial patents to test the research model developed during Phase I. A cross-sectional method was chosen in order to investigate the probability of imitation occurring and the timing of imitation. This chapter elaborates on the two-phase approach utilized in this study. It next describes the data collection effort and justifies the choice to test the research model using financial patents as a proxy for critical resources. Then, the population and sample used in the study is presented. Lastly, the operationalization of the variables in the research model is presented along with a plan to analyze the data.

Phase I: Exploratory Study

Phase I consists of an extensive exploratory study of financial innovation and patenting in the financial services industry. Central to this phase is the interviewing of six SMEs – practitioners with intimate knowledge of the field of financial services, especially the development, deployment and protection of financial innovations. Interviews are an important

tool used by researchers in the social sciences (McGrath, 1982). Interviews provide the opportunity to gain useful knowledge, sentiments not generally captured in surveys or through secondary data collection and the ability to probe more deeply into a phenomenon. For example, interviews yield rich qualitative depth, test for previous inconsistencies, validate the contextuality of the research domain, which can further refine the initial research model. The interviews were not intended to function as the primary data source for this study, but to help refine the constructs and research model developed through the literature review. Data gathered during the interviews and through subsequent interactions with the SMEs were necessary to develop and validate the measures used in this study.

As noted above, the goal of this phase is to ground the phenomenon in order to refine the constructs, and to validate the measures used to test the theoretical model. To this end, a diverse set of SMEs were selected to conduct the interviews. The SMEs in the sample possessed expertise in each stage of the financial patenting process, from discovery of the novel idea, to the prosecution of the patent with the USPTO, to the eventual deployment of the patent within the firm's value chain. For example, two of the SMEs, an entrepreneur and a banker specializing in ATM technologies, discovered a financial protocol which eventually was patented. An attorney was an expert on the patenting process, and the vast prior art referenced by many of the financial patents. Lastly, two additional bankers and a consultant had substantial experience in deploying patented technologies. Appendix A provides a brief description of the six subject matter experts employed during this phase.

Through the SME interviews, the objective is to obtain qualitative and subjective understanding of the financial patenting process. The interviews focus on the following: 1) development process of financial inventions, 2) adoption of critical inventions within the

financial services industry and 3) the initial decisions concerning deployment and protection of these discoveries. These three focus areas are important because the ability to patent financial innovation is a complicated, considerable process (cf. Lerner, 2002, 2003). For instance, many of the most important early financial innovations were not patentable at the time in which they were invented. Therefore, it was critical to determine when a financial innovation was truly invented, and if and when it was actually patented. For example, when measuring the variable *patent innovativeness*, the innovativeness of the patent must be measured relative to the prevailing financial innovations that were never patented. Here the SMEs are invaluable; they are able to place a financial patent in its evolutionary context. Also, because they are neutral parties to the research conducted, many of the interview-related biases, such as self promotion or prior beliefs that often surface, are kept in check (de Vaus, 2001; McGrath, 1982).

This phase is described as a series of active interviews, but because developing qualitative case studies is outside the dissertation domain, the interviews were not transcribed. Instead, attention is focused on gaining deeper understanding of the evaluation processes of financial innovation and their impact on imitation: resource attributes and commercial viability, protection and deployment criteria, and post-deployment imitation. Attempting to build a comprehensive picture of the phenomenon, the interview script consists of an open-ended questionnaire that maximizes the time with each SME. Based on extensive research of the financial innovation literature the following critical topics are identified. Appendix B describes the interview outline used for this study.

1) Background and short history of financial innovation: At the onset of each interview, in order to "break the ice" and build rapport and credibility, the opening dialogue included a broad overview of each SME's current role and overall expertise. The opening

question, intended to stimulate discussion, focused on the evolution of financial innovation, including key milestones over the past 25 years. In order to make the data more reliable, the interviews were conducted in informal, natural language, which set the interviewees at ease. This created an environment of inhibition, where personal viewpoints were more easily expressed, thus presenting a more realistic "snap- shot" to the investigator (de Vaus, 2001). The ultimate goal was to set the stage for a more in-depth dialogue regarding the key constructs described earlier.

2) Resource Attributes & Commercial Viability: This line of questioning was meant to tease out the most important endogenous characteristics of financial patents; what makes them rare and valuable (Markman et al., 2004). The questions centered on what makes a financial innovation patentable, and what attracts competitor firms to attempt to imitate a financial innovation. Also discussed were the evaluation processes firms use to determine the commercial viability of a new discovery.

3) Protection and Deployment Criteria: Next**,** the focus turned to the protection and deployment mechanisms firms use in order to buttress barriers to imitation, beyond the normal barriers created with IP protection. Additionally, the discussion centered on how firms deploy their financial patents in order to maximize their rent-producing potential, without increasing vulnerability to imitation.

4) Protection and Deployment Criteria: Questions focused on the nature of financial patent imitation once it has been fully deployed by its owner. Of interest was whether firms were generally aware that their patents were being imitated, and what factors impacted the likelihood and timing of imitation.

5) Conclusion and Debriefing: Each interview concluded with a summarization of the discussion, and an invitation to participate in a follow-up interview. Finally, any closing questions were addressed as well as discussion about the goals and methods of the study.

In sum, in order to collect rich qualitative data, interviews were conducted with six SMEs. After a brief telephone conversation informing them of the study's broad purpose, interviews were scheduled based on their own time contingencies. Prior to each interview, each participant's biography was reviewed (the bios were culled from web searches and from previous email communications). This previous knowledge helped this investigator to foster legitimacy and trust. Each initial interview was conducted in person, and as expected lasted approximately 60 minutes. As noted above, at the end of the interview, each participant was asked to participate in a follow up interview. Follow-up interviews were conducted with five of the six SMEs. The sixth SME was unavailable for a follow-up interview. Follow-up interviews were conducted via the telephone, and were meant to triangulate the data accumulated after the initial set of interviews. In addition, these follow-up interviews were intended to initiate the measurement validation process, which will be described in detail later in this chapter. Approximately 35 hours were spent interviewing the SMEs, which includes post-interview debriefing.

Phase II: Cross-sectional Study

Phase II consists of a cross-sectional study using the full sample of 1911 financial patents to test the research model developed during Phase I. The determination to focus exclusively on patentable innovations was based on data collected from the exploratory study. Financial patents are a good proxy for financial innovation. This conclusion was further justified by the following three reasons. First, previous research has tended to use narrow subsets of financial innovation

to test theory. For example, in his study of first-mover advantage in the investment banking industry, Tufano (1989) sampled only 58 innovations in corporate and mortgage-backed securities. While the study's findings gave insight into how innovators leveraged their first-mover position, scholars should use caution interpreting the results, given the limited scope of the sample. Further, in their review of empirical studies of financial innovation, Frame and White (2004) called for using broad sampling strategies. Researchers using narrow samples are restricted in their ability to identify effects of the external environment and internal behavior by firms on antecedents to and outcomes of financial innovation. Clearly the narrow focus of previous samples tempers the generalizability of their findings. In contrast, the financial patents in this study cover a much broader set of innovations, ranging from financial instruments, to back-office processes, to support technology. Because financial patents cover a broad range of financial innovation, they offer greater generalizability of the research findings.

Second, financial patents offer clear and concise data about the innovations, specifically concerning the initial deployment, timing of imitation, and breadth of imitators. There is a strong empirical tradition for the use of patent data. For example, researchers have used patent data to study a variety of industries including: software, financial services, pharmaceutical, biotechnology, and consumer electronics (Ahuja & Katila, 2004; De Carolis, 2003; Lerner, 2003; Mansfield, 1986; Markman et al., 2004; Merges & Nelson, 1990; Rosenkopf & Nerkar, 2001; Spencer, 2003; Wu et al., 2005, just to name a few). Data gathered from patents are easily interpretable; detailed information is provided regarding the domain of the technology and the claims of the inventor. There is little ambiguity into the nature of a patent, it is codified knowledge. In addition, patent analysis allows researchers to track the diffusion of the innovation through forward citation. This objective data compliments the rich data gathered from the

interviews with the SMEs conducted in Phase I. Lastly, the use of patent data offers strong reliability and validity of the key variables of interest.

Third and most importantly, the patenting of financial innovations has grown exponentially during the past 25 years and has become a critical component in achieving a competitive advantage in the industry (Lerner, 2003; Merges, 2003). Several factors explain the spike in patenting, especially financial innovation patenting. First, the legal environment changed when in 1982, the US Congress created a specialized appellate court to hear patent cases, the Court of Appeals of the Federal Circuit (Kortum & Lerner, 1999). This court's decisions have been widely regarded as 'pro-patent', they have broadened the technological contexts in which discoveries can be patented, and have strengthened the rights of patentees. This was the most significant shift in domestic patent policy over the past 150 years. The end result has been the proliferation of patenting into technological domains such as financial algorithms, which up to approximately 1980 would have been deemed un-patentable (Merges, 2003).

To summarize, I chose to sample financial patents to test the theoretical model because financial patents offer advantages over other measures of critical resources. Unlike previous studies which used narrow subsets of financial innovation, financial patents cover an extensive range of financial innovation, which improves the generalizability of the study. In addition, financial patents contain concise data innovations, including the initial deployment, timing of imitation, and breadth of imitators. Lastly, in concert with the general trend of increased patenting, the patenting of financial innovations has had tremendous growth during the past 25 years. Financial patenting is an important strategy financial services firms utilize to create barriers to imitation and establish competitive advantage.

Sample Characteristics

As noted above, this dissertation focuses on imperfectly imitable resources to test the research model. The sample consists of one class resources, patents. A patent is a tangible incarnation of invention. Patents indicate the creation of knowledge that is (1) novel to the current state of practice; (2) can potentially provide some economic value to the greater society in which it is granted; and (3) is not an obvious or commonly understood. A patent, therefore, represents in invention; it is a novel and potentially valuable combination of knowledge that is a significant improvement over preceding knowledge.

To proxy financial innovation, the sample contains financial patents. Bounding the sample within a particular technological domain is justified because the research model is at the resource level. Thus, the unit of analysis for this study is at the resource or patent level. There are several advantages for building theory at the resource level of analysis. First, the study focuses on one particular type of resource, thus avoiding much of the criticism about "broad" resource definition associated with past RBT empirical work (Newbert, 2007; Priem & Butler, 2001). Second, focusing on one form of resource limits much of the "noise" common in studies where resource bundles are aggregated at the firm level (Foss & Foss, 2005). Lastly, the study develops a finer-grained, mid-range theory concerning the relationship between resource's endogenous attributes, firm purposeful action, and resource-based imitation, which extends RBT.

The sample is constructed following the technique used by Lerner (2002, 2003). It includes all financial patents issued during the 25 year period between1980-2004. Financial patents are defined as all patents assigned to the following USPTO subclasses: 705[6], "Data Processing: Financial, Business Practice, Management, or Cost/Price Determination"; 705/35-38,

[6] At the time of its award, each patent is assigned to one or more of approximately 100,000 patent classes. These patent classes are updated periodically by the USPTO, when new subclasses are created.

and 705/4, considered to be traditional financial patenting, subclasses 705/39-45 and 902/1-41, which are associated with back-office processes (Lerner, 2003). Appendix C provides an overview of the patenting process and the patent class definitions as provided by the US Patent and Trademark Office.

To avoid selection bias, the sample is parsed into several sub samples. The first set of sub-samples is created using Excel Spreadsheet and the "randomize" command function to generate sub-samples consisting of 10%, 25%, and 50 % of the overall sample. The second set of sub-samples is parsed by patent year of issuance; 1) a sub-sample of patents from the first ten years, 1980-89; 2) a sub-sample of patents from the next ten years, 1990-99; and 3) a sub-sample of patents from the last five years, 2000-04. For both the "randomized" and "date" parsing sub-samples, no significant differences were identified. The full sample consisted of 1911 financial patents from the subclasses noted above. Approximately 800 firms or private citizens are represented in the full sample. Descriptive statistics of the full sample is reported in the next chapter (see 10).

Other Measurements and Instruments

Dependent Variables

This dissertation employs two imitation related measures: 1) likelihood that imitation of the resource would occur and 2) given resource imitation, the length of time it took for imitation to take place after its initial deployment. These measures are further explained below.

Probability of Imitation. To distinguish if the patent is imitated after its issuance, forward citation by an external party other than the inventing firm is measured. Hence, the first dependent variable refers to forward citation, where patents that were forward cited by another entity are coded 1; if no forward citation occurred the patent is coded 0. For this study, a valid

forward citation occurred when another firm or organization referenced the focal patent through backward citation. Therefore, self-citations by the patenting company or any of its subsidiaries or strategic partners are not included. Because patent citation can occur at any moment in time after issuance, right-censoring is used for this measure. Of the 1911 patents in the study, 1523 are cited or 79.7% of the sample. The *probability of imitation* variable also served as a right-censor dummy variable for the other dependent variable, *timing of imitation*. Citation data for each patent in the sample is collected from the USPTO database via a patent web search.

Timing of Imitation. To determine the timing of imitation after patent issuance, the length of time (in number of days) to the first forward citation by an external party is measured. A valid citation occurred only if an external entity outside of the patent's ownership referenced the patent. As with the probability of imitation measure, self-citations by the patenting company or any of its subsidiaries or strategic partners are not included. Data on this measure is collected for each patent in the sample from the USPTO website search.

Independent Variables

The independent variables employed in this dissertation are grouped among two meta-constructs: resource attributes and deployment mechanisms. I used this parsing strategy in order to distinguish between resource's endogenous attributes and purposeful action firms take to deploy their resources. These measures and their likelihood and timing of imitation are further explained below.

Resource's Endogenous Attributes

Patent Scope. The scope of a resource is a function of its design and control. Resources vary in terms of scope, based upon their usability across different functions within a firm's value chain. In the context of patents, scope refers to the breadth of use, or the usability in various

technological domains. In the literature, patent scope is usually operationalized as the set of patent claims, which define the scope of the invention or the technological territory under the inventor's control, defended through litigation if necessary (Merges & Nelson, 1990). Further, patent claims distinguish the inventor's intellectual property from the adjacent terrain, which is analogous to the metes and bounds of a real property deed.

In this study, I use two measures of patent scope: PS1) patent claims, and PS2) USPTO classes and subclasses in which the patent is assigned. The Patent claims measure consists of two items: PS1a) the number of patent claims assigned by the USPTO; and PS1b) the number of primary patent claims. The USPTO distinguishes between primary patent or the actual novel inventions of the patent, and secondary claims, which are in conjunction with the primary claims. For example, patent number 5,878,215 System and Method for Processing Multiple Electronic Transaction Requests, assigned to Mastercard International Inc. obtained 19 patent claims from the USPTO. Of these 19 claims, 4 are primary claims describing a novel way to use an electronic transaction apparatus, and 15 are secondary claims, which reference the 4 primary claims of the patent. The USPTO Classes measure consists of three items: PS2a) the number of USPTO classes in which the patent is assigned; PS2b) the number of USPTO subclasses in which the patent is assigned; and PS2c) the number of International Patent Classifications (IPC) in which a patent is assigned. These measures are shown in table 5. Data on this measure is collected directly from each patent in the sample from the USPTO website search. In order to abate heteroscedasticity, non-linearity, and non-normality, a logarithmic transformation is used on the measure, number of patent claims.

Table 5: Item Measures for Patent Scope

PS1	Patent claims
	PS1a: Number of patent claims
	PS1b: Number of primary patent claims
PS2	Patent classes and subclasses
	PS2a: Number of USPTO classes to which patent is assigned
	PS2b: Number of USPTO subclasses to which patent is assigned
	PS2c: Number of International Patent Classifications (IPC) classes to which patent is assigned

Patent Innovativeness. This variable is generally measured on an incremental-radical continuum. For example, the creation of the combustible engine at the end of the 19th century was considered a radical innovation at the time, whereas technologies making engines more fuel efficient would be considered an incremental innovation. In the context of patents, two measures of innovativeness were employed: 1) a 7-point Likert scale developed after an extensive review of the finance literature and during field interviews with subject matter experts (SMEs) during Phase I (cf. Frame & White, 2004; Kortum & Lerner, 1999; Lerner, 2002, 2003; Miller, 1986; Tufano, 2003) and 2) a measure of patent sub-class assigned, relative to patent sub-class cited in prior work.

For the SME-generated measure, a 7-point Likert scale is used, where a 7 indicates a highly radical patent, and a 1 indicates an incremental patent. The scale was developed using a 100 patent random sub-sample of the full patent sample. For the 100 patent sub-sample, all six SMEs were asked to rate the patents on their level of innovativeness using the 7-point Likert scale. This method resulted in strong inter-rater reliability score of .94. The remaining 6 patents were assigned an innovativeness rating by taking the average of the three scores and rounding up. This is an appropriate technique when strong inter-rater reliability scores occur (cf.

Tabachnick & Fidell, 1996). The remaining sample of patents was assigned to two SMEs based on their area of expertise. Again, inter-rater reliability scores were used in order to confirm the reliability of the measure. For the full sample, the inter-rater reliability score is .92. As with the 100 patent sub-sample, the remaining patents were assigned an innovativeness rating by taking the average of the two scores and rounding up.

The second measure is based upon Rosenkopf and Nerkar's (2001) measure of technological radicalness or innovativeness. Here innovativeness is measured using the number of technological subclasses to which an invention was assigned, but from which the invention did not cite prior art (Katila and Shane, 2005). In order to abate heteroscedasticity, non-linearity, and non-normality, a logarithmic transformation was used for this measure.

Table 6: Item Measures for Patent Innovativeness

PIa A 7-point Likert scale developed after an extensive review of the finance literature and through during field interviews conducted with subject matter experts (SMEs) during Phase I
PIb Number of subclasses assigned to patent, but not cites in prior art (Rosenkopf & Nerkar, 2001)

Patent Internal Linkages. Resource linkages describe the extent to which a resource fits within an existing network of resources. Two resource categories are prominent in the literature: contained resources and system resources. A contained resource is a simple configuration of a network with defined boundaries, which can be valued and traded in factor markets. A system resource exists within a complex network, with no defined boundaries, making it difficult to trade in factors markets. Hence, how firms arrange their resources within an existing system, be it a simple or complex network, may enhance or mitigate their imperfectly imitable attributes (Black & Boal, 1994). One way firms arrange their resources is by embedding or linking them to internal resources. How firms embed their resources in organizational routines and processes

has received a great deal of attention in the literature (Eisenhardt & Martin, 2000; cf. Teece, et al., 1997).

In the context of patents, resource linkages usually indicate reference to prior art. In this study, the *patent internal linkages* consists of two items: PILa) the number of patent self-citations of prior art (i.e. backward citation); and PILb) the number of non-patent self-citation of prior art. Data on these measures are collected directly from each patent in the sample from the USPTO website search. In order to abate heteroscedasticity and non-normality, a logarithmic transformation was used for both measures.

Table 7: Item Measures for Patent Internal Linkages

PILa	Number of patent self-citations of prior art (i.e. backward citations)
PILb	Number of non-patent self-citation of prior art

Patent External Linkages. In addition to linking their resources with firm-specific knowledge and routines, firms also rely upon external resource systems and knowledge to deploy their critical resources. In the context of patents, resource linkages usually indicate reference to prior art. In this study, the *patent external linkages* measure consists of four items: PELa) the number of patents that are cited as prior art (i.e. backward patent citations, less all self-citations); PELb), the number of non-patents that are cited as prior art (i.e. backward patent citations, less all self-citations); PELc) the number of foreign patents that are cited as prior art (i.e. backward patent citations, less all self-citations); and PELd) the length of time in days from the first backward patent cite to the last backward patent cite. Data on these measures are collected directly from each patent in the sample from the USPTO website search. In order to abate heteroscedasticity, non-linearity, and non-normality, a logarithmic transformation was done for each measure

Table 8: Item Measures for Patent External Linkages

PELa Number of patents that are cited as prior art (i.e. backward patent citations, less self-citations)
PELb Number of non-patents that are cited as prior art (i.e. backward non-patent citations, less self-citations)
PELc Number of foreign patents that are cited as prior art (i.e. backward patent citations, less self-citations)
PELd Length of time in days from the first backward patent citation to the last backward patent citation (excluding self-citations)

Deployment Mechanisms

Patent Visibility. As noted, resources support various activities throughout a firm's value chain. Some resources, such as HR software packages, support what are traditionally considered *back-office* processes. Other resources, such as sales & marketing software packages, support what are traditionally considered *front-office* or customer-facing functions. For this study, patent visibility refers to how resources are deployed, either to support processing or back-office functions, or to support customer-facing of front-office activities.

In the context of patenting, the variable patent visibility is defined by what activities it supports; either *front-office* activities such as products or services, which are highly observable, or back-office activities such as processes or routines, which are generally unobservable (Berger, 2003; Teece, 2000). Two measures are used for *patent visibility* in this study: 1) a *product* / *process* dummy variable designation where product is coded 1 and process is coded 0, and 2) 5-point Likert scale of patent visibility. Each measure was developed during the exploratory study in Phase I. The SMEs were asked to code a patent as 1 if it supports a customer-facing activity, and a 0 if it supports a back-office activity. Again, inter-rater reliability was performed for each patent. A near unanimous .99 inter-rater reliability score was secured. For the remaining 19

patents in the sample, this investigator held discussions with two opposing SMEs and through an intellectual exercise of compromise, the final coding was done. In most cases, there is a tendency to code the patents in question a 0, but this is not the case for all the disputed patents.

For the other SME-generated measure, a 5-point Likert scale is used, where a 5 indicates a patent-supported activity that is unobservable, and a 1 indicates a patent-supported activity that is highly visible. The scale was developed using a 100 patent random sub-sample of the full patent sample. For the 100 patent sub-sample, all six SMEs were asked to rate the patents on their level of visibility using a 5-point Likert scale. This method resulted in strong inter-rater reliability score of .92. The remaining 8 patents were assigned a visibility rating by taking the average of the three scores and rounding up. As noted above, this is an appropriate technique when strong inter-rater reliability scores occur (cf. Tabachnick & Fidell, 1996). The remaining sample of patents was assigned to two SMEs based on their area of expertise. Again, inter-rater reliability scores were used in order to confirm the reliability of the measure. For the full sample, the inter-rater reliability score was .90. As with the 100 patent sub-sample, the remaining patents are assigned an visibility rating by taking the average of the two scores and rounding up.

Table 9: Item Measures for Patent Visibility

PVa Product / process dummy variable, where product is coded 1, and process is coded 0
PVb a 5-point Likert scale developed after an extensive review of the finance literature and through during field interviews conducted with subject matter experts (SMEs) during Phase I

Control Variables

Control variables were also defined for other possible influences on imitability probability and timing. Control variables are employed for firm-level, industry-level, and

environmental-level effects. *Patent issue year* is used to control for temporal effects. To control for the effects of other patenting activity, a dummy variable, *international patenting* is coded 1 if a patent referenced an international patent application and a 0 otherwise. To control for firm and environmental effects four measures are employed as covariates: first, *firm age*, which was measured in years and collected from firm websites and from the Hoovers database. For newly emerging firms or ones that are pre-nascent, the age given to them is 0. Second, *firm diversification*, is measured as the number of 2-digit SIC codes in which the firm participates. Pre-nascent or newly established entrepreneurial firms are assigned 1, SIC code 6794 for "patent owners and lessors". Data was collected from firm websites and confirmed using the Hoovers database. Third, a *financial industry* dummy variable is used to indicate if the firm, which owned the patent is a financial service firm with a primary SIC code 60-64. Financial service firms are coded 1, and all other firms are coded 0. Lastly, a *patent ownership change* dummy variable was created to measure if the patent changed hands through M&A activity, strategic partnering, or firm failure. The variable is coded 1 if any form of ownership change occurred and 0 otherwise.

Statistical Analyses

Two statistical methods, logistic regression and accelerated event-time, are used to test the hypotheses. These techniques have been used in previous studies to measure probability and timing of entrance into the diagnostic imaging industry (Mitchell, 1989) and the likelihood of an organization's response to a changing environment (Ginsberg & Buchholtz, 1989).

Logistical Regression.

Because logistical regression is commonly used in organizational literature, it is only briefly outlined here. Test of the imitation probability hypotheses were carried out by calculating a logistical regression equation:

$P_i / (1 - P_i) = a + BX_i$

Where P_i is the probability that the *i*th will experience an event (in the study, the probability that a patent will be forward cited by another firm). The log odds of the probability is held to be linearly affected by a vector of covariates X_i with coefficient vector *B* and intercept *a*. The effect of a one-unit change of the *j*th covariate X_{ij} on the probability of observation *i* imitating a patent is $B_jP_i(1-P_i)$. No grouping of the data is necessary because the estimates were obtained with maximum likelihood methods (Tabachnick & Fidell, 1996).

Accelerated Event-Time Models

Logistic regression is best suited to testing predictions concerning the probability of imitation. However, to test the timing of imitation, accelerated event-time method is the appropriate statistical tool because it provides the means of estimating influences on the length of waiting periods.

A primary advantage of the accelerated event-time method over convention regression techniques is its use of right-censored cases. This is critical to this study because of the 1911 patents in the sample, only 1523 (or approximately 80% of the cases) were cited by the end of 2005, or the end of the study period. Right-censoring minimizes the downward-bias associated with later patents, which had shorter waiting periods. Event-time analysis controls for variation across waiting periods because it incorporates the information that some incumbents had not entered.

For this study a Cox regression model, a method of accelerated event-time analysis, is used to test the timing of the first patent forward citation, or the first time the patent was imitated. The additive logarithmic form of the model is expressed as:

$T_i / = a + BX_i + se_i$

Where T_i is the observed event-time of the *i*th case; X_i is the vector of covariates associated with the *i*th case; *a* and *B* are an intercept and vector of coefficients associated with the independent variables. A positive *B* accelerates the baseline distribution of event times and a negative coefficient decelerates the distribution. The error vector *e* is distributed according to the Cox distribution and is scaled by a variance-related factor (Tabachnick & Fidell, 1996).

CHAPTER 5: RESULTS

Analyzing the Data

The means and standard deviations for each variable are listed in Table 10. The reliability scores are listed in Table 11, Table 12 compares the means and standard deviations of the factor items for those patents that were imitated and those that were not. The correlation matrix is listed Table 13. With the exception of the innovativeness and internal linkages variables, the reliabilities of the independent measures are strong with Cronbach alphas higher than .65. The zero-order correlation table highlights some interesting relationships among the variables. Significant relationships between several of the independent variables were identified. As expected there was a strong negative relationship between the control variable -patent issue year- and the two dependent variables-probability and the timing of imitation - (-.51 for and -.79 respectively). The correlation between the two dependent variables is .44.

The remaining correlations were well below the widely used cutoff of .80 as the minimum threshold for conditions of multicollinearity (Pedhazur & Schmelkin, 1991; Tabachnick & Fidell, 1996). I conducted two additional tests to determine the presence of multicollinearity: variance inflation factor (VIF) and tolerance. VIF and tolerance figures yielded fairly clean data. The largest VIF scores, (*Scope Claims* = 1.73 and *External Linkages* = 2.11), are well within the acceptable level of 4.0 for multivariate analyses (Pedhazur & Schmelkin, 1991). For the test of tolerance, the lowest score (*Scope Classes* = .71), is below the recommended cutoff of .80 (Pedhazur & Schmelkin, 1991). Based upon the above evidence, I determined that multicollinearity is not a concern and data analysis proceeded.

As noted, where issues arose concerning normality, linearity, and homoscedasticity log transformations were performed on the variables. After log transforming the variables, the data appears to be relatively normal as skewness and kurtosis are approaching zero. The largest skewness score, (*Visibility* = .70), is well within the acceptable range of +2 to -2 for multivariate analyses (Pedhazur & Schmelkin, 1991). For the test of kurtosis, the largest score, (*Innovativeness* = 1.05), is well within the acceptable range of +2 to -2 for multivariate analyses (Pedhazur & Schmelkin, 1991). Based upon this evidence, I determined that the data were normally distributed and data analysis proceeded. Appendix D details the statistical assumptions adhered to in this analysis.

Table 10. Descriptive Statistics

Variable	Mean	Std. Deviation
1. Probability of Imitation	.80	.40
2. Timing of Imitation	3423	1328
3. Scope – Claims	2.89	.87
4. Scope – Classes	1.22	.65
5. Innovativeness	2.50	1.03
6. Internal Linkages	.17	.49
7. External Linkages	1.84	.96
8. Visibility	3.02	.94
9. Patent Issue Year	1999	4.5
10. International Patenting	.14	.34
11. Firm Age log	2.66	1.
12. Firm Diversification log	.64	.69
13. Financial Industry	.16	.36
14. Ownership Change	.80	.40

Table 11. Reliability Analysis

Construct	Number of Items	Cronbach Alpha
Scope – Claims	2	.81
Scope – Classes	3	.65
Innovativeness	2	.55
Internal Linkages	2	.49
External Linkages	4	.68
Visibility	2	.69

Table 12. Mean Values of the Independent Variables for the Imitation Occurrence

	Action[a]		
Variables	**Imitation**	**No Imitation**	***t***
1. Claims log	2.905 (.857)	2.844 (.928)	-1.217
2. Primary Claims log	1.033 (.691)	.8744 (.650)	-4.096***
3. USPTO Subclasses log	1.224 (.649)	1.216 (.650)	-.200
4. USPTO Classes log	.499 (.513)	.437 (.469)	-2.156*
5. Int'l Classes log	.180 (.373)	.115 (.319)	-3.197***
6. Innovativeness Scale	2.52 (1.04)	2.43 (1.00)	-1.482
7. Innovativeness Classes	.371 (.547)	.307 (.540)	-2.063*
8. Visibility Scale	3.03 (9.18)	3.00 (1.04)	-.562
9. Visibility – Product/Service	.08 (.278)	.11 (.311)	1.495
10. Internal Linkage – patents self-citation log	.158 (.432)	.233 (.686)	2.656**
11. Internal Linkage – non-patent self-citation log	.097 (.360)	.078 (.325)	-.936
12. External Linkage – patents citation log	1.820 (.961)	1.955 (.971)	2.466**
13. External Linkage – non-patent citation log	1.171 (1.320)	1.112 (1.218)	-.804
14. External Linkage – foreign patent citation log	.404 (.776)	.596 (.900)	4.192***
15. External Linkage –patent citation length log	7.830 (1.740)	7.697 (1.921)	-1.306

[a] Figures in the parentheses are standard deviations. Of the 1911 patents, 1523 were cited by an external firm and 388 were not.

[t] $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Confirmatory Factor Analysis

I conducted a confirmatory factor analysis on the predictor variables, including the independent variables (scope, innovativeness, internal linkages, and external linkages) and the

moderator variable (visibility). Varimax rotation is used in this analysis in order to obtain a simple structure. The Varimax rotation enhances the interpretability of the principal components or factors. With the Varimax rotation, each component correlates high with a small number of variables and low with all the others (Tabachnick & Fidell, 1996). The results of the CFA are presented in Tables 14.

Items that loaded on one factor above .5 and loaded on other factors below.3 were retained in the factor analysis. There were no items that did not load on any of the factors or loaded significantly on more than one factor, thus no additional items were deleted from the analysis. However, after initial analysis showed poor results for the Scope measure, it was determined to use two factors for Resource Scope – Claims and Classes. The completed factor analysis had six factors: Scope-Claims, Scope-Classes, Innovativeness, Internal Linkages, External Linkages, and Visibility. With the exception of Scope-Classes and External Linkages, which have three and four items respectively, the remaining factors have two items. This solution results in the six factors that explain over 70% of the total variance.

Hypothesis Testing

As noted in the previous chapter, two statistical methods, logistic regression and accelerated event-time, are used to test the hypotheses. Logistical regression is used to test the first set of hypotheses 1-6, concerning the probability of imitation. In the first step of the regression analysis, the control variables were entered. In the second step, each indicator variable representing resource attributes was entered. The third step the moderator variable, visibility, was included. In the last step, the interaction terms were added.

Hypothesis 1. This hypothesis examines the relationship between the scope of a resource and its probability of being imitated. Specifically, this hypothesis predicts that the greater the

Table 13. Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Probability of Imitation														
2. Timing of Imitation	.44**													
3. Scope – Claims	.02	-.08**												
4. Scope – Classes	.02	-.04*	-.02											
5. Innovativeness	.03	.04*	-.023	.19**										
6. External Linkages	-.04*	-.15**	.14*	.10**	-.16**									
7. Internal Linkages	-.02	-.04*	.04*	.05**	-.06**	.03								
8. Visibility	.01	-.02	.-07**	.15**	-.14**	.06**	.13**							
9. Patent Issue Year	-.51**	-.79**	.10**	.03	-.05**	.01	.05**	.17**						
10. International Patenting	-.04	.05*	-.16**	.09**	.06**	.20**	.02	-.12**	-.04*					
11. Firm Age log	-.06**	-.03*	-.02	.04*	.04*	.10**	.19**	-.01	.06**	.21**				
12. Firm Diversification log	-.03	-.03	-.02	.05**	.03	.12**	.17**	-.01	.04*	.26**	.54**			
13. Financial Industry	.01	.01	.04	-.15**	-.01	-.14**	.03	-.00	.01	-.15**	.27**	.25**		
14. Ownership Change	-.06**	-.06**	.00	.04*	-.01	.07**	.09**	-.04*	.06*	.15*	.15	.17**	-.06*	

N = 1911 Patents
* Significant at the 0.05 level.
** Significant at the 0.01 level.

Table 14. Confirmatory Factor Analysis

Variable Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Scope – Claims log	.907	-.078	.092	-.107	.059	-.058
Scope - Primary Claims log	.916	.001	.065	.041	.046	.028
USPTO Subclasses log	.006	.867	.080	.110	.158	.106
USPTO Classes log	-.019	.740	-.019	.241	.091	2.63
Int'l Classes log	-.030	.894	-.100	-.037	.027	.192
Innovativeness Scale	-.005	-.264	.582	-.264	-.278	-.183
Innovativeness Classes	-.007	-.081	.835	.062	-.200	.063
Internal Linkage – patents self-citation log	.058	-.028	.167	.603	-.018	.292
Internal Linkage – non-patent self-citation log	.014	-.028	-.063	.817	.012	-.011
External Linkage – patents citation log	.108	-.022	.005	.211	.756	-.018
External Linkage – non-patent citation log	.138	-.146	-.239	.159	.698	-.206
External Linkage – foreign patent citation log	.015	.053	.095	.295	.632	-.050
External Linkage –patent citation length log	.026	-.066	.026	.044	.843	.039
Visibility Scale	-.029	.100	-.017	.036	.123	.838
Visibility – Product/Service	-.032	.062	.009	-.043	-.056	.843
Eigenvalue	2.98	2.46	1.72	1.43	1.11	1.08
% of Variance Explained	19.85%	16.37%	11.44%	9.54%	7.17%	5.85%
Cumulative % of Variance	19.85%	36.22%	47.66%	57.20%	64.37%	70.22%
Cronbach's Alpha	.814	.646	.553	.492	.684	.693

scope of a resource (e.g. financial patent), the more likely it is imitated. The regression analysis shows the prediction to be partially accurate. The results of this analysis are shown in Table 15. The relationship between the patent claims composite and the probability of imitation was positive and significant ($\beta = .286$, $p < .001$); however, the patent classes composite was not significant. Thus, the hypothesis was partially supported.

Hypothesis 2. This hypothesis examines the relationship between the innovativeness of a resource and its probability of being imitated by a competitor. For example, the greater the innovativeness of a financial patent, the more likely it is imitated. The results show that the relationship between patent innovativeness and the probability of imitation was positive and significant ($\beta = .192$, $p < .05$). Thus, the hypothesis was supported, although the standardized beta is somewhat low.

Hypothesis 3. This hypothesis examines the relationship between the extent to which a resource is linked within internal resource systems and its probability of being imitated by a competitor. For example, the greater a financial patent is internally linked with other firm-specific resources, the less likely it is imitated. There is expected to be a significantly negative relationship between internal linkages and the probability of imitation. In contrast to what was predicted, the relationship between internal linkages of a patent and the probability of imitation was positive and not significant. It appears that linking financial patents to an internal knowledge base (e.g. self-citation of patents and non-patents) is unrelated to imitation. Thus, hypothesis 3 was not supported.

Hypothesis 4. This hypothesis examines the relationship between the extent to which a resource is linked to external resource systems and its probability of being imitated by a competitor. For example, the greater a financial patent is linked with other external resources,

the more likely it is imitated. The results show that the relationship between external linkages of a resource and the probability of imitation was positive and significant ($\beta = .240$, $p < .01$). Thus, resources such as financial patents that are linked to external sources of knowledge are more susceptible to imitation.

Hypothesis 5. This hypothesis examines the relationship between the extent to which a resource is visible and its probability of being imitated. For example, the greater the visibility of a financial patent (e.g., how it is deployed), the more likely it is imitated. The hypothesis was supported, the relationship between the visibility of a resource and the probability of imitation was positive and significant ($\beta = .200$, $p < .01$).

Hypothesis 6a-d. These hypotheses examine whether resource visibility acted as a moderator between the independent variables –scope, innovativeness, internal and external linkages- and the probability of imitation. Specifically, hypothesis 6a predicts that greater resource visibility intensifies the positive relationship between scope and the probability of imitation. Visibility significantly moderates the relationship between patent scope and the probability of imitation. For the patent claims composite the results were ($\beta = .307$, $p < .001$), and for the patent classes composite the results were ($\beta = .277$, $p < .001$). It is this dissertation's contention that when broadly scoped resources- in this case, financial patents- are deployed in highly visible, customer-facing processes, they become more susceptible to imitation. Thus, hypothesis 6a was strongly supported.

Hypothesis 6b examines the relationship between resource visibility, innovativeness and the probability of imitation. In contrast to what was predicted the relationship was not significant and the coefficient was negative. Thus hypothesis 6b was not supported.

Hypothesis 6c examines the relationship between resource visibility, internal linkages and the probability of imitation. For example, when firms deploy their financial patents in highly visible products and processes, some the barriers to imitation derived from the internal linkages would dissipate. The relationship between visibility, internal linkages and probability of imitation was positive, but not significant. Thus hypothesis 6c was not supported.

Hypothesis 6d examines the relationship between resource visibility, external linkages and the probability of imitation. For example, greater patent visibility would intensify the relationship between its external linkages and the probability of its imitation. The results of this analysis show that the relationship between visibility, internal linkages and probability of imitation is positive and significant ($\beta = .191$, $p < .05$). Thus hypothesis 6d was supported.

The log likelihood for the model is significant; which suggests that the interactive model contributes significantly more than a model containing only an intercept. The chi-square statistic for improvement over the no-covariate likelihood (946.76) is 39.87 ($df = 12$, $p < .001$). The likelihood ratio statistic assesses the fit to the data. Under the null hypothesis that a model fits the data, a log likelihood has an approximate chi-square distribution with the probability (p) that a higher chi-square value will be obtained, if the model fits. Therefore, the higher the value of p, the better the fit the model. A probability greater than .05 is generally considered adequate. As shown in Table 15, the non-interactive model did not provide good fit.

A Cox regression model is used to test the second set of hypotheses 7-12 concerning, the timing of imitation. Like the logistical regression described above, control variables were added in the first step of the analysis. In the second step, each indicator variable representing resource attributes was entered. The third step the moderator variable, resource visibility, was included. In the last step, the interaction terms were added.

Hypothesis 7. This hypothesis examines the relationship between the scope of a resource and the timing of its imitation by a competitor. For example, the greater the scope of a financial patent, the faster it is imitated, suggesting a negative relationship between patent scope and the timing of imitation. In contrast to what was predicted, the relationship between the patent classes composite and the timing of imitation was positive and significant ($\beta = .100$, $p < .001$); the patent claims composite was positive but not significant. It appears that financial patents with greater scope are not imitated faster than ones with more limited scope. Thus, the hypothesis was not supported.

Hypothesis 8. This hypothesis examines the relationship between the innovativeness of a resource and the timing of its imitation by a competitor. For example, the greater the innovativeness of a financial patent, the slower it is imitated. In contrast to what was predicted, the relationship between patent innovativeness and the timing of imitation was positive, but not significant. Thus, hypothesis 8 was not supported.

Hypothesis 9. This hypothesis examines the relationship between the extent to which a resource is linked within internal resource systems and the timing of its imitation. For example, the greater a financial patent is internally linked with other firm-specific resources, the slower it is imitated. In contrast to what was predicted, the relationship between internal linkages of a patent and the timing of imitation was negative and not significant. Thus hypothesis 9 was not supported, it appears that internal linkages are a negligible barrier to imitation.

Hypothesis 10. This hypothesis examines the relationship between the extent to which a resource is linked to external resource systems and the timing of its imitation by a competitor. For example, the greater a financial patent is externally linked with other external resources, the

faster it is imitated. The hypothesis was supported; the relationship between external linkages of a resource and the timing of imitation was negative and significant (β = -.092, $p < .001$).

Hypothesis 11. This hypothesis examines the relationship between the extent to which a resource is visible through its deployment and the timing of its imitation by a competitor. For example, the greater the visibility of a financial patent (e.g., how it is deployed), the faster it is imitated. In contrast to the prediction, the relationship between patent visibility and the timing of imitation was positive and significant. Instead of accelerating imitation as predicted, patent visibility actually impedes competitor imitation. The relationship between the visibility of a resource and the timing of imitation was positive and significant (β = .140, $p < .001$). Thus, the hypothesis was not supported.

Hypothesis 12a-d. These hypotheses examine whether patent visibility acted as a moderator between the independent variables –scope, innovativeness, internal and external linkages- and the timing of imitation. For example, greater visibility would intensify the negative relationship between scope and the timing of imitation. In contrast to what was predicted, visibility moderates the relationship between patent scope and the timing of imitation, but instead of intensifying the negative relationship, it tempers it. For the patent claims composite the results were (β = -.115, $p < .10$), and for the patent classes composite the results were positive, but not significant. Thus, hypothesis 12a was partially supported.

Hypothesis 12b examines the relationship between visibility, innovativeness and the probability of imitation. For example, greater patent visibility would temper the positive relationship between patent innovativeness and the timing of imitation. Of the moderator hypotheses, this result is the most robust. Visibility intensifies the negative relationship between

innovativeness and timing of imitation; the result was negative and strongly significant (β = -.472, p < .001). Thus hypothesis 12b was strongly supported.

Hypothesis 12c examines the relationship between visibility, internal linkages and the probability of imitation. For example, greater patent visibility would temper the positive relationship between internal linkages and the timing of imitation. The relationship between visibility, internal linkages and probability of imitation was positive, but not significant. Thus hypothesis 12c was not supported.

Hypothesis 12d examines the relationship between visibility, external linkages and the probability of imitation. For example, greater patent visibility would intensify the negative relationship between external linkages and the probability of imitation. The relationship between visibility, external linkages and probability of imitation was negative and significant (β = .098, p < .01). Thus hypothesis 12d was supported.

The log likelihood for the model was strongly significant; the model contributed significantly more than a model containing only an intercept. The chi-square statistic for improvement over the no-covariate likelihood (1755.55) was 64.63 (*df* = 12, p < .001).

Table 15. Logistic and Accelerated Event-Time Estimates of on Probability & Timing of Patent Imitation

Variables	Probability	Timing
Main Predictors:		
Scope – Claims	.286*** (.088)	.015 (.024)
Scope – Classes	.159 (.117)	.100*** (.030)
Innovativeness	.192* (.112)	.017 (.030)
Internal Linkages	.017 (.081)	-.005 (.029)
External Linkages	.240** (.100)	-.092*** (.030)
Visibility	.200** (.087)	.140*** (.027)
Interactions		
Scope – Claims X Visibility	.307*** (.165)	-.115 [t] (.067)
Scope – Classes X Visibility	.277** (.084)	.009 (.022)
Innovativeness X Visibility	-.033 (.089)	-.472** (.171)
Internal Linkages X Visibility	.125 (.094)	.109 (.067)
External Linkages X Visibility	.191* (.083)	-.098** (.113)
Intercept	1.366*** (.057)	4.033*** (.043)
Other Influences:		
Patent Issue Year	-1.232*** (.066)	.482*** (.010)
Int'l Patenting	.616** (.269)	.160** (.077)
Firm Age	-.069 (.065)	-.096*** (.019)
Firm Diversification	.055 (.158)	.103** (.047)
Financial Industry	-.186 (.258)	.006 (.074)
Ownership Change	.130 (.225)	-.094 (.062)
Patents (Imitated)	1880 (1498)	1880 (1498)
Model Log Likelihood	946.76***	1755.58***
Cox & Snell R^2	.395	
Df	12	12
Log Likelihood chi-squared	39.87***	64.63***

[t] $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests)

Standard errors are in parentheses. Negative logistic regression coefficients in column 1 indicate lower imitability probability. Negative accelerated event-time coefficients in colum2 indicate earlier imitability.

Table 16. Summary of Results

Hypotheses	**Findings**
H1: The greater the scope of a resource, the more likely it is imitated	Partial Support
H2: The greater the innovativeness of a resource, the more likely it is imitated	Moderate Support
H3: A resource which has greater internal linkages with other firm-specific resources is less likely to be imitated	Not Supported
H4: A resource which has greater external linkages with external resource networks are more likely to be imitated	Strong Support
H5: Resource imitation is more likely when resource deployment is highly visible (e.g., customer-facing activities and processes)	Moderate Support
H6a: Visibility moderates the relationship between the scope of a resource and its probability of imitation such that greater visibility makes imitation more likely. *H6b: Visibility moderates the relationship between the innovativeness of a resource and its probability of imitation such that greater visibility makes imitation more likely.* *H6c: Visibility moderates the relationship between the internal linkages of a resource and the probability of its imitation such that greater visibility makes imitation more likely.* *H6d: Visibility moderates the relationship between the external linkages of a resource and the probability of its imitation such that greater visibility makes imitation more likely.*	Strong Support Not Supported Not Supported Moderate Support
H7: The greater the scope of a resource, the earlier it is imitated.	Not Supported
H8: The greater the innovativeness of a resource, the later it is imitated.	Not Supported
H9: The greater a resource is internally linked with other firm-specific resources, the later it is imitated.	Not Supported
H10: The greater a resource is externally linked with interfirm resources, the earlier it is imitated.	Strong Support
H11: Resource imitation occurs earlier when resource deployment is highly visible (e.g., customer-facing activities and processes).	Not Supported
H12a: Visibility moderates the relationship between the scope of a resource and the timing of its imitation such that greater visibility accelerates imitation. *H12b: Visibility moderates the relationship between the innovativeness of a resource and the timing of its imitation such that greater visibility accelerates imitation.* *H12c: Visibility moderates the relationship between the internal linkages of a resource and the timing of its imitation such that greater visibility accelerates imitation.* *H12d: Visibility moderates the relationship between the external linkages of a resource and the timing of its imitation such that greater visibility accelerates imitation.*	Partially Supported Strong Support Not Supported Moderate Support

CHAPTER 6: DISCUSSION AND CONCLUSION

Firms create value and develop competitive advantage from their resources through acquisition, deployment and exploitation processes (Sirmon et al., 2007). Despite the importance of a comprehensive resource management strategy, past research has tended to focus on initial resource acquisition as a prelude to value creation and competitive advantage. It is through the accumulation of VRIN resources that firms are able to generate and sustain competitive advantage (Barney, 2003). While acknowledging the importance of initial resource acquisition, this dissertation shifts the focus towards purposeful actions firms take to protect and deploy their resources. It answers a question at the heart of strategic management research; what isolating mechanisms do firms employ to reduce resource imitation? To address this question, it offers a framework to explain and predict why, when, and how firms deploy resources while reducing the risk of imitation.

This study specifies inherent resource attributes and a firm deployment mechanism which influence the likelihood and timing of imitation. Clarifying how firms erect barriers to resource imitation beyond decisions at the resource acquisition stage informs RBT on the relationship between resource management, value creation and competitive advantage. How firms deploy their resources influences how quickly rent-generating resources erode through competitor imitation (Reed & DeFillippi, 1990). A framework explicating the actions firms take to protect resources against imitation adds specificity and conceptual nuances to RBT's treatment of

imperfectly imitable resources (McEvily et al., 2004). This study found empirical support that resource imitation is not solely a function of intrinsic resource traits, but additionally the choices firms make concerning deployment and subsequent resource protection.

By specifying these critical relationships, the research model extends RBT logic and provides normative insights. Ultimately RBT's effectiveness as a theory of competitive advantage lies in its ability to predict firms' strategic action; how firms leverage critical resources to exploit opportunities, while neutralizing the effects of competitor actions. By examining the how and when of resource imitation, this dissertation offers a salient test of RBT. Predicting the likelihood of resource imitation is best understood by investigating both resource attributes and how firms protect and deploy their resources.

As indicated in Chapter Five, the statistical results supported the majority of the hypotheses tested. There are a number of significant and interesting findings related to the research model. This includes findings related to the probability and timing of imitation which were contrary to what was predicted. The remainder of this chapter reviews the major findings of the study, addresses implications for practicing managers, offers avenues for future research, and discusses the study's limitations. In order to be consistent with structure utilized throughout this dissertation, the discussion of the major findings is organized sequentially in accordance with the order of the hypotheses.

Probability of Imitation Hypotheses

According to RBT, we should expect that only attribute measures (i.e. the ones which proxy intrinsic characteristics of the resource) have an effect on the likelihood of resource imitation. Some of this study's findings confirm this to be true, but the explanation is incomplete. The hypotheses which test the relationship between resource deployment and the

probability of imitation provide some evidence of the importance of a firm's purposeful action to limit imitation. Each hypothesis is discussed in greater detail below.

Hypothesis 1 predicts that resource scope has a positive impact on the likelihood of imitation. To test this relationship, two measures of patent scope-claims and classes-were analyzed. This hypothesis was partially supported and the results suggest that the patent claims measure is a strong predictor of imitation. The greater the number of patent claims, the more likely the patent will be imitated. This finding is intuitive; one would expect a resource to be imitated if it has broad applications and could be used in a variety of firm processes. In the case of patents, claims determine the technological space an inventor is granted, and with greater number of technological claims brings about more vulnerability of imitation. This finding is in agreement with the interviews conducted with the six SMEs, who reinforced that firms often face the dilemma of making their patents too broad for fear of extensive and rapid diffusion through imitation.

The second measure of resource scope, patent classes, was positive but not significant. One explanation for this finding is that patent classes are a less explicit measure of scope and thus are susceptible to confounding effects. For example, patent classes and subclasses are assigned by the USPTO examiner and speak more to the breadth of the technological domain of a patent rather than the actual scope of its usability. As learned through the interviews and through past discussions with patent examiners, patent class and subclass assignment is generally a function of the prior art cited by the patent. The technological domain of the patent as measured by the number of patent class and subclass assignment is thus very past-oriented because it is rooted in its citation of prior art (Merges & Nelson, 1990).

As a means to examine how the novelty of a resource affects its likelihood of imitation, hypothesis 2 suggests that resources vary in their innovativeness (either characterized by radical or more incremental traits), and this variety will have differing influences. The hypothesis predicts a positive relationship between resource innovativeness and the probability of imitation; resources which are more innovative are more likely imitated. The hypothesis was modestly supported. The findings suggest that competitors will seek out highly innovative resources and will make efforts to imitate them even if imitating more incremental resources may be easier.

The modest support raises some interesting questions about the nature of incremental and radical innovations. There exists a debate in the strategic management literatures regarding the importance of incremental versus more innovative inventions on value creation and performance advantages. Proponents of organizational learning and change theories argue that firms are more apt to initiate strategic action following localized search (Cyert & March, 1963; March, 1991). Firms have limited ability to absorb new knowledge, especially discoveries that are far a field from their technological expertise (Zahra & George, 2002). Firms can only manage minimal changes to the existing organization because bottlenecks of learning exist, which prevent rapid change (Levinthal, 1997).

In contrast, scholars from organizational and Austrian economics argue with highly innovative discoveries, incumbent firms must act quickly to absorb the new knowledge and adapt accordingly (Ketchen et al., 2004; Tushman & Anderson, 1986). In this case, Schumpeter's "creative destruction" is a powerful force, motivating firms to respond to the technological upheaval. Performance advantages derived from the new discoveries will persist without some form of intervention from competing firms (McEvily & Chakravarthy, 2002). This intervention generally takes the form of imitation because incumbent firms are unable to enact a "leap-frog"

strategy (i.e. out invent the new technological threat) because of their limited knowledge base concerning the new discovery. The findings from this study support the latter proposition; namely that firms are more likely to imitate highly innovative resources versus incremental resources because of the performance advantage stake it represents.

Hypotheses 3 and 4 examine the effects of linkages on the likelihood of resource imitation. Hypothesis 3 predicts a negative relationship between internal linkages and the probability of imitation; resources with more internal linkages are less likely to be imitated by competitors. Hypothesis 4 predicts a positive relationship between external linkages and the probability of imitation. Resources with more external linkages are more likely imitated. The hypotheses yielded some surprising results. Instead of a negative relationship for hypothesis 3 as predicted, the relationship was positive, but not significant. In addition, its beta was exceedingly small, which indicates internal linkages have little or no effect on imitation. These findings appear counter-intuitive; theory suggests that linking or embedding resources in internal routines will create isolating mechanisms and effective barriers to imitation (Sirmon, et al., 2007; Teece, et al., 1997). Yet, it appears that internal resource bundling is not the panacea for sustaining resource advantages. Rather, firms face the same level of vulnerability if the resource was a stand-alone, without any internal linkages or if it was bundled with external resources.

There are two primary explanations for this finding. First, because the sample consists of patents which are publicly published when issued, the codified knowledge within the patent is easy to access and to synthesize. Linking patents with additional internal resources may not overcome the relative ease of replication that is indicative with highly codified knowledge (Liebeskind, 1996; Teece, 2000). In order to make the measure more robust, non-patent linkages were included; yet this validation step did not achieve its desired result. Second, the act of

bundling or linking resources may be too simplistic a notion. Theory acknowledges the importance of embedding resources in internal processes or routines as a means of creating a resource advantage (Teece et al., 1997); however, the theory does not explicitly explain how and where embedding resources will be maximal for preventing imitation. The measures used in this study addressed how resources are linked (i.e. the number of patent and non-patent backward citations), but not where resources should be linked. This under specification may very well explain the contradictory and non significant findings. Thus, despite substantial conceptual and empirical effort put into the construct, the hypothesis yielded non significant results.

As hypothesis 4 suggests, a positive relationship between external linkages and the likelihood of imitation is expected. This study's findings support this hypothesis; the relationship was positive and significant with a fairly strong beta. Creating linkages with external complementary resources increases the likelihood of imitation. Although supported, the findings raise questions about the efficacy of external partnerships as a means to exploit firm resources. One can argue that creating network resources (i.e. through external sharing arrangements) may increase the social complexity, and even the causal ambiguity of the resource, which RBT states are vital characteristics of imperfectly imitable resources (Lavie, 2006). In fact, network theorists and proponents of interconnected firms argue that there are advantages to be gained and rent to be earned through shared or linked resources (Eisenhardt & Schoonhoven, 1996; Lane, Stalk, & Lyles, 2001). These scholars argue that marrying of complementary resources, knowledge, and experience into a dynamic alliance yields appropriated relational rent, which is the common benefit that accrues through combination, exchange and codevelopment of idiosyncratic resources (Lavie, 2006). Yet, the risk of outbound spillover rent appears to be great because of the increased likelihood of competitor imitation.

Hypothesis 5 introduces the resource deployment construct developed within the research model. This hypothesis examines the relationship between the extent to which a resource is visible through its deployment and its probability of being imitated. The hypothesis predicts a positive relationship between resource deployment visibility and the likelihood of imitation. The result of the analysis was positive and significant, thus supporting the hypothesis.

This finding demonstrates the vulnerability to imitation that firms face when deciding how and where to deploy their resources. It gives credence to the notion that imitation is not solely attributable to intrinsic traits of resources as RBT maintains. Rather, firms have the ability to influence the likelihood of imitation based upon their decision concerning resource deployment. This suggests that RBT must adopt a richer definition of imperfectly imitable resources which includes factors related to resource protection and deployment. This finding in concert with recent theory, which emphasizes the importance of resource management processes related to resource acquisition, as well as bundling and deployment (Makadok, 2003; Sirmon et al., 2007). It is hoped that these findings will spur researchers to more closely examine post acquisition processes of erecting barriers to imitation and creating value in order to develop more dynamic models of resource imitation.

Hypotheses 6a-d examine the moderating effect resource deployment visibility has on the four predictor variables–scope, innovativeness, internal and external linkages. These hypotheses address the primary contributions of this dissertation. Hypothesis 6a predicts that visibility intensifies the positive relationship between scope and the probability of imitation. Deployment visibility acts as an accelerator of imitation, especially for resources that have broad usability. Findings support this hypothesis; the relationship was positive and significant with a strong beta. Resource deployment has an influence on the attributes of imperfectly imitable resources.

This finding suggests that resource deployment plays an important function in the process of imitation. Deployment infers resource activation for the owning firm, but it also implies that deployment can act as a catalyst for competitor imitation. This has important implications for RBT and the numerous theories of business imitation. The above finding indicates that RBT narrowly defines the inimitable construct; rather than model resource imitation as largely a function of inherent attributes, RBT must integrate theories of deployment and protection (Foss & Foss, 2005). For the boarder literature on interfirm imitation, this finding is a call to strategic management scholars to take a more exact account of the costs and benefits of imitation. Specifically, information-based theories of imitation must integrate the resource deployment choice when examining the antecedents to and outcomes of resource imitation (Lieberman & Asaba, 2006).

Hypothesis 6b predicts that deployment in highly visible processes intensifies the positive relationship between resource innovativeness and the likelihood of imitation. The findings did not support the hypothesis. In contrast to what was predicted the coefficient was negative and the relationship was not significant. The beta coefficient from the analysis was very small, which indicates that visibility has no measurable effect on the probability of imitating highly innovative resources. There is no clear theoretical justification for this finding to occur; however, a possible explanation may lie in the fact that resource visibility does not add any additional motivation for competitors to imitate highly innovative resources.

Hypothesis 6c predicts that deployment in highly visible processes tempers the negative relationship between internal linkages and the probability of imitation. When resources are deployed in highly visible products and processes, firms should expect that the efficacy of the barriers of imitation will internally erode. The results of the hypothesis are positive, but not

significant. This finding did not come as a complete surprise given that the results from hypothesis 3-testing the relationship between internal linkages and likelihood of imitation-was also not significant. This finding is another indication that the ability of internal resource bundling to act as a barrier to imitation is inadequate, and firms should take notice when enacting resource management strategies (Sirmon et al., 2007).

Hypothesis 6d predicts that deployment in highly visible processes intensifies the positive relationship between external linkages and the probability of imitation. As predicted, the findings provide moderate support for the hypothesis. The findings suggest that deployment visibility interacts with external linkages to make imitation more likely. This finding has implications for theories of alliance networks, which suggest competitive advantages are gained through the formation of strategic alliances in networked environments (Das & Teng, 2000; Gulati, 1998). The promise of *network resources* as an opportunity to extend the boundaries of the firm and extract rent from shared resources must be tempered by fact that externally linked resources are more susceptible to imitation, especially when deployed in highly visible processes.

Timing of Imitation Hypotheses

According to RBT, we should expect that only attribute measures (i.e. the ones which proxy intrinsic characteristics of the resource) have an effect on the timing of resource imitation because they are solely responsible for creating isolating mechanisms and barriers to imitation. To broaden RBT, I tested hypotheses which examine the relationship between resource deployment and the timing of imitation. Unfortunately, the majority of these hypotheses were not confirmed with this data sample. Each hypothesis is discussed in greater detail below.

Hypothesis 7 predicts that resource scope has a negative relationship with the timing of imitation; imitation will occur more quickly for resources with broader scope. In contrast, the relationship between the second measure of scope, patent classes, and the timing of imitation was positive and significant, although the beta score was small. The first measure of scope, patent claims, was positive but not significant. It appears that financial patents with greater scope are not imitated at a faster rate than ones with more limited scope. Thus, the hypothesis was not supported. An explanation for this finding may be concerned with the quality of the patent. The intellectual property literature is divided on whether patent scope, as measured by its claims, is an indication of its overall quality. Some scholars suggest that patent claims only measure the technological domain granted by the USPTO examiner (Merges & Nelson, 1990), while others argue that the patent claims are one measure of patent quality (Griliches, 1990; Kortum & Lerner, 1999; Lerner, 1995). If scope does not equal quality or technological importance, then it is feasible that broad patents may not be imitated faster than more narrow patents.

Hypothesis 8 predicts a positive relationship between resource innovativeness and the timing of imitation. This hypothesis posits that resources that are more innovative will take longer to imitate. The result of the hypothesis was not significant; the analysis yielded a positive relationship between patent innovativeness and the timing of imitation. This finding is somewhat surprising and appears counter-intuitive. As noted above, the literature is divided when explaining which type of innovation is most likely to be imitated. Yet, theory is fairly uniform when addressing the timing of imitation; more innovative discoveries take longer to imitate because the competing firms generally lack the knowledge, competencies and experience with replicating the technology, in addition to inertial forces which prevent firms from acting quickly (Christensen, 1997; Lieberman & Asaba, 2006; Teece, 2000). Empirical support

confirms that advantages obtained from innovative discoveries, knowledge and capabilities will persist for a longer term than those secured form more incremental resources (McEvily & Chakravarthy, 2002). One explanation for this finding is that codified resources, (e.g., patents) provide sufficient information to make the difference between imitating incremental and innovative patents negligible.

Hypothesis 9 predicts a positive relationship between patent internal linkages and the timing of imitation; resources with greater internal linkages take longer to imitate. The finding was in contrast to the prediction and was not significant. It appears that internal linkages are not substantial barriers to imitation and do not meaningfully affect the timing of imitation. This finding may be influenced by the sample. Publicly available patents may be unable to build effective imitation barriers because the knowledge embedded in them is so readily available. The use of a more secretive resource sample may alter the results. Alternatively, internal linkages may not capture a bundling process, but may only represent a process of incremental knowledge building (Sirmon et al., 2007). The former may result in stronger barriers to imitation, whereas the latter is only a method of reconfiguring or enriching existing resources (Eisenhardt & Martin, 2000; Sirmon et al., 2007).

Hypothesis 10 predicts a negative relationship between resource external linkages and the timing of imitation. Resources which have more linkages to external resources are imitated more quickly. The hypothesis was strongly supported; the relationship between external linkages and timing of imitation is negative. The implications of this finding coupled with the results of hypotheses 4, 6d, and 12d suggest that external linkages are an important factor in determining the probability and timing of innovation. This result strengthens RBT's conceptualization of

imperfectly imitable resources because it can be argued that externally linked resources are likely to be causally ambiguous and socially complex.

Hypothesis 11 examines the relationship between a resource's visibility when deployed and the timing of its imitation. It predicts a negative relationship between resource visibility and the timing of imitation. In contrast to the prediction, the relationship was positive and significant. Rather than facilitating imitation, resource visibility actually impedes competitor imitation. This finding seems to be counter-intuitive; theory suggests that highly visible resources deployed in customer-facing products or processes are easier and faster to imitate (Liebeskind, 1996; Teece, 2000). One explanation is that firms have a hierarchical system of resource deployment; their most critical resources are deployed in back-office processes to protect them form imitation, while they deploy their least impactful resources in front-office processes which are more susceptible to imitation. Although a plausible explanation, it is not likely that firms deploy only their most important resources in back-office processes and their least important resources in front-office processes.

Hypothesis 12a-d. These hypotheses examine the moderating effects of resource visibility on the relationship between the independent variables –scope, innovativeness, internal and external linkages- and the timing of imitation. Hypothesis 12a predicts that greater visibility intensifies the negative relationship between scope and the timing of imitation. Visibility tempered the negative relationship between the first measure of scope, patent claims and the timing of imitation. This was in contrast to the prediction. The results of the second measure of scope, patent classes, were positive, but not significant. Thus, hypothesis 12a was not supported.

Hypothesis 12b predicts that greater resource visibility tempers the positive relationship between scope and the timing of imitation. Visibility facilitates imitation; it counteracts the

difficulty of replication associated with highly innovative resources. The results are the most robust of this set of moderator hypotheses. As predicted, visibility made what was a positive relationship, negative, strongly supporting the hypothesis.

Hypothesis 12c predicts that greater resource visibility tempers the positive relationship between internal linkages and the timing of imitation. The relationship between visibility, internal linkages and probability of imitation was positive, but not significant. Resource visibility has no significant influence on the timing of internally linked resources. Thus hypothesis 12c was not supported.

Hypothesis 12d predicts that greater resource visibility intensifies the negative relationship between external linkages and the probability of imitation. As predicted, the relationship between visibility, external linkages and probability of imitation was negative and significant ($\beta = .098$, $p < .01$). Despite the relatively small beta score, hypothesis 12d was supported.

Overall, the results from these hypotheses are mixed; two hypotheses (12a, 12c) were not significant, while the other two receive moderate (12d) and strong (12b) support. Arguments are made providing explanations for the lack of findings. It is possible that these two resource attributes are not important determinants of imitation timing. Perhaps other environmental contingencies, not controlled for in the model have a stronger impact on imitation. It is also possible that the measures developed in this study were problematic. In particular, the reliability coefficient for the internal linkages measure was lower than the .60 cutoff which is recommended for exploratory research (Tabachnick & Fidel, 1996). This level of reliability indicates that there is a notable amount of unexplained error associated with the measure.

The results shed some light on influence of resource visibility on the timing of imitation for innovative resources. As discussed above, it is accepted in the literature that more innovative discoveries take longer to imitate because of the dearth of knowledge competing firms have to understand the new technology. Yet, when resources are deployed in highly visible products or processes, the challenges related to imitating substantially innovative resources are decomposed. This suggests that firms should be mindful of how they deploy their most important resources. This finding also informs RBT, because it alludes to the importance of firm purposeful action in preventing the imitation of resources.

Implications for Practice

These findings generate some interesting managerial implications-how to delay the imitation of a firm's most important resources in order to sustain existing resource advantages. Perhaps the most interesting findings relate to the relationships which have the most impact on facilitating or delaying imitation. One relationship in particular stands out; how resource deployment as measured by visibility interacts with resource innovativeness as a catalyst for more rapid imitation. As discussed above, highly innovative resources are difficult to replicate, and generally take longer for competing firms to imitate. This is critical for innovating firms, because theory suggests that these resources will denote first-mover advantages. This study's findings suggest that a serious threat to this position is how the resource will be deployed. If top managers choose to deploy the resource to support simultaneously highly visible, customer-facing processes, then they run the heightened risk of imitation and possible misappropriation.

Another important finding (or non-finding) concerns the ineffectiveness of creating internal resource linkages. The results suggest that internal resource linkages are not a strong substitute for other forms of barriers to imitation such as intellectual property, first-mover

advantages, or dynamic capabilities. Linking to internal resources has no significant influence on limiting the likelihood of imitation or delaying the timing of imitation. The findings also imply that there are other important contingencies related to the internal linkages and imitation relationship. Specifically, managers must pay greater attention to environmental factors that may affect the efficacy of resource bundling strategies. As Sirmon and his colleagues (2007) note, creating synchronization of a resource portfolio involves all stages of the firm's resource management process, which includes synthesizing salient cues about coming changes in the external environment. This suggests it is important to place resource bundling strategies in the proper environmental context.

Implications for Future Research

This study examines influences on the probability and timing of resource imitation. While the results of the study are very interesting and offer insight into resource-based imitation, the questions "under what conditions is resource imitation likely to occur and how does resource deployment affect the probability and timing of imitation" were not fully answered. In addition, the findings suggest several new directions for research. Below are suggestions for future research which answer the above research questions as well as related research topics.

As noted above, this study employs only one type of resource-financial patents- to test the research model. Future researchers could use more diverse samples including both tangible and intangible resources to broaden the theory and to more fully test the research model empirically. Researchers have effectively used patent samples as proxies for VRIN resources and to examine the relationships between imperfectly imitable resources, competitive advantage and performance (cf. De Carolis, 2003, Markman et al., 2004; Newbert, 2007). However, building and testing theory on the back of patents is not ideal. Patents are a special class of

resource; they have different levels of use across firms and industries, and their effect on competitive advantage and value creation is highly dependent upon the technological domain and industry under investigation. Patents represent codified knowledge which is easily discernable by potential competitors. In addition, the use of patent citation data to tease out imitation, may obscure the extent of actual imitation. To minimize the shortcomings of using patent samples, researchers should follow Black and Boal (1994) and divide resources by categories (i.e. contained vs. system), and employ more sophisticated measures of system and competency resource networks. In his review of empirical research on RBT, Newbert identifies the numerous ways researchers have operationalized resources, capabilities, and competencies, but notes that this diversity has yielded strikingly different results:

> An overwhelming minority of resources examined (only 10 of 26, or 38%) have received empirical support at least 50 percent of the time, whereas an overwhelming majority of capabilities examined (26 of 32, or 81%) and all six of the core competencies examined have received empirical support at least 50 percent of the time. (2007; 131)

These findings demonstrate there is a great need for scholars to identify additional proxies for knowledge-based resources and capabilities other than patents (or other intellectual property). This may be done through the use of triangulation of data samples; use secondary data sources discerned from financial statements and triangulate it with survey data.

This study proposed several measures of imperfectly imitable resources, a central construct in RBT's theory of competitive advantage, which have not been used in previous studies investigating resource imitation. The findings for the imperfectly imitable construct provide an excellent first step towards developing alternative measures to causal ambiguity, social complexity and unique historical conditions, which are prevalent in RBT research and are difficult to operationalize. This study should spur future research interest in both

operationalizing this important construct, but also examining its relationship to competitive advantage and firm performance (DeCarolis, 2003). For example, there may be other resource attributes (besides scope, innovativeness, and linkages), which help to explain the probability and timing of imitation. The best strategy for uncovering other important attributes is triangulation; obtain secondary data on other resource attributes such as resource complexity or longevity, and triangulate the data using perceptual data obtained through surveys. This strategy will yield more robust measures of resource attributes. Researchers could also investigate different measures of resource deployment. This study used one measure – the level of visibility by external parties; however, other deployment measures may contribute to our understanding of how firms protect critical resources. For example, one form of resource deployment is through licensing relationships with strategic partners. Does the choice to license critical resources make firms more susceptible to imitation?

Another avenue of research to explore is the possibility that firms whose resources have been imitated may in fact learn from the imitator. Firms may better understand how best to protect and deploy resources after they have been imitated (Zahra & George, 2002). Because this study employs a cross sectional research design it is unable to model for temporal effects. It does not measure whether a patent issued to firm 'X' in 2002 was not imitated or imitation was delayed because of lessons the firm learned from the 1997 issued patent it previously deployed. For example, Merrill Lynch secured one of the first financial patents in 1982 and has obtained 23 others since. It would be interesting to examine if the subsequent patents were less often cited or cited later holding constant this study's predictor variables. Hence, did Merrill Lynch learn anything of significance from previous patent deployment? A scholarly examination of how imitation of knowledge-based resources may impact the innovator of that knowledge would

provide intriguing insights for the strategic management, organizational learning, and technology management literatures.

This study proposed a model of resource imitation that tested effects on the probability and timing of imitation. It did not address questions related to 'who' imitates. Given a particular resource with distinctive attributes, what type of competitors–actual, newly emergent, or potential-are most likely to imitate a firm's resource? Theory from the competitive dynamics literature has developed models related to competitor identification and conditions when firms initiate and respond to strategic action (Chen, 1996; Cf. Peteraf & Bergen, 2003); however, these models do not specify who is most likely to imitate a competitor's critical resource (Ketchen et al., 2004). The erosion of advantages initially gained from deploying resources can occur across a myriad of competitor types, and developing a model which integrates competitor identification and resource imitation will inform not only RBT, but also theories from competitive dynamics.

Lastly, another avenue of research is to explore the costs associated with protecting and deploying resources, as well as those associated with resource imitation. Transaction costs-the costs of exchanging, protecting, and deploying resources-are important to strategy in general, and RBT in particular because they influence the value that a resource can appropriate when deployed. This study did not include the impact of transaction costs in the research model; in fact, it assumed that costs were not a significant consideration during the possessing firm's deployment decision, and the subsequent decision by the competitor to imitate. An explicit focus on transaction costs helps to explain how value can be created through transaction cost reduction, or eroded through increasing transaction costs, under the increasing threat of imitation (Foss & Foss, 2005). In the context of financial patents, transactions costs will increase under the weight of potential litigation when competitors seek to imitate not only the knowledge embedded in the

patent, but also infringe upon its technological claims. The importance of transaction costs is most acute in technology standard races, where the winner-takes-all will escalate costs from the competing parties (Schilling, 1998; Teece, 2000). Incorporating the impact of transaction costs in a theory of resource imitation will shed more light on the relationship between resource protection, deployment and firm performance.

Limitations

As is the case with all research, this study has several limitations. While the study's findings shed light on some of the predictors of probability and timing of resource imitation, their interpretation and subsequent discussion must be considered in the context of the study's limitations.

The sample consists of one type of resource, which is most prevalent in the financial services industry. As such, the study's findings lack generalizability across different resource types and industries. Findings may differ when other resources such as human capital, knowledge competencies, or financial capital are tested in a similar manner. As noted earlier, there are several benefits of using a financial patents only sample. However, financial patents remain a relatively small part of the resource portfolio of most financial firms. Most financial firms still rely upon other types of resources in order to create value and gain a competitive advantage. Deeper insight on the effects of resource attributes and deployment on the probability and timing of imitation could be gained by examining other resource types as well as different industries.

A second limitation concerns the dependent variables probability and timing of imitation. This study uses forward citation of patents by an external party other than the inventing firm to measure imitation. This measure assumes that citation is a form of imitation; citing firms actual

imitate the knowledge embedded in the previous patent without infringing on its property rights. In rare instances is an object perfectly imitable; resources as well as products are often modified, albeit slightly, during the replication process (Rivkin, 2001; Teece, 2000). That being said, there is no way to determine how much of the patent's knowledge or claims are actually being imitated by the citing firm. Further, forward citation may also be influenced by a USPTO patent examiner, who has limited discretion in determining which prior art (i.e. patents) need to be cited in order for the focal patent to be issued. These exogenous effects may create confounding effects on the probability and timing of imitation. That being said, this measure of imitation has held up to the scrutiny of scholarly review and therefore I believe it to be a valid measure of imitation (cf. DeCarolis, 2003).

A third limitation of this study is its reliance on one source for the majority of the data. This raises concerns of a common method bias. Many of the independent variables as well as the two dependent variables were captured using patent data obtained from the USPTO database. To mitigate the risk of common method bias, rich measures were developed using SMEs for two of the predictor variables- innovativeness and visibility. In addition, I collected data for three control variables from other sources: data on *firm age* came from the Hoovers database and data on *firm diversification* and the *financial industry* dummy variable were obtained from the Census Bureaus database of SIC codes, and through an analysis of each firm's SIC designation.

A fourth limitation of this research stems from its strengths; it is one of the first studies to develop stylized measures of patents that fit a technology-specific context. The use of newly developed subjective measures for patent innovativeness and visibility are noteworthy. While elegant resource-based theories on firm behavior and performance exist, empirical efforts to craft measures for resource attributes and resource deployment have lagged. The measures were

validated using inter-rater reliabilities from the six SMEs interviewed for this study; however, the factor reliability scores were a bit low. Specifically, the Cronbach's alpha for the innovativeness factor was .55, acceptable, but not particularly strong. Likewise, the Cronbach's alpha for the internal linkages factor was .49, again acceptable, but weaker than one would like. Regardless, I believe the subjective measures are consistent with the nature of patent innovativeness and visibility. However, others are encouraged to take up the challenge of developing and refining the measures necessary for fine-tuning the theory.

A fifth limitation is the cross sectional nature of the research design. Although the cross sectional nature of this dissertation allows for the examination of the relationships concerning imitation at one point in time, it does not allow for these patterns to change over time. It does not infer any causality in the relationships examined in the analysis. The data covered only a select time period. Because financial patenting is a relatively recent phenomenon, collecting data over longer time periods was not possible. Prior to 1980, many inventions within the business method domain were not patentable. Only with the proliferation of computer software has patenting business method inventions such as financial innovation been possible (Allen & Gale, 1999). Because of this constraint, many of the patents are very recent (of the 1911 patents in the sample, 780 were assigned during the first 20 years of the sample time, 1980-1999, whereas 1131 were assigned during the lat 5 years of the sample time, 2000-2004. Longer time frames may shed light on the robustness of the hypothesized relationships. Although the Cox regression method allows for right-censoring of the data to ensure greater accuracy, using a longer gestational period, may enhance the robustness of the findings.

An additional limitation relates to firm intention. As noted above, because I used a cross sectional design causality in the relationships tested cannot be inferred. It is often the case in

strategic management literature and in practice that strategic outcomes misrepresent intent. For example, Mintzberg and Waters (1985) found that an *emergent strategy* plays just as an important role as a *planned strategy*, and often the two are indiscernible unless highly scrutinized. This may present in the case of resource deployment; how resources are used may or may not be due to a planned effort by the firm. That being said, because of the difficulty in identifying actions post-hoc, this study must rely on strategic outcomes culled from secondary data. Hence, it is a limit to the potential results derived from the empirical test.

The final limitation relates to the focus of the study. Because the unit of analysis is at the resource, the focus of the theory is on resource attributes and deployment decisions of the patent holder, without considering characteristics of the imitating firm. Future work should consider both significant characteristics of the resource holder, the imitating firms, as well as the specific attributes of the resource. When and under what conditions should competing firms exploit a resource's know-how through imitation, through licensing from the resource holder (if possible), or pursue independent searches for resource substitutes? Empirical insights into these questions would provide a more complete picture of the resource-based imitation phenomenon and the dynamics between a resource creator and imitator.

Conclusions

The purpose of this dissertation is to examine how firms purposely deploy their resources to achieve maximum protection in order to limit the likelihood or delay the timing of imitation. RBT maintains that inherent attributes, such as causal ambiguity, social complexity, and unique historical conditions explain resource imitation and are most likely to confer competitive advantage (Barney, 2003; Hunt & Morgan, 1995). Yet, we know very little about how firms impede the imitation of their critical resources to sustain their advantages. One possibility,

which supports RBT, is that certain resources naturally diffuse slowly. Another is that firms make resources more fungible through deployment and thus mute or delay their imitation. This dissertation provides evidence for both propositions. Specifically, the research model proposes resource attributes, deployment, and their interaction affect the probability and timing of imitation. Overall, the results support RBT's contention that imitation barriers are at least partially located in resources; the resource attributes in the study -scope, innovativeness, and linkages- either accelerate or retard imitation. However, the findings offer qualifications to the theory-most importantly that for knowledge-based resources such as patents, resource deployment measured by relative visibility can accelerate imitation (i.e. when resources are deployed in highly visible customer-facing products or processes), or can hinder imitation (i.e. when resources are deployed in highly unobservable back-office processes).

To date, the challenges associated with measuring knowledge-based resources and barriers that protect them from imitation remain a central concern of RBT; it is the primary reason for the lack of empirical studies testing RBT's predictions (McEvily & Chakravarthy, 2002). This dissertation offers an approach for tackling these issues. First, one difficulty associated with empirically validating RBT is identifying unique resources and accurately observing if and when imitation occurs. At least part of the knowledge underlying any patented innovation is idiosyncratic to the firm, which makes organizational and technological innovations a good focal point for research RBT (Newbert, 2007). Second, the link between resource attributes, protection and deployment mechanisms and imitation is rather complex, so applying aggregated levels of analysis (i.e. at the firm-level) may obscure any interaction effects. This focus on the resource, keeping the level of analysis at the resource, which helped clarify the

various effects on imitation. Research at this level when resource deployment is more important than relying on firm attributes alone to limit the likelihood of imitation.

In conclusion, this dissertation entreats RBT scholars to take more explicit account of the imitation construct. The factors that predict imitation are numerous and complex; not only inherent attributes explain resource imitation. This study provides a theoretical extension to RBT's treatment of imperfectly imitable resources and preliminary empirical confirmation of the relationship between resource attributes, deployment, and imitation. Given the importance of imitation barriers in generating resource advantages and the creation of value within the firm, developing a more robust theory of resource imitation is a worthy objective. This dissertation provides a first step towards this objective. Much useful research to strengthen RBT and its treatment of resource imitation remains to be done.

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APPENDICES

APPENDIX A: Description of the Subject Matter Experts*

	Position	Experience	Expertise
SME # 1	Patent attorney	15 years as patent attorney – 5 years as IP attorney with Fortune 500 bank	– expertise in software (i.e. business method or financial patents) – worked on patents for technical entrepreneurs as well as patents for large firms – successfully defended several patent interferences, and 1 litigation
SME # 2	Entrepreneur / Consultant	3 years as entrepreneur 18 in financial services industry – 3 years head of R&D at Fortune 500 bank	– Successfully commercialized a financial patent through the formation of a new venture – created many financial innovations while at Fortune 500 bank – expert witness during several patent interference hearings
SME # 3	Banker	8 years in financial services industry	– runs back-office department, which implements several financial innovations
SME # 4	Banker	13 years in financial services industry	– head of mutual funds servicing department – co-inventor of patent for servicing index funds
SME # 5	Banker / Consultant	5 years as consultant 25 years in financial services industry	– consults on technology integration in the financial service industry – created many financial innovations while at Fortune 500 bank
SME # 6	Academician	15 years as finance professor; 10 years in financial services industry	– research expertise in financial innovation adoption and diffusion

* As part of their condition to participate in this study, all six SMEs requested anonymity

APPENDIX B: Active Interviews

Background:

1. I am not familiar with the technological evolution of financial innovation, could you please briefly describe the past 25 years of financial innovations including the firms / inventors who developed the major financial innovations, when they were commercialized, and their impact on the financial services industry.

Resource Attributes & Commercial Viability:

1. Which resource attributes are most important when identifying a viable financial innovation such as a technological discovery?
2. Which resource attributes are most likely to attract attention from potential imitators?
3. What processes are used to evaluate the potential of a financial innovation?

Protection and Deployment Criteria:

1. Which criteria are used for making the decision to patent a financial innovation?
2. What other forms of protection – IP-based and non IP-based - are explored prior to the patenting decision?
3. What criteria are used to determine how a financial patent should be deployed by the firm?

Post-Deployment Imitation:

1. How aware are you that your financial innovations are being imitated: if, when, and by whom?
2. Who is most likely to imitate a financial innovation? What if any are the contingencies?

APPENDIX C: Description of Patents and Patenting Process

Patent Class Definitions as Provided by the US Patent and Trademarks Office

The following definitions are taken from the US Patent and Trademark Office Website. Due to the technical and legal nature of some paragraphs, they were not included in their entirety. However, some paragraphs were directly transcribed.

What is a Patent?

A patent for an invention is the grant of a property right to the inventor, issued by the United States Patent and Trademark Office. Generally, the term of a new patent is 20 years from the date on which the application for the patent was filed in the United States or, in special cases, from the date an earlier related application was filed. U.S. patent grants are effective only within the United States, U.S. territories, and U.S. possessions. The right conferred by the patent grant is, "the right to exclude others from making, using, offering for sale, or selling" the invention in the United States or "importing" the invention into the United States. What is granted is not the right to make, use, offer for sale, sell or import, but the right to exclude others from making, using, offering for sale, selling or importing the invention.

Three types of Patents

Utility Patents	Granted for process, machine, article of manufacture or composition of matter
Design	Granted for original ornamental design for an article of manufacture
Plant	Granted for invention/discovery of new variety of plant

What Can Be Patented?

In the language of the statute, any person who "invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent," subject to the conditions and requirements of the law. The word "process" is defined by law as a process, act or method, and primarily includes industrial or technical processes. The term "machine" used in the statute needs no explanation. The term "manufacture" refers to articles that are made, and includes all manufactured articles. The term "composition of matter" relates to chemical compositions and may include mixtures of ingredients as well as new chemical compounds. These classes of subject matter taken together include practically everything that is made by man and the processes for making the products.

The patent law specifies that the subject matter must be "useful." The term "useful" in this connection refers to the condition that the subject matter has a useful purpose and also includes operativeness, that is, a machine which will not operate to perform the intended purpose would not be called useful, and therefore would not be granted a patent.

Interpretations of the statute by the courts have defined the limits of the field of subject matter that can be patented, thus it has been held that the laws of nature, physical phenomena, and abstract ideas are not patentable subject matter.

A patent cannot be obtained upon a mere idea or suggestion. The patent is granted upon the new machine, manufacture, etc., as has been said, and not upon the idea or suggestion of the new machine. A complete description of the actual machine or other subject matter for which a patent is sought is required.

Conditions for Obtaining a Patent

In order for an invention to be patentable it must be new. If the invention has been described in a printed publication anywhere in the world, or if it was known or used by others in this country before the date that the applicant made his/her invention, a patent cannot be obtained. If the invention has been described in a printed publication anywhere, or has been in public use or on sale in this country more than one year before the date on which an application for patent is filed in this country, a patent cannot be obtained. In this connection it is immaterial when the invention was made, or whether the printed publication or public use was by the inventor himself/herself or by someone else. If the inventor describes the invention in a printed publication or uses the invention publicly, or places it on sale, he/she must apply for a patent before one year has gone by, otherwise any right to a patent will be lost. The inventor must file on the date of public use or disclosure, however, in order to preserve patent rights in many foreign countries.

Even if the subject matter sought to be patented is not exactly shown by the prior art, and involves one or more differences over the most nearly similar thing already known, a patent may still be refused if the differences would be obvious. The subject matter sought to be patented must be sufficiently different from what has been used or described before that it may be said to be nonobvious to a person having ordinary skill in the area of technology related to the invention. For example, the substitution of one color for another, or changes in size, are ordinarily not patentable.

Publication of Patent Applications

Publication of patent applications is required by the American Inventors Protection Act of 1999 for most plant and utility patent applications filed on or after November 29, 2000. On filing of a plant or utility application on or after November 29, 2000, an applicant may request that the application not be published, but only if the invention has not been and will not be the subject of an application filed in a foreign country that requires publication 18 months after filing (or earlier claimed priority date) or under the Patent Cooperation Treaty. Publication occurs after the expiration of an 18-month period following the earliest effective filing date or priority date claimed by an application. Following publication, the application for patent is no longer held in confidence by the Office and any member of the public may request access to the entire file history of the application.

Nature of Patent and Patent Rights

The patent is issued in the name of the United States under the seal of the United States Patent and Trademark Office. The patent contains a grant to the patentee. The grant confers "the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States" and its territories and possessions for which the term of the patent shall be generally 20 years from the date on which the application for the patent was filed in the United States.

The exact nature of the right conferred must be carefully distinguished, and the key is in the words "right to exclude" in the phrase just quoted. The patent only grants the right to exclude others from making, using, offering for sale or selling or importing the invention. Since the patent does not grant the right to make, use, offer for sale, or sell, or import the invention, the patentee's own right to do so is dependent upon the rights of others and whatever general laws might be applicable. An inventor of a new automobile who has obtained a patent thereon would not be entitled to use the patented automobile in violation of the laws of a state requiring a license, nor may a patentee sell an article, the sale of which may be forbidden by a law, merely because a patent has been obtained. Neither may a patentee make, use, offer for sale, or sell, or import his/her own invention if doing so would infringe the prior rights of others.

Assignments and Licenses

A patent is personal property and may be sold to others or mortgaged; it may be bequeathed by a will; and it may pass to the heirs of a deceased patentee. The patent law provides for the transfer or sale of a patent, or of an application for patent. The assignee, when the patent is assigned to him or her, becomes the owner of the patent and has the same rights that the original patentee had. The statute also provides for the assignment of a part interest, that is, a half interest, a fourth interest, etc., in a patent. There may also be a grant that conveys the same character of interest as an assignment but only for a particularly specified part of the United States.

An assignment, grant, or conveyance of any patent or application for patent should be acknowledged before a notary public or officer authorized to administer oaths or perform notarial acts. The certificate of such acknowledgment constitutes prima facie evidence of the execution of the assignment, grant, or conveyance.

Joint Ownership

Patents may be owned jointly by two or more persons as in the case of a patent granted to joint inventors, or in the case of the assignment of a part interest in a patent. Any joint owner of a patent, no matter how small the part interest, may make, use, offer for sale and sell and import the invention for his or her own profit provided they do not infringe another's patent rights, without regard to the other owners, and may sell the interest or any part of it, or grant licenses to others, without regard to the other joint owner, unless

the joint owners have made a contract governing their relation to each other. It is accordingly dangerous to assign a part interest without a definite agreement between the parties as to the extent of their respective rights and their obligations to each other if the above result is to be avoided.

The owner of a patent may grant licenses to others. Since the patentee has the right to exclude others from making, using, offering for sale, or selling or importing the invention, no one else may do any of these things without his/her permission. A patent license agreement is in essence nothing more than a promise by the licensor not to sue the licensee. No particular form of license is required; a license is a contract and may include whatever provisions the parties agree upon, including the payment of royalties, etc.

Patent classes in the study:

1) **Class 705: Data Processing**

This is the generic class for apparatus and corresponding methods for performing data processing operations, in which there is a significant change in the data or for performing calculation operations wherein the apparatus or method is uniquely designed for or utilized in the practice, administration, or management of an enterprise, or in the processing of financial data. This class also provides for apparatus and corresponding methods for performing data processing or calculating operations in which a charge for goods or services is determined.

SCOPE OF THE CLASS- The arrangements in this class are generally used for problems relating to administration of an organization, commodities or financial transactions.

2) **Class 902: Electronic Funds Transfer**

This cross-reference art collection provides for disclosures of "systems", "components" of systems, or "peripherals" to systems designed to facilitate the exchange of monetary value via electronic means. A device within a data processing system designed to process data (e.g. encryption, modulating, transmitting, receiving, comparing, performing arithmetical calculations, etc.) after it has been entered by a user (i.e. input) in order to formulate a response to the user (i.e. output) or to protect the data.

APPENDIX D: Statistical Assumptions and Data Screening

Statistical Assumptions

Most statistical techniques rely on several assumptions including homoscedasticity, normality, linearity, multicollinearity, and the absence of outliers. What follows is a brief description of each of these assumptions and an explanation of how violations of the assumptions are tested. Homoscedasticity is the assumption that the variability in scores for one variable is roughly the same for the other variables. It is related to normality; when normality is not found, variables are not homscedastic. Linearity is the assumption that there is a one-dimensional relationship between variables. It is essential when calculating multivariate statistics as it is the basis for the general linear model (GLM) and the assumption of multivariate normality. Multicollinearity exists when there is significant interdependence between variables. The SPSS software package generates two measures of multicollinearity: variance inflation factor (VIF) and tolerance. When the VIF, which ranges from 1 to infinity, approaches one, the variable of interest is unaffected by multicollinearity. Tolerance, which is the opposite of VIF, ranges from zero to one, as the value gets closer to zero it indicates a higher level of multicollinearity. Tests were conducted to determine the presence of multicollinearity in this study.

Outliers are extreme cases or a combination of variables, which can have a strong influence when statistics are calculated. Transformations are a remedy for outliers, as well as for failures of normality, linearity, and homoscedasticity. Multivariate normality is the assumption that all variables and all combinations of the variables are normally distributed. When the assumption is met the residuals are normally distributed and the differences between predicted and obtained scores (the errors) are symmetrically distributed around a mean of zero (i.e. there is no patter to the errors). Statistical methods were used to screen the data for normality.

Data Screening

Prior to any analysis it is important to thoroughly screen the data. The order of data screening is important because actions taken at earlier stages will influence subsequent decisions made at later stages. For example, if the data are non-normal and have outliers, if a decision is made to transform the data at an early stage, there is likely to be fewer outliers during the later stages of the analyses. However, when the outliers are initially deleted or modified, there are likely to be variables that are non-normal. Hence, transformation is usually preferred, as it tends to reduce the number of outliers, and is more likely to produce normality, linearity, and homoscedasticity. Screening data is an essential step in any research study, because it helps isolate data peculiarities and it allows the researcher to adjust the data for further multivariate analysis. The table below describes the sequential steps for data screening undertaken for this study (Tabachnick & Fidell, 1996). The list indicates key decisions that I made to prevent data analysis problems.

Table A.1: Data Screening Checklist

1. Inspect univariate descriptive statistics for accuracy of data entry
   a. Out-of-range values, apply measurement scales
   b. Plausible means and standard deviations
   c. Coefficient of variation
2. Evaluate amount and distribution of missing data and with any problems
3. Ensure independence of variables
4. Identify and deal with nonnormal variables
   a. Check skewness and kurtosis using probability plots
   b. Transform variables, when desirable
   c. Check results of transformation
5. Identify and deal with outliers
   a. Variables causing multivariate outliers
   b. Description of multivariate outliers
6. Check pairwise plots for non-linearity and heteroscedasticity
7. Evaluate variables for multicollinearity and singularity
8. Check for spatial auto correlation

Adapted from Tabachnick and Fidell (2001; 85)