THREE ESSAYS ON PRODUCT FORM CHOICE

by

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DEDICATION

This dissertation is dedicated to the memory of my Mother, Kim Marie Frias.

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ABSTRACT

Innovators and high-technology entrepreneurs have three principal options for transforming their innovations into viable business models and deriving value from their innovations. They may: market intellectual know-how (via licensing and/or proof-of-concept), market intermediate products (i.e., sell components/sub-systems), or market end-products (i.e., sell complete systems/solutions). In this dissertation, I aim to contribute to the organizational design and marketing strategy literature with three separate essays that study these fundamental strategy alternatives, which are called "product form choice". In the first essay, I explore product form choices in the context of early-stage and established firms engaged in new product development projects, and generate a theoretical framework that shows (a) how technology, market, and enterprise-resource related factors systematically impact this choice, and (b) how the enterprise coordinates with other actors in its "eco-system" to design, produce, and market effective products/solutions based on the core innovation. The other two essays use two different methodologies and contexts to systematically test some key refutable predictions from the framework developed in Essay 1. In particular, in the second essay, I use simulated experimental scenarios and ordered-choice models to investigate explore product form choices in the context of early-stage ventures seeking angel investor funding to examine the effect of technology, marketing, and firm-level factors on product form decisions. In the third essay, I use primary survey data obtained from executives from firms selling industrial equipment in four industry sectors to study how coordination and safeguarding

motives, in conjunction with a firm's unique set of product development resources impact their product form decision.

1. INTRODUCTION

Technological advances in a wide variety of business-to-business product and service markets originate and are developed in established industrial firms as well as in high-technology start-up ventures and university-based research laboratories. One of the most critical strategic marketing decisions faced by these firms is the question of what to sell. In other words, firms must essentially ask themselves, "In what 'saleable form' should we offer our innovation in the marketplace (and derive economic value/revenues from it)?" The three principal *pure play*[1i] options that firms usually have to transform their innovations into viable business models are: marketing *intellectual know-how* (via licensing and/or proof-of-concept), marketing *intermediate products* (i.e., selling components/sub-systems), or marketing *end-products* (i.e., selling complete systems/solutions). I call these alternatives "product form choices." Consider two examples of alternative modes of product formation:

- Bio-medical and nano-engineering based biotechnology firms are developing techniques that improve the prospect of micro-dosing and direct drug delivery to specific organs. Firms in this line of business have three options for deriving commercial value from their techniques. They may license the technology to established pharmaceutical companies, which then might go on to develop the micro-dosing platforms on their own. Alternatively, they may develop a broad drug delivery platform (for different drugs addressing different ailments) that embodies the technology and sell this platform to various drug manufacturers on a non-exclusive basis. The drug manufacturers might then configure this platform around their drug. Finally, the firm may customize the delivery mechanism to an organ/ailment and co-develop the delivery system with the specific drug– in effect offering a complete "drug and delivery" solution.

[1] *Pure play* is a common term used by business analysts and other industry practitioners that refers to a company devoted to one line of business or a company whose stock price is highly correlated with the value of a specific investing theme or strategy.

- A high-technology medical-devices firm developed specialty bone anchor implants for knee replacement surgeries. The venture could have chosen to market only the anchors (a component strategy) and let the surgeons integrate it with other components and devices while performing the surgeries. Instead, they developed and marketed an entire solution tool-kit built around these anchors that included a GPS-type device that would help orthopedic surgeons properly align the replacement knee-cap with a patient's bones, tendons, and tissues (see Appendix A).

Similar product-form related decisions are made by prominent established firms that choose to enter adjacent markets. For instance, Oracle, the business software company, not only acquired hardware manufacturer SUN Microsystems to compete in the systems market against IBM, but recently has been keen on acquiring some micro-processor chip manufacturers so that it may offer a complete "one-stop solution" to their customers (as opposed to being primarily a business-software vendor). Likewise, in many cases, prominent drug manufacturers license their compounds to other companies for development of commercial treatments rather than attempt to develop and market drugs themselves. For example, Bayer gave Pfizer exclusive worldwide license for DGAT-1 inhibitors, compounds that showed promise in developing a treatment for diabetes and obesity.

Even within one product market, major competitors may choose to sell their technologies with differing product form strategies. Some firms sell only one product form in the market while others sell multiple products to both intermediate and final goods' markets. Consider the Flat-panel HDTV market and the current product offerings of prominent firms. Chungwa Picture Tubes sells only flat panel displays to other TV manufacturers while Samsung sells flat panel displays and TVs (under its own brand). Meanwhile, Sharp manufactures flat panel displays solely to be incorporated into its own

branded TVs while Vizio and Sony sell TVs but procure the flat panel displays from other components vendors (e.g., Samsung).

These decisions have important implications for the development of an effective marketing and business strategy because, depending on where the firm chooses to participate in the value chain for that technology (i.e., whether the firm chooses to market the intellectual know-how, an intermediate product, or a final product based on the know-how), its set of direct customers, immediate competitors, and key value-chain activities change. For instance, in the drug-delivery example, the "drug and delivery solution" product-form option would entail decisions regarding (a) which drug and ailment the mechanism should be specifically developed for, (b) whether to customize the product to a particular pharmaceutical manufacturer's drug, and potentially (c) if the product is to be customized to a particular pharmaceutical manufacturer's drug, who should invest in the customization efforts and what would the form of the vertical trading relationship be.[2] Likewise, in the knee replacement device example, the firm had to invest in and develop deep expertise and skills in the design, development, and integration of the complementary products and components (e.g., the GPS device, the knee bracings and brackets, the software, etc.) around its core innovations in order to offer a viable solution to orthopedic surgeons.

Product form decisions are a costly endeavor at any stage of firm development. More importantly, this decision is a fundamental strategic decision undertaken by the firm with a widespread impact on such questions as "what is the market", "who are the

[2] Pfizer, for instance, acquired Meridica, a drug-delivery venture, to customize Meredica's drug-delivery platform to specific organ types and Pfizer drugs that target those organs.

potential customers for the product" and "what is a potential strategy for market entry". Although the aforementioned questions have been explored in prior studies, these studies have largely ignored the product form decision. Typically the firm's market offering is taken for granted and much of the focus of study reflects the field's interest in developing targeting, positioning and segmentation strategies to generate the greatest profit potential. This is somewhat surprising as the product form provides the foundation for exploring all other marketing related decisions made by the firm. Furthermore, an initial decision to sell in a components market may prove successful for a time. However, the product form decision is also required of technologies with waning revenue, evolving markets, and changing customer needs. For example, Oracle announced the introduction of the Sun Microsystems/Oracle partnership in 2006 with advertisements touting the Oracle/Sun Micro partnership as the foundation for the development of a new server. The advertisement directly compared the Sun/Oracle Server with the fastest IBM server and argued that the Sun SPARC server outperforms IBM's best server. This advertisement demonstrates how a firm may use advertising to promote a transition (e.g., a merger) as a product form to customers. In this case, Sun/Oracle purports to offer increased product performance through the enhanced capabilities of their newly merged firm. Oracle's decision to acquire Sun was valued at nearly $7 billion dollars in 2010 (according to an Oracle press release made available on January 27, 2010). This acquisition also allows Oracle to expand their product offerings from strictly components to components and systems, which enhances Oracle's ability to compete with a systems supplier like IBM. Notice that Oracle's competitors in the software business are companies like SAP,

Peoplesoft, Salesforce.com, and, of course, IBM, but its competitors in systems markets may also include a variety of different prevailing firms. As such, what a firm chooses to sell is a materially significant strategic decision with important implications for the longevity of the firm. Additional examples of alternative modes of product formulation can be found in the service industry (e.g., Ritz Carlton), consulting businesses (e.g., IBM), and consumer products (e.g., Procter and Gamble).

Despite its importance, scant attention has been paid to when and why firms choose a particular product-form. In my dissertation, I use a multi-method approach to study this choice. First, I use a qualitative grounded-theory building approach (e.g., Eisenhardt 1989; Glaser and Strauss 1967) to study these choices in the context of early-stage product-development projects undertaken by established firms in high-technology B2B/Industrial sectors. The aim here is to gain an understanding of how decision makers conceptualize this problem, "the question of what product form to choose," and to generate a testable framework that implicates certain factors and their impact on product-form choice. This analysis is provided in Essay 1. This Essay seeks to answer the following three questions: (1) What is product form choice and how does it play a role in marketing strategy? (2) What are the underlying factors associated with this choice? (3) How do these drivers impact this decision?

In Essay 2, we systematically examine the underlying factors impacting product form choice, as revealed in Essay 1, to understand how these factors influence product form choice in early-stage ventures. This study examines product form choice in the context of early-stage ventures since this stage in the firm's development typically

suggests the firm is making deliberate strategic decisions about commercializing one primary technological idea. Second, anecdotal evidence uncovered during participation observation (conducted during Study 1) suggests the product form decision is a frequent consideration of angel investors when evaluating potential investments. As such, Essay 2 requires active angel investors to evaluate fictitious business proposals based upon technology, marketing and firm-level factors for their evaluations of product form choice.

In Essay 3, I use primary survey data obtained from executives, working within established firms, which sell industrial equipment operating in four industry sectors to determine the factors impacting their decision of which product form to sell. Unlike the prior two studies, this study limits the product form choice decision to either a component or a system. Executives are surveyed regarding the product line with the highest revenue to constrain responses to their most critical product line. I conclude with the theoretical and managerial implications of my research.

1.1 Existing Theory

1.1.1. Boundaries of the Firm.

It is increasingly recognized that the development and commercialization of new products and processes has an important bearing on firm and industry structure (Teece 1996; 1982; 1980; Novak and Eppinger 2001; Jacobides and Winter 2005). Often called "scope of the firm," "vertical architecture" or "vertical positioning," this literature emphasizes the importance of the characteristics of the core innovation, the institutional environment to which the innovation could enter, and the capabilities of the firm. Although there is no unifying theory that can explain what product form the firm chooses to sell, these streams of literature shed light on the scope

of activities the firm should pursue and have implications for the determinants of product form choice. Early work on the "scope of the firm" identifies the need for further examination of firm activities beyond a simple analysis of economies of scale (Panzar and Willig 1977). This work suggests technological determinants may impact the structure of both the firm and industry since variable costs associated with multiproduct technologies create production cost differentials and thereby influence how firms choose to organize within an industry (Willig 1979).

Arguing that the theory of industrial organization is unable to explain why firms operate in variable product markets and diversify among products in different ways, Teece (1980) began exploring the implications of earlier work by Coase (1972) and Williamson (1975) to study diversification among firms. Using the "scope of the firm" rationale, Teece (1980; 1982) develops a basis for determining how such resources as organizational knowledge, used in the joint production of two or more manufacturing processes, may provide an improved cost savings, and hence efficiency if organized within one multiproduct firm as compared with acquisition in capital markets. Teece places emphasis on the supply of proprietary know-how rather than on the supply of physical inputs, as it is the know-how that is difficult and costly to transfer outside of the firm. While this work is suggestive of when it is likely to be cost effective to transform know- how into multiple products, this concept of diversification is unable to explain why firms operate in different markets and subsequently choose to diversify among product alternatives in unique and unpredictable ways.

More recent work by Jacobides and Winter (2005) and Jacobides and Billinger (2006) examines firm boundaries with transaction cost economics (TCE) as their theoretical lens. They argue that researchers over the last decade have recognized the complexity of firm boundary decisions but have done little to understand how the transaction cost framework may be extended to firm-level decision making. Instead, traditional organizational theory has remained focused on the canonical "make versus buy" question and its derivatives. Jacobides and Billinger (2005) extend TCE and work on the *scope of the firm* by considering a systemic view of the governance of transactions, specifically by conducting an analysis of firm instead of transactional boundaries. This is crucial to their extension of prior TCE work since this allows the authors to consider firm-level factors (e.g., firm resources that differentially impact productivity, innovation potential, or ability to coordinate) that are largely ignored in traditional approaches. Following the Resource-Based View (RBV) extensions of the "make versus buy" question examined in organizational theory, strategy, and marketing, *scope of the firm* researchers have also considered firm-boundaries through a combined theoretical lens (Cacciotori and Jacobides 2005; Jacobides and Winter 2005). For example, "vertical architecture" explores the firm's choice of (1) where to participate in the value chain, (2) how to interface with channel members, and (3) vertical and horizontal relationships (e.g., transfer pricing, resource allocation) to most efficiently align the firm's activities (Jacobides and Billinger 2006). Findings reveal that transaction cost reductions, along with capability differences, alter "vertical scope" or the activities of the firm and are contingent upon evolving industry contexts. This dynamic perspective on the boundaries

of the firm suggests that proper resource management and the attributes of a particular exchange environment provide the underlying drivers for the variable forms of business organizations (Teece et al 1994). Specifically, across different streams of literature, the underlying mechanisms of transaction costs economics (Williamson 1985; Coase 1972) and, more recently, RBVs of the firm have been used to explore the underlying mechanisms impacting *scope of the firm* decisions (Novak and Wernerfelt 2008).

Second, as the aforementioned discussion suggests, this work has largely shifted the typical TCE focus from transactional examinations of exchange to firm-level governance decisions. In particular, these studies have focused on the *configurations* of transactional choices occurring along a firm's value chain and consequently investigate a firm's boundary decision rather than individual transactions in isolation (Jacobides and Billinger 2006). Expressed another way, this work considers the most efficient governance mechanism or firm boundary of any specific organization rather than the governance of individual transactions. Thus, it deemphasizes taking a micro-analytic approach and emphasizes factors that operate at the firm level (e.g., innovative potential, systemic adaptation, capabilities) by arguing that the traditional TCE approach neglects firm-level resources and environmental attributes impacting the firm. This refocus of the TCE approach implies that the underlying mechanisms of transaction cost analysis (e.g., safeguarding, adaptation) can be extended beyond the micro-analytic level of analysis to understand bundles of transactions. For example, Novak and Wernerfelt (2008) find the frequency of needs for adjustment predicts the firm will integrate activities when it is cheaper to internalize those activities rather than attempt to organize activities in the

market. Findings reveal the supply chain can be manipulated and designed as a solution to the costs associated with varying levels of interdependence between product components.

Third, while the focus of recent studies extends our understanding of the efficiency-based rationale to explore its implications at the firm-level, these studies explore the firm's decision to vertically integrate into adjacent markets through both coordination and production efforts(Novak and Eppinger 2001; Novak and Wernerfelt 2008). For example, if a particular widget requires *component A* and *component B* to become *System W*, then the firm, if it chooses to sell *System W*, is assumed to produce *component A* and *component B*. Utilizing the auto industry as their context, Novak and Wernerfelt (2008) find that adjustment costs associated with the production processes required to coordinate single or multiple components in the global automobile industry direct the firm's boundary decision. As a result, the firm should group its production tasks and, therefore *boundary*, based upon costs of adjustment frequency and co-production. As such, the possibility of choosing to sell different product forms across product lines is left unexamined. Similarly, Jacobides and Billinger (2006) find a firm in the fashion industry is able to create further revenue by altering its product offerings to sell in intermediate markets (e.g., selling components) while not altering the scope of the firm. Specifically, these firms may choose not to integrate complementary production processes to generate final goods; rather, they may sell semi-complete goods to downstream manufacturers without changing their own production processes. Although this study reveals the possibility of differences between firm-level boundaries and

product-line decisions, Jacobides and Billinger (2006) do not explore the implications of these differences and remain focused on firm-level decisions. Not surprisingly, their study mirrors the "make versus buy" focus common to TCE and assumes the production processes required of a firm to sell a product will guide the boundaries of the firm.

In contrast, the product form choice decision examined in this dissertation does not presume that a firm's decision to sell a multi-technology product (i.e. two components as a system) also parallels their decision of what to produce. Instead the product form decision is considered a separate choice of what to sell rather than what to produce. Subsequently, according to my examination of this question, the firm could choose to sell *System W* without necessarily producing both *Component A* or *Component B.*

1.1.2. Vertical Positioning. Alternatively, one study in marketing provides a framework for understanding the firm's decision of what to sell that does not adhere to prior assumptions about parallel firm and product-level integration or the production focus associated with studies of *vertical architecture* and *vertical scope*. Instead, John et al. (1999) provide a conceptual framework for understanding product form choice that concentrates on product-line level decisions (see Appendix C). Utilizing this product-level focus allows these authors to identify factors specific to the technology and its complementary technologies while not assuming this firm will produce all of the components necessary to sell a particular product offering. This work classifies alternative product form choices from *high* to *low*. Specifically, the *vertical positioning* continuum of product form alternatives identifies the product offerings available to

commercialize an innovation and organizes the alternatives along a range of choices based upon the resources required of potential customers. High vertical positioning (e.g., licensing and the sales of a proof-of-concept) is termed high because this position requires less resources of the focal firm and relatively more resources of the buyer to transform this technology into a commercializeable market offering. For example, selling a license for a pharmaceutical compound requires relatively more resources of the buyer to generate a final product as compared with buying the ready-for-market medication. Relatively moderate positioning include components and subsystems, which are considered intermediate goods and require coordination and development resources of both the seller and the buyer. At the low end of the spectrum are complete goods and final solutions. This positioning requires relatively little or no resources of the buyer. For example, a consulting firm designing, developing, and maintaining all of the buyer's front and back-office software integration needs with relatively little or no resources of the buyer would be termed a low vertical positioning.

Although this framework does not make direct reference to TCE or Resource-based views of the firm, the underlying mechanisms impacting the firm's ability to trade know-how (e.g., safeguarding proprietary knowledge, difficulties associated with trading tacit information) and their depiction of the factors impacting know-how suggest the TCE/RBV combinative lens may be an appropriate framework for empirical examination of this phenomenon. Like Teece (1980; 1982), these authors consider the sale of scientific know-how to be the platform for determining how to best enter a market. This is consistent with the efficiency-based rationale provide by Williamson (1985), which

suggests proprietary know-how has implications for organizing governance. Further evidence to support my use of the TCE/RBV lens is explicitly noted by John et al. (1999) in their discussion of the importance of resources in new product development. Specifically, their vertical positioning continuum is organized by the amount of variable resource expenditures required of the buyer (p. 83). Thus, the decision to sell one product form alternative rather than another is contingent upon the focal firm's resource outlay and the potential resource expenditures of the buyer. As such, their work provides a continuum of product form alternatives based upon product design decisions and outlines propositions which may impact the focal firm's decision of product form choice.

Contrary to prior work on the *scope of the firm,* this framework asserts that the decisions made by the firm at the product-line level are not necessarily synonymous with firm boundary decisions. Citing multiple vertical positions within one firm as a growing phenomenon, these authors argue that vertical positioning is not tantamount to vertical integration or the *scope of the firm* (John, Weiss and Dutta 1999, p. 84). Instead, vertical positioning is a product-level decision about which product formulation to sell and does not necessarily require that the firm produce any of the necessary elements of a product to sell it.

Although *vertical positioning* is not necessarily synonymous with *vertical integration*, it could be that a firm chooses to sell a two-component system and make both components (i.e. vertical positioning and vertical integration are synonymous); however, the firm could also choose to sell a two-component system and have both

components outsourced. Thus the "how do we make it" decision (i.e. vertical integration) is made only after the "what do we sell" question (i.e. vertical positioning) has been answered. For example, imagine a firm has the technical blueprints to develop and sell a form of transportation designed to travel by roads and air (e.g., a flying car). This firm must decide how to transform this idea into a revenue-generating product offering. The firm must choose a product form to sell: the engine components or the complete car. This is the *vertical positioning* question. Subsequently, they then must determine which of the necessary components they should manufacture or source from others. That is the *vertical integration* question.

Vertical positioning also differs from traditional positioning strategies in marketing. A traditional positioning question considers how to arrange a market offering in a clear, distinctive, and desirable place relative to competing products in the minds of target consumers (Armstrong and Kotler 2011). "What to sell" relates to this question as it provides a market for examining potential competitors and a platform for determining typical differentiating factors such as the level of quality or price. Returning to our flying car example, the traditional market positioning question considers how I should differentiate my car relative to other flying cars (assuming there was a market for these vehicles). Again, the traditional market positioning question considers only how to arrange the market offering relative to competitors once the potential competition set is known. This can occur only after the vertical positioning determination has been made. Imagine the set of potential customers are likely to be different if the firm chooses to sell engine components as compared with complete vehicles.

1.2 My Theoretical Lens

Although the data analysis will provide a more detailed account of the underlying theoretical support for our findings, I find it is helpful to provide an assumptive framework for this article. This is explained in part to introduce the reader to the theoretical lens utilized by the author prior to undergoing data collection efforts, but also to identify for the reader the relevance of this theory for understanding the emergent findings and their implications for practice (Strauss 1987; Eisenhardt 1989; Eisenhardt and Graebner 2007). I propose a combinative lens similar to Zajac and Olsen's (1993) "transaction cost analysis". I emphasize the relevant dimensions of creating and claiming value in interfirm relationships (Ghosh and John 1999; Teece 1986), heterogeneity from the resource-based view (Peteraf 1993: Barney 1991; Wernerfelt 1984) and the hazards associated with institutional environment and intellectual property protection (Henisz 2000; Henisz and Williamson 1999; Oxley 1999). Specifically, I consider the value and costs associated with *coordinating* the design and development of complementary technologies through commercialization, the costs associated with *safeguarding* proprietary assets with variable levels of intellectual property protection and the benefits associated with firm-level *resources* related to technological and marketing capabilities . These themes are consistent with fundamental underlying motives of coordination (Coase 1960; Wernerfelt 1994, 2005) and safeguarding (Williamson 1985) in the organization design literature, the value of non-imitable and dynamic resources and capabilities in the Resource-Based View (Madhok 2002; Foss 2005), and models that integrate the two perspectives (Ghosh and John 1999; Madhok 2002).

Coordination refers to the ease with which the focal firm can interact with other independent external parties as well as internally with other functional divisions to organize the design, development, production, and marketing of the product-form (and potentially the parts thereof) to generate or create the value from it; Safeguarding refers to the ability of the focal firm to prevent the value from its innovations from being appropriated by other known or unknown independent parties; and Resource profiles refer to the skills/capabilities that the focal party and its partners possess that help them generate the value from their innovation

1.2.1. Coordination. Coordination efforts to ensure adaptation refers to the costs of making ongoing changes to an agreement as events occur to accommodate for changing circumstances. Historically, adaptation has been observed as a main concern of organizations, according to Barnard (1938) as he noted, "the survival of an organization depends upon the maintenance of an equilibrium of complex character… [this] calls for readjustment of processes internal to the organization…by which [adaptation] is accomplished" (p. 6). Arguing that adjustment processes (also termed management processes) become the most important limitations to complex cooperative organizations, Barnard recognized that changing environmental circumstances will likely be a detriment to formal organization (p. 35). While Barnard largely ignored the adaptive properties of markets, the characteristics of informal and formal organization provided a useful structure for the subsequent development of transaction cost economics (Williamson 1990).

Adaptation costs, according to Williamson (2005), reflect the "disturbances to which transactions are subject" (p. 47). Citing both autonomous and cooperative adaptation concerns, transaction cost economics argues that the performance of the economic system must be understood for both markets and hierarchies (p. 47-48). Part of the "New Institutional Economics" paradigm, Williamson adds conceptual precision to the seminal work of Coase (1937) with the development of transaction cost analysis (Williamson 1975; 1985). According to the theory, the unit of analysis is the transaction. Governance structures differ in their transaction costs and competencies with respect to adaptation (and safeguarding). The appropriate governance structure to support a transaction between parties is one that has a lower sum of production and transaction costs. Since production costs are theoretically minimized, it is the transaction cost that becomes the primary determinant of governance mechanisms. Thus, the choice of a particular governance mechanism is one in which the comparative costs of transacting are less than the alternative (Williamson 1996). Overwhelmingly, empirical studies suggest more hierarchical governance mechanisms will be chosen when transaction costs are high enough to exceed the production costs of coordinating with the market. This could take the form of more hierarchical employment relationships (Lo et al 2011; Erramilli and Rao 1993; Anderson 1988; Oliver and Anderson 1987; Anderson 1985); more closely coordinated buyer-supplier relationships (Carson et al 1999; Heide and John 1992; Masten, Meehan and Snyder 1991; Noordewier, John and Nevin 1990; Masten 1984); leasing arrangements (Ghosh and John 1999; Masten and Snyder 1993); and horizontal inter-organizational relationships (Wathne 2000; Gates 1989).

Of particular importance to understanding adaptation needs in new product development is the importance of technology-related factors. In addition to transaction-level variables impacting inter-organizational relationships, researchers have also examined how market-level variables may influence adaptation. For example, concerns about product obsolescence have a negative impact on the firm's decision to vertically integrate (Balakrishnan and Wernerfelt 1986). Similarly, characteristics of the industry (Nickerson and Silverman 2003; North 1981), including norms of flexibility and coordination (Granovetter 1983), strength of the intellectual property protection (e.g., software versus pharmaceuticals) (Henisz 2000), and industry maturity (Christenson et al. 2001) have also been considered as market-level factors impacting adaptation costs. Thus, adaptation costs can occur as a result of a variety of mutual adjustments required of trading parties.

1.2.2. Safeguarding. Coordination efforts to plan for specific events or activities ex post are known as safeguarding costs. This implies the parties take ex ante actions to consider the conditions and possible actions of parties beyond the initial inception of the agreement (Williamson 1985). Safeguarding issues arise when the relationship between the parties is supported by specific assets. Specific assets refer to relationship-specific assets whose values are limited outside of the focal relationship. The safeguarding problem arises due to these specific assets since market competition no longer serves as a restraint to opportunism (Levy 1985). For example, technological know-how has been considered extensively a proprietary asset at risk of appropriation by transacting parties and, thus, a focus of much research to determine how to formulate safeguards (Oxley

1999; Teece 1980). Specifically, alternative and more hierarchical governance mechanisms are found to be less risky when trade becomes difficult (Teece 1982). Trading difficulty may result from the complexity of a technology (Oxley 1997); the inability of the firm to acquire complementary technologies (Pisano and Teece 2007; Teece 1994); and extensive coordination and dialogue requirements (Polanyi 1962).

Weak appropriability regimes, specifically inadequate intellectual property protections also have a significant and widespread impact on the ability of new firms to derive value from their innovations (Pisano and Teece 2007). Transaction cost theory suggests more internal governance mechanisms may be required to capture value when the trade environment does not provide sufficient protection against appropriation (Henisz 2000). Thus firms should organize their transactions with more hierarchical governance mechanisms and rely less on market exchange. Consistent with transaction-level studies, research aimed at understanding transactional hazards at the product level has similar findings. One strategy to reduce these hazards is to bundle intellectual property into one product offering. Bundling offers a better opportunity to recoup if infringement occurs and consequently, becomes a stronger deterrent against appropriation (Farrell 2002). Increasing the tacit know-how embodied within a technological innovation (Teece 1986) and designing products to be more interdependent (Christensen et al. 2001) have also been suggested as safeguarding devices at the product-line level.

1.2.3. Resources. In addition to the extensive stream of conceptual and empirical work developed from transaction cost analysis, an independent stream of literature simultaneously evolved to become a dominant paradigm in strategy: the resource- and

capacity-based views of the firm. The foundation for this approach to understanding firm action emphasizes the importance of firm-specific resources (Penrose 1959). The fundamental assumption is that organizations are rarely self-sufficient, and therefore they rely on other organizations for the supply of needed resources. This poses a challenge to the firm because the focal firm loses control of its desired outcomes. Without control of its resources, the firm becomes dependent on other parties for trade and therefore at risk of opportunism. Simultaneously, firm-specific resources also act as barriers to new market entrants. Researchers such as Wernerfelt (1984) and Barney (1991) further developed this stream of research by emphasizing the importance of these inimitable resources for strategic competitive advantage. In particular, Wernerfelt was one of the first researchers to emphasize the relationship between firm-specific resources and the new product development process (1984).

Many empirical studies began to explore this relationship through a variety of product-related topics. For example, scholarly articles have considered new product success. Specifically, new product performance is positively impacted by high levels of product/firm synergy (Cooper 1993; Cooper and Kleinschmidt 1993; Cooper and de Brentani 1991). Further research by Leonard-Barton (2002) argues that core capabilities both enable and hinder product innovation since capabilities lead to constraints inhibiting future innovation. Similarly, her work found the synergies between the firm's core capabilities and those of the product had a positive impact on the new product performance. In contrast, new products lacking the four dimensions of a firm's core capabilities (employee skills and knowledge, technological systems, administrative

systems, values and norms) were hindered. Understanding the resource- and capability-based views provided a snapshot interpretation of the strategic implications of firm-specific resources; theorists also began to examine how capabilities may influence firm strategy over time.

"Dynamic capabilities" (Teece, Pisano, and Shuen 1997) called attention to the need for firm capabilities to evolve in changing environments. Resource-based scholars also began to look at the dynamic nature of capabilities over time (Helfat 2000). Specifically, researchers recognizing the limitations of considering static intra-firm or dyadic relationships called for systemic and co-evolutionary perspectives to highlight the importance of endogenous change in transaction costs (Jacobides and Winter 2005). This work seeks to combine the transaction cost theory with firm-level capabilities to understand how a firm's vertical scope (boundaries) may be impacted by these conditions and which possible products will be chosen by any individual firm at a given time. Additionally, this work emphasizes the context of the interactions between parties as being a critical and often neglected aspect of early work within transaction costs. Specifically, vertical scope is determined by the combination of capability differences for vertical specialization, industry context and transaction cost reduction. In addition, studies of vertical scope move the analysis from the transaction to the individual firm-level and promote a larger systemic examination of supporting channel members (Jacobides and Billinger 2006). Finally, this perspective provides conjecture as to the significance of vertical scope and capabilities development with broader conclusions related to industry structure.

Similar to the work of vertical scope (also termed vertical architecture), Adjustment Cost Theory seeks to understand how firms' boundaries are established as a result of the frequency of adjustments required of product-related subtasks necessary within and across firms (Novak and Wernerfelt 2008; Wernerfelt 2004). While Novak and Wernerfelt do not explicitly address firm-level resources, it can be assumed that firms with relatively more technical skills, for example, would require fewer adjustments internally than firms operating without those resources. As such, the firm may internalize more of their production-related tasks as compared with less technical firms. Firm boundary decisions have an impact on the division of labor within the supply chain and ultimately, the optimal grouping of product tasks across firms throughout an industry (Novak and Eppinger 2001). However, consistent with studies of vertical scope, Adjustment cost theory has primarily studied the firm boundary decision under the presumption that product and firm-level scope is synonymous. For example, the grouping of production tasks *A* and *B* require extensive iterations and are comparatively less costly if sold as a combined system. Adjustment Cost Theory would suggest the added efficiency associated with selling components *A* and *B* as a system would also suggest components *A* and *B* should be manufactured internally (i.e. creating the firm's boundaries). Thus this work suggests a parallel product and firm-scope will result.

The research contributes to the theoretical and substantive literature in the following ways: First, it builds upon disparate streams of conceptual work including the scope of the firm (Teece 1982), vertical positioning (John et al 1999), vertical architecture (Jacobides and Billinger 2006), and adjustment costs (Novak and Wernerfelt

2008) to develop a cohesive and comprehensive set of factors that impact this choice. Second, it provides the first systematic evidence on when and why firms choose a particular product-form. Third, the work extends the safeguarding versus adaptation dynamics inherent in transaction cost economics (Williamson 1985) from a micro (transaction-level) to a meso (product-line) level of analysis. In this light, the product-form decision can be thought of as a product-level governance choice, which simultaneously creates value through enhanced coordination with other entities while also securing value through safeguarding the returns from its innovations. Further, this research shows that the product-form decision is fundamentally different from the vertical coordination (e.g., vertical integration) decisions. To wit, even when a firm chooses to sell systems, it is not necessary for the firm to make *all* the constituent components in-house (see Appendix C-product form alternatives). Rather, it suffices that the enterprise closely and actively coordinates and controls these activities through a network of relationships. Finally, by showing the value of product development resources, I build on extant work in governance value analysis (Ghosh and John 1999) to show the impact of a resource profile on product-line choices.

1.3 Dissertation Overview

Essay 1. One of the most crucial strategic marketing decisions faced by innovative entrepreneurial ventures as well as established firms is the "saleable form" in which to offer their ideas/innovations to the marketplace. The principal "pure-play" **product-form** alternatives that firms/ventures usually have to transform their ideas/ innovations into viable business models (and derive the revenues from it) can be broadly classified into

three categories: market intellectual know-how (via licensing and/or proof-of-concept); market intermediate products (sell components/sub-systems); and market end-products (sell complete systems/solutions). Despite the strategic importance of product form choice scant attention has been paid to systematically examine when and why firms choose a particular product form. I use a grounded theory approach to develop a conceptual framework for understanding how established firms in high-technology sectors choose among these strategic alternatives. Findings reveal that (a) three key rationales seem to be the primary drivers of this product-form decision – the *ability to coordinate* (work with other actors in the eco-system) the *ability to safeguard* (secure the proceeds from their innovation), and the *ability to garner internal resources;* and (b) a multiplicity of environmental (e.g., IP enforceability), technology (e.g., modularity and complexity), venture-level (e.g., internal product development resources), and customer-level (e.g., end-customer expertise) factors impact the firm's ability to coordinate, safeguard, and generate internal resources. Crucially, these rationales are consistent with those espoused in organization design theories such as transaction cost analysis and the resource-based view of the firm; in that light, these product-form decisions can be considered as product-level governance decision.

Essay 2. "Product Form Choice: A Simulated Protocol Analysis with Angel Investors," is comprised of two studies: a qualitative exploration of angel investor screening processes and an experimental study of the effects of coordination, safeguarding, and firm-level resources on the product form decision. While *Essay 1* broadly explores the process of making product form decisions by established firms, in Essay 2, I investigate whether

these drivers impacting product form choice in early-stage ventures. I begin with a qualitative inquiry into the choice with professional angel investor networks. In particular, angel investors are appropriate for exploring this phenomenon because (1) angel investors as well as venture capitalists have expansive input in the commercialization process; (2) angel investors are often the first group of "outsiders" to evaluate a technology; and (3) these investors often possess more seasoned expertise in the area of commercializing technologies (DeGennaro 2010). Findings reveal the emergent mechanisms from Essay 1 are reflective of the factors impacting product form choice among angel investors and are suggestive of the relevance of TCE and RBV based motivations for conducting an empirical investigation. The second study was an experiment designed to gather systematic evidence as to the impact of the three core mechanisms on the investor's preferred product form choice. Informants were active accredited angel investors and members of professional angel networks. Informants evaluated 8 fictitious venture proposals and chose the product form alternative they believed to be most value-generating based upon the characteristics of the business environment in each venture. Findings reveal (a) modularity has a significant impact on product form choice and increases the likelihood that firms will sell licensed technology rather than systems, and (b) firm-level resources also impact whether a firm chooses to sell a less or more integrative product form. Enforceability is directionally consistent with my hypotheses in both the main effects and the interaction with modularity.

Essay 3. Even within a particular legal environment, there are large variations in the enforceability of intellectual property (IP) rights. For instance, IP protection is generally

weak in the software sector and strong in the pharmaceutical sector. The emergent framework from Essay 1 points to this appropriability hazard as one of the key drivers of product-form choice. In this essay, I systematically examine the impact of enforceability of IP and industry-level relational norms on product form choice in established firms and within one industry sector. Furthermore, I investigate how the firm's own resource set enables it to choose a product form that minimizes the appropriation risks arising out of weak IP enforcement. These issues are investigated using primary survey data obtained from vendors of complex industrial products. The focus is on the choice between selling a system or a component to customers that act as end-users. The primary objective is to understand how a firm's strategy differs when it is relatively easier and more valuable to appropriate returns from an innovation and how product form is altered as a result.

2. ESSAY 1: AN INDUCTIVE STUDY OF PRODUCT FORM CHOICE

2.1. In this Essay, I examine the product form decision and conduct a multi-method qualitative inquiry into the choice. I begin with an ethnographic study of product managers, executives, and investors operating within high-technology sectors. This context is useful for exploring this phenomenon because (1) anecdotal evidence suggests product offerings change the marketing strategy of established firms' market offerings; (2) new product offerings are often widely publicized and quite expensive endeavors for established firms; and (3) product managers, although operating within established firms, must make resource allocations when deciding which new technologies to support. Key informants included executives, product line engineers and managers, venture capitalists, and angel investors from a multitude of firms across industries, including some Fortune 50 companies. Study participants were often introduced to the primary researcher by other informants, which is consistent with the "snowball" technique (Bernard 1995). Informants recommended prospective informants because they believed these individuals were regularly evaluating technologies for product form. The interviews were loosely structured, and questions were construed broadly; however, after I probed informants regarding their experiences with new technologies, they typically described a similar understanding of product form alternatives and outlined quite consistent sets of factors impacting their decisions. After analyzing the data collected from both depth interviews and observations, I found that these individuals held a consistent view of the possible alternatives for converting an innovation into a saleable good. I find the sale of intellectual property via licensing agreements, components, and/or systems were the primary product form alternatives considered by these informants. Findings reveal that

(a) three key rationales seem to be the primary drivers of this product-form decision – the *ability to coordinate* (work with other actors in the eco-system), the *ability to safeguard* (secure the proceeds from their innovation), and the *ability to garner internal resources*; and (b) a multiplicity of environmental (e.g., IP enforceability), technology (e.g., modularity and complexity), venture-level (e.g., internal product development resources), and customer-level (e.g., end-customer expertise) factors impact their ability to coordinate, safeguard, and generate internal resources. Crucially, these rationales are consistent with those espoused in organization design theories such as transaction cost analysis (Williamson 1985) and the resource-based view of the firm (Wernerfelt 1994); in that light, these product-form decisions can be considered as product-level governance decisions.

2.2. Method and Design. A key feature of the emergent-theory paradigm is that *a priori*, the researcher should have a rudimentary framework on the phenomenon under investigation (Eisenhardt 1989). As the research progresses through a series of theory-building, in-depth qualitative analyses, this framework either gets bolstered or rejected and finally leads to testable propositions. I based my rudimentary framework on the efficiency rationale of organizational design theories (Williamson 1985; Wernerfelt 1994). Accordingly, I treat these product-form choices as alternative organizational (or institutional) forms and start with the premise that product-line executives, guided by their product development teams, act as a team and purposefully choose the product form that provides them with the opportunity to derive higher economic value and extract higher net benefits/profits from their know-how/IP.

Depth Interviews. To understand these decisions, I used the "emergent-theory" approach to conduct depth interviews with product-line managers, engineers, marketing executives, and investors to gain insights into their mental model for the product-form they sought for that innovation. I completed a series of semi-structured personal interviews that lasted from several hours to several days (including tours of their R&D/product development facilities and neighboring partner firms involved in those ventures). These interviews I conducted predominantly in the high-technology industry sectors, in particular, the electronics and instrumentation, medical devices, and computer industry sectors in the United States. These industries reflect widely contrasting views of the need for increased enforceability of intellectual property in the United States (e.g., patents) and are recognized by scholars as possessing differing philosophical beliefs about the rewards of innovation (Abramowicz 2011). Constituents of opposing views of recent patent legislation reflect a similar divide (Senate Judiciary Committee Hearing on the Patent Reform Act of 2009). Thus, I believe this varied set of viewpoints regarding the commercialization of know-how will bring additional diversity to our sample.

To further ensure the generalizability of the theory that I intended to generate, I sampled cases with extreme differences or "polar types" (Pettigrew 1988) in which the phenomenon of interest is observed. In my case, "polar types" specifically refers to well-established firms with very large R&D and marketing budgets as well as early-stage start ups. Of the 16 in-depth interviews, approximately half were conducted with executives at established firms, and the rest with executives, CEOs, VCs, and AIs at start-up

ventures. Quite often, these executives and investors had extensive executive-level industry experience (~ 10-20 years) and could also speak to the technologies developed during their tenure with those established firms. The informants were probed on all the technology commercialization issues and problems for 2-3 specific technologies/ innovations in order to develop a deeper understanding of the path to commercialization. Depth interviews offered me an opportunity to probe a broader spectrum of organizational factors and decisions (McCracken 1998) as well as to explore a tightly-guarded moment in the new product development process. Retrospective as well as ongoing accounts of product-form and related technology development decisions (Eisenhardt and Graebner 2007; Leonard-Barton 1990) were probed throughout the interviews. With multiple cases, a diversity of technologies and informants across multiple functional units and corporations limits bias and offers diverse perspectives related to the phenomena of interest. Access to this type of data is often impossible and thus inadequately obtained by other methods. Further, this complex social process cannot easily be disentangled by quantitative methods when no theoretically supported empirical evidence exists (Eisenhardt and Graebner 2007).

Participant Observation. In addition to conducting depth interviews with managers and angel investors, I performed participant observation of angel investment screenings in order to examine product form choice in early-stage ventures seeking outside funding (Arnould and Wallendorf 1994). Rather than relying on prior theories to test data (Keaveney 1995), I utilized an inductive approach to understand whether and how product form choice was important to investors evaluating prospective investments.

Observations occurred during screening meetings between angel investors and entrepreneurs across four professional angel investor networks. One researcher initially conducted a series of participant observations during a professional angel network meeting. Subsequent depth interviews and observations across several angel networks followed (Deshpande 1983: Glaser and Strauss 1967). To ensure these investors are actively evaluating and investing in multiple start-up ventures, I chose to conduct our studies with the assistance of professional angel networks rather than individual investors. In total, the membership of these networks equaled approximately 1,000 accredited angel investors. While a network may have many registered investors typically only a small fraction of those members are consistently active in attending the screening meetings and investing in new ventures. As a result, approximately 30% of the members (in each network) attend the meetings regularly. Much fewer invest in each venture.

Observations occurred at a major Southwestern University (the location of the professional investment networks' meetings), a conference hotel in the southwest, and at several country clubs as these facilities offer large angel networks with the opportunity to hold monthly and quarterly meetings at a convenient location. Network meetings typically consisted of 4-8, 20-minute presentations given by founding member/s of a venture seeking potential investors' support, question and answer sessions of the invited ventures, a brief discussion of the progress of prior investments, occasionally due diligence reports, and lunch or some other form of social time for networking among members.

Although these meetings are referred to as "prescreening meetings," the ventures invited to present their company to the entire membership have undergone an initial cursory screening by either the chairperson or a small committee of members designated to make initial cuts among proposals. Proposals are submitted online at the network's website and are either unsolicited requests for an invitation for screening or recommended proposals. Recommended proposals are disclosed by the company's founders in their proposal and during screening meetings. Typically, a recommending member will introduce the company as his or her invited guest to ensure disclosure of this relationship with the company and lend credibility to his or her request. Invited ventures normally give a 10-20 presentation of their company, technology, financials, and credentials and their plan for the requested funds. Upon completing their presentations, members are then given 5-15 minutes to ask questions of the entrepreneurs. Audience members typically question the pre-money valuation of the company, financial statements, sales figures, intellectual property rights, and prospective customers. At the culmination of the Q and A period, presenters are commonly asked to leave the room while the angel investors discuss and evaluate whether the venture should move toward further screening rounds. Each venture is normally discussed for 15-45 minutes, and in some networks the presenters will be invited back in the room immediately for a decision. Other networks follow up with the presenters shortly after the meeting.

For those ventures moving to later stage screenings, the chairperson often seeks 1-3 volunteers to act as the "deal lead." Those individuals are normally highly interested investors who agreed to coordinate future screening meetings and due diligence

disclosures, and also are responsible for reporting back to the entire membership on their progress. My observations consisted of the initial screening meetings held for the entire membership. During these meetings, the investors give their initial reaction to the venture, ask questions and provide responses to the entire membership, and determine whether more detailed due diligence will occur. Finally, observations across several networks revealed this is also the stage in the screening process when investors decide whether the ventures' product form choices are suitable for their investment purposes, whether an alternative product or service offering is more desirable if they were to invest, or if the venture is not an appropriate investment for their group.

On the basis of these observations, I visited several network meetings across four networks and collected 26 venture proposals, typically 1-3 pages in length and containing all of the necessary details for the members to review prior to the initial screening meeting. In addition, I also collected 10 full business proposals submitted to the angel investing group during subsequent screening rounds. These proposals are typically 25 pages in length, contain a market and industry analysis, descriptions of the business model, product offering and value proposition, their perceived competitive advantage, marketing plan, and financial statements. I offered a copy of our findings as an incentive for their participation. I also conducted 7 depth interviews with active angel investors. These informants were either very active members in the network or held leadership positions, such as Chairperson or Managing Director, within the network. They each had at least 10 years' experience as an angel investor, and some had over 30 years investing in early-stage ventures. Because casual conversations among the researcher and angel

investors revealed some angel networks prefer technologies in a particular industry or market sector, I deliberately sought to observe and interview investors across states and interests to ensure a greater diversity in ventures presented. Overall, the triangulation of depth interviews, archival data (funding proposals), and participant observation enabled us to generate a rich and relatively accurate understanding of the phenomena (Eisenhardt 1989; Kumar, Stern and Anderson 1993).

2.3 Analysis and Results. From audiotapes, detailed field notes, venture proposals, and depth interviews, analysis proceeded primarily across projects/ventures to identify a priori factors impacting the investors' decision of whether to further evaluate the ventures for investment, the factors impacting their choices, and their discussion of what product or technology to market as their firms' core innovation. Through careful iterations with committee members, I performed axial coding of the interview transcripts, investment proposals, and observations noting relationships between codes (Miles and Huberman 1994). The interviews were transcribed with the aid of a computer-based text analysis package, NVivo. Patterns of interest were sought and identified within individual interviews, across informants' interviews, and across data sources (Eisenhardt 1998; Spiggle 1994; Mick and Buhl 1992). Consistent agreement was met after discussions of themes and patterns between committee members (Wallendork and Belk 1989).

I have organized the findings around important issues and themes that emerged with respect to the product-form decision in this setting. A set of three general issues/questions are provided herein: First, what are the meanings of product form within the context of the new product development processes? Second, what marketing-related

consequences are influenced by this decision? Third, what are the core rationales that drive these choices, and what are some conditions under which a venture would prefer to choose one product form over its alternatives? The major result is a theoretical framework that is consistent with organizational design theories (Williamson 1985; Wernerfelt 2005) in the sense that firms do treat these choices as alternative governance formats that help them create and secure the most value from their IP/know-how. Notably, the framework incorporates data from established firms across industries because these patterns emerged regardless of the type of industry sector. The findings reveal conditions under which these firms tend to choose one product-form over another.

2.3.1. Product Form Alternatives. I began by exploring the product-form alternatives these informants considered during their product development process. In general, informants described one of the two alternative choice sets: components/systems or licensing/components/systems. When asked to define each of these options, in general this is what informants had to say: Licensing is the transfer of technology/IP/know-how to another independent party, for a fee, on an exclusive or non-exclusive basis for a pre-specified time period. These contracts might also specify the range of applications for which the licensee could use the technology. A component was defined as a part or element of a larger composite product that needs to interact with other complementary parts and elements to generate some valuable output. In other words, components are intermediary products that add functionality and create value only when combined with other components. Finally, informants generally defined systems as "stand-alone" or "plug-and-play" or "finished" products that are a combination of a variety of intermediate

products (components) that interact in specific ways within the system as per its "design architecture." These definitions are consistent with those offered in the literature (e.g., John, Weiss, and Dutta 1999; Somaya and Teece 2001).

Regarding product-form decisions, Bill, a co-founder of a software company, described these alternatives as the continuum of choices executives may make once they have a core technology.

> "We were building this technology, but then the question was how do you take that technology and go to marketplace with the technology? We wound up looking at essentially all of the alternatives, do you want to sell the IP, do you want to sell the components that are built around the IP, or do you want to build an entire system and sell the entire system?"

Similarly, Robert, a vice-president of an electronics company described the alternative formulations for build products around technological know-how.

> "… the value creation is, it's either a licensed type of agreement, or if it's a subset or a component, or if it's an end-product."

Notably, when informants did not initially include licensing as the third major alternative, it was because they did not consider that option as value generating in their context; however, further probing revealed IP *was* a third alternative. For example, Keith, the global brand manager of a medical devices company, admitted that he didn't mention licensing IP because selling his company's IP, he said sarcastically, was equivalent to giving away all their R&D investments. However, he acknowledged that licensing could be a feasible alternative in other contexts.

> "That was our business model too … We didn't license products out to other people based on inventions; we just kept it all for ourselves."

Field notes reflect this terminology was commonly used during investment prescreening meetings by investors as they questioned prospective investments, as well as by

entrepreneurs when describing their technology. Further, the principal investigator used this terminology in interviews once a pattern of use by informants emerged. None of the informants inquired about the definitions of the terms or asked for clarification in their meaning, which suggests most informants in the sample were comfortable with this terminology and the distinctions between these alternatives. In sum, the general consensus among informants was that licensing v/s intermediate component v/s final end-products/systems were the three broad product-form alternatives.

The following section highlights some of the relevant considerations made by decision makers as a result of their product-form choice and suggests how the product-form decision may relate to market strategy and inter-firm relationships more specifically.

2.3.2. Strategic Marketing Decisions and Product Form Choice. Defining and analyzing potential customers and the competitive set was the most far-reaching strategic marketing issue raised by my informants. Tracy, the CEO of a software consulting firm, describes her decision to focus on customized software solutions rather than off-the-shelf software modules as one which defines who her primary competitors are. She described her primary competitors as large service companies such as IBM, but she also noted that her firm's recent decision to offer customized "back-end functions for their [customers] database integration" has made ad agencies her primary competitors. The company was also exploring the prospect of offering "off-the-shelf" software programs and IP licenses, and its main criteria for the go-no go decision was "understanding the new competitors and developing a market entry strategy to counter them." Similar issues were raised by

informants selling in the electrical power industry. Robert, the VP of the electronics corporation, distinguished between his immediate customers and final end-customers.

> "Is ours a direct sell? Who is our customer? If we sell something to an IBM, we're not selling directly to the end-customer, we're selling to an IBM … they are our customer."

Ivan, a co-founder of a software company, talked about these same issues and their impact on the marketing mix.

> "The question is more about how to market the product, how you sell the product, how you advertise for it. We need to service this technology."

His comments reflect how product-form decision had such critical influence on subsequent segmentation and targeting issues, and also suggests these decisions are sometimes made in combination. For example, Bill, the co-founder of the software company, said product-form choice is the "foundation for both inbound and outbound marketing decisions" and raised questions related to market entry, market drivers, sales, segmentation, product design and packaging, future product releases, and expected returns as examples of the types of questions asked regarding a technology once the product form decision has been made.

> "… focusing primarily on helping the product architect figure out what are the drivers; how's the market changing, what are the important features that should be getting into the next version of the product, where do they think opportunity exists, how can you address those market drivers, what are the cost tradeoffs? If I address this particular segment of the marketplace, can I increase my sales 10%? How much cost do I have to drive into the product to do that? Is that a good return?"

Contrary to traditional marketing textbooks (Kotler and Armstrong 2011), targeting and segmentation issues arise in tandem with the product form decision. Informants consider the alternatives possible for the technology while simultaneously predicting the implications of choosing one alternative versus another, rather than starting with a finite

technology and then making a choice of how and where to sell it as suggestive of typical marketing textbooks.

In addition to impacting customers and competitors, product form choice was also a consideration when informants considered their (the firm's) ability to coordinate with other actors in its "eco-system" for the design, development, production, and marketing of effective products/ solutions based on the core innovation. The value of choosing appropriate inter-firm partners and relationships seems to matter more when the technology was offered through a more finished "systems" approach. Many informants noted that this was one of the most critical, costly, and many times the "bottleneck" decision made by the firm. Specifically, choosing to sell a system rather than a component or IP could be extremely risky and sometimes disastrous if the firm could not rely on upstream suppliers. Keith, the global brand manager for Diagnostica Labs, described how costly and difficult outsourcing became once the firm chose to sell final goods.

> "It's a whole combined system ... we learned our lesson years ago by outsourcing certain parts of the process. We had, I mean like 10 vendors externally. But, one of the key tolerances was specified with one of the vendors, they made on the high-end, and then one [vendor] made a tolerance of something else on the low-end, and then these things just leaked like crazy."

Keith describes the challenges associated with building systems and making frequent changes and adaptations when firms need vendors to build sub-parts/components to appropriate specifications and/or the quality requirements. This challenge in coordinating such relationships as ex post adjustments become more frequent is consistent with the organizational design issue posed in Novak and Wernerfelt (2008).

Depth interviews and observations across several networks revealed product form choice was a common conference during screening meetings. In some cases, product form choice determined whether the investors would even invite a venture to return for a follow-up meeting. Often, informants began interviews with statements similar to "we are deliberating over that very issue right now" when provided with an introduction to the research topic. Although informants sometimes preferred to omit specific technological details related to their investments to protect vital knowledge believed to be part of their competitive advantage, they described the process of building "around" a core idea or innovation as being one of the most critical for early-stage investments. Early-stage investments typically focus on one core innovation defined by informants as the value proposition for the company and had enormous implications for return on investment. For example, observations during a screening meeting of approximately 30 investors and 6 prospective ventures revealed investors were unsure whether they would invest in a company that sold nutrition bars and other snack foods touted to reduce the early onset of Alzheimer's disease (through proper nutrients). While the company's founders had extensive technical expertise and the potential market for this product was lucrative, investors believed selling this doctor's knowledge about Alzheimer's disease was a better product for market entry. Investors offered to fund the entrepreneur if he would be willing to market his expertise to large insurance companies as a preventive care "well-being program" with information regarding nutrition, daily activities, and exercises to inhibit the early onset of Alzheimer's disease. They believed a nutrition/wellness program marketed to medical insurance companies could be quite profitable, especially

since the venture's team consisted of leading researchers in the area of brain health and dementia prevention. The nutrition bars/snacks were proposed as only one component of the wellness program; however, if the entrepreneur insisted on selling only nutrition bars (e.g., components) then the investors would not invite the venture back for further screening.

Field notes reflect these types of propositions are common during investor screening meetings. Post-meeting discussions with the investors reveal that the current state of the economy created added pressures that made product form choice especially important since normal return were much longer than they had been in the past. Informants typically estimated their "exits" to be 6-7 years rather than 3-4 as in the past. In particular, product form greatly altered the design and development needs of each technology, and consequently, their time-to-market and return on investment. Peter, the CEO of one of his investments and an experienced angel investor, describes investment decision as being different based upon the factors associated with each proposal. In medical devices, selling a complete system or a final product is a much lengthier life cycle than selling a component. Although medical devices may be lucrative upon exit, the risks associated with a 10-year investment cycle are enormous for a small angel investor like Peter:

> Intellectual property approaches, medical devices is a good example. The… amount a time it takes to get to market and the amount of money required to get to market make it very hard for an angel investor to be a part of. As I'm a small angel investor, I don't make very large investments. But if you get behind a company in its series A round and it's secured a way from actually having a product that's going to market, which means it's 10 years away from any kind of real market traction, you're looking at a really long lifecycle.

Other factors such as the industry environment, particularly the ability to protect intellectual property, the entrepreneurial team, technological capabilities of the start-up, the entrepreneur's credibility, the potential market of entry, and the potential partners for commercialization were factors impacting many of the investors' evaluations of prospective proposals. The "best" investments were described by investors as those with a proven record of sales and increasing cash flows regardless of all other factors. Many investors would prefer to be investing in firms that are generating revenues prior to their request for funding; however, ventures in "stealth mode" (not publicly advertising) can sometimes be more lucrative in the long term because investors can guide the entrepreneur on a better commercialization path and sometimes join a deal with higher returns if entry is early.

Typically, the investment screening meetings provide a time for members to ask both narrow and specific questions about the venture, the founding team, and the personal lives of founders (when appropriate) and assess their knowledge of the market, technical expertise, and understanding of potential customers. Importantly, the product form choice presented by the entrepreneur acts as an anchor for investors to use during all evaluation periods. For example, a venture may propose his or her technology be sold as a system to final consumers (e.g., farmers). Investors utilize the entrepreneur's commercialization choice—the system—to question the entrepreneur and deliberate over possible competitors, customers, and sourcing requirements. However, alternative product form scenarios have tremendous impact on various strategic marketing decisions and are explicitly discussed, evaluated, and sometimes changed during screening

meetings to make the investment more attractive. For example, investors may ask something similar to "what if you hadn't chosen to sell the complete system but instead decided to sell Component A, who would be your competitors and customers?" Investors cited product-form choice as being integrally tied to firm growth, competitive advantage, and profitability. This has important implications for firm boundaries and the structure of industry, and reflects the constraints and opportunities faced by a venture/firm (Wernerfelt 2005).

2.3.3. Three Mechanisms Driving Product Form Choice. The analysis of the informant comments and descriptions of what motivated them to choose a particular product-form for their technologies enabled me to extract three core themes-- *coordination, safeguarding, and resource exploitation*-- as the primary drivers of this decision. I describe the three underlying mechanisms behind my informants' decision in the context of product/service examples. Note these include retrospective and prospective accounts of their decisions to choose one product form alternative over another and also reflect commercialized technologies as well as those that never reached commercialization. I provide this diversity of accounts in order to illustrate the range of deliberations and outcomes associated with this decision.

Coordination. Coordination refers to the ability of the focal firm and the eco-system to organize the activities needed to develop a product. The value of a particular product-form option in a particular context depends on the comparative costs of coordination under these alternative formats (Baldwin and Clark 2000). In general, factors that make it comparatively more costly to coordinate with the external market on the development of

the technology into a saleable output are likely to force the firm/venture to take greater control over these activities, resulting in a more complete "systems" products. The key factors that emerged through my interviews that impact such coordination costs can be categorized into technology and customer factors. Within the category of technological factors, two stood out: complexity and the ability to mix-and-match complementary technologies. The key customer factor was aggregate, or market-level, customer expertise.

Complexity. "Complex" and "cutting-edge" were terms used interchangeably to describe technologies that were interdependent and sometimes difficult to communicate to outside vendors and customers (Sanchez and Mahoney 1996; Kogut and Zander 1992). This could arise because the interfacing between interdependent parts is not codifiable and tacit, or could occur if deep human skills are necessary to make appropriate adjustments. It was observed that firms/ventures whose innovations were complex and interdependent commercialized the technology as systems. For instance, at Diagnostica Labs, the cell staining process for disease diagnosis was very complex and required extensive readjustments to and monitoring of its computerized, automated cell staining instruments as well as discussion among the scientists. The company did not consider offering any product other than the complete system, due to the complex and delicate nature of the process. Furthermore, given the sensitivity of the instruments to tolerance levels etc., Diagnostica also chose to backward integrate into manufacturing all the components and parts.

On the other hand, Don, the co-founder of Orthodyn Inc., a medical device company that designed bone anchors and GPS-type devices to aid in orthopedic surgeries, described the company's inability to offer anything other than a system simply because the technology was such a radical departure from older surgical methods that an internal sales and support team was essential for the proper education of the surgeons and to ensure a correct fit between the knee-cap, the tendons, the muscles, and the support and brackets. The complexity of the technology and the "radical" nature of its capabilities were the key drivers of Orthodyn's decision to sell systems. In contrast with Diagnostica Labs, Orthodyn did not manufacture all of the integral components internally. Instead, it focused on the architecture between the GPS-type devices and the software to ensure optimal reliability, and closely coordinated the design and development of the support brackets with a vendor-partner. When probed further, Don also revealed that the firm deliberately chose to narrow the "scope of use" for its particular technology (i.e., specialize in knee alignments only) to further mitigate the complexities associated with systems development and commercialization. Unlike licensing or selling components, the design and development of a system was often more costly and involved a longer investment cycle, which was often a deterrent to investors interested in potential medical device *deals.*

While several investors found investments in ventures likely to sell their technology through licensing agreements to be attractive because of the speedy exit and the relatively few resources required of the start-up, others were hesitant to become involved in "licensing deals" because they were often plagued with severe drawbacks.

Typically, investors were required to wait for royalties from the purchaser of the license, with many investors citing examples of technologies that were licensed but never generated any revenue. Investors also provided retrospective accounts of companies that sold their IP to a customer who bought the license and did not commercialize the technology only to sell their own competing product rather than the technology purchased. Alternatively, licensed agreements are often devoid of the extensive tacit knowledge of the developers and, thereby, may make it difficult for the purchaser to extract the full potential for the technology (Bhide 2008); as such, the investors do not generate the returns expected from the technology.

However, observations revealed investors sometimes suggest selling licensed agreements even when the entrepreneur believes an alternative product form is preferable. After evaluating an agricultural start-up (who presented their technology to approximately 30 potential investors) seeking a $2 million capital investment to sell a system composed of tangible equipment and a consumable powder that coats and protects cured meats against bacteria growth, investors invited the entrepreneur to participate in further screening but agreed conditional upon the technology being sold as a system to IP (sold as multiple nonexclusive licenses). The investors argued that the meat coatings were not proprietary, and the machinery could easily be reverse-engineered and probably manufactured with more efficient processes by the companies holding ownership of the coatings themselves. The investors urged the entrepreneur to license the core innovation—the bonding technology—to the coating companies in order to create multiple streams of revenue. Although licensing would not draw the profit margins that

could be acquired from a successful systems offering, this venture was not in a competitive position against systems' manufacturers. Further, the coating companies would find the technology beneficial for their current product lines because the entrepreneur had a better technology for ensuring bacteria did not seep into meat once it was coated, thereby reducing salmonella growth. This new coating powder would also work well with current coating machines, thereby reducing adjustment costs between the technologies (Wernerfelt 1994). The formula could easily be produced by current manufacturers since the ingredients and spraying process could be made explicit through the license agreement. Examples similar to the aforementioned meat coatings company revealed that selling licensed technologies was typically advantageous when technologies were easily incorporated with complementary technologies sold by potential customers, the intellectual property was highly enforceable, and the entrepreneur was overpowered by the resources of a potential competitor.

One possible resolution to the enhanced difficulties associated with selling intellectual property through licensed agreements was to design a licensed agreement that also contracts for the entrepreneur's skills for a specified period of time post-purchase. This required the entrepreneurs/scientists to work as consultants for the buyer to ensure the technology could be made useful post-purchase. For example, an early-stage medical technology company touted its product as a simple blood test for the diagnosis of multiple sclerosis. After initial investments, investors and founders realized the technology was less reliable than earlier believed and, as such, sold it as a licensed agreement to pharmaceutical companies developing multiple sclerosis drugs. These

companies purchased the protein as well as the assistance of the developing doctors to ensure the protein could be used for their specific drug development needs. While this added consulting agreement did alleviate the difficulties associated with selling complex technologies as licensed agreements, it was not conducive to generating large returns for all technologies. In my observations, licensed agreements for complex technologies often were the most desirable product form choices when the company was based around one technology with specific applications and was highly desirable to a specific sales prospect.

Mix-and-match compatibility. Many informants described that their technologies were indeed complex, but interdependency with complementary parts was not a problem because the technology could be organized into more manageable modules that could easily interface with other complementary technologies. This "modularity" (Baldwin and Clark 2000; Sanchez 1999), they claimed, not only enabled them to offer a variety of functionality and performance but to focus their attention on developing the best use for their own technology because it was de-coupled from the interdependencies with the complementary technologies or products embodying it. The integration of such modular products within the systems architecture required less dialogue and collaboration then technologies without standard interfaces. In general, firms that worked with technologies that were modular and easy to mix-and-match tended to commercialize the technology as intermediate products or components.

For instance, Bill, the co-founder of a software company, described this modularity as "stacked architecture," where complex technologies could be developed to

more easily interface with other components by structuring the different "layers of the stack [to] correspond to roughly different layers of technology." He recalled that Cybolt, one of the world's largest IT companies where he had worked previously, developed (with outside suppliers) the technology to build hybrid fiber-coaxial transceivers, transmitters, and receiver sets to be used over hybrid fiber coax. The system was designed such that these technologies will be independent, stacked technologies to provide "abstractions" while simultaneously offering a product that could be integrated easily by the owner of the systems architecture and be highly functional.

> "The abstraction of the communication stack allows that (independent development) to occur. The beauty of stacked communication is what provides you the abstraction … can be integrated easily into any systems architecture and fly."

This ease of mix-and-match also makes it easier to integrate components and organize the technologies into a more complete final product. It was also suggested that this kind of technology architecture, also termed as "modular design," creates value by dividing up design tasks into independent modules and enabling different teams/firms to focus on developing and improving the functionality of individual components (Baldwin and Clark 2000). Similarly, firms with modular technologies still in the development stage can share them with collaborators to test possible design glitches without revealing the innards of their technologies. Informants also reasoned that complex but modular technologies provided the firms an opportunity to sell to different types of customers who may be purchasing it for different functional purposes.

In sum, complexity and modularity were factors that were described as important technological characteristics affecting product-form choice. Complex, interdependent

technologies were commonly offered as systems, and complex but more modular technologies were offered as components because attempting to organize the development of such technologies with complementary technologies offered by outside parties would likely impede the time-to-market and product performance. Further, offering a component as part of a modular architecture expands the market for the component at a faster pace, the principal reason being that other actors can envision "emergent" uses for the component that the focal firm had itself not planned for.

Customer-level expertise. Customer expertise here refers to the general levels of skills and knowledge within a potential set of customers in configuring the technologies into more usable final products. In contrast with Stremersch et al. (2003) and Ghosh, Dutta and Stremersch (2006), this customer-level expertise is hence defined at the aggregate and not an individual customer-level variable. In general, I observed that ventures/firms were more likely to sell the systems when customers did not have the expertise to coordinate the integration of multiple components (or IP) into a functional and usable final product. For example, Diagnostica Labs suggested that it sold diagnostic machines and proprietary reagents for the diagnosis of cancer as a system because Diagnostica Labs could offer "convenience" and "ease of use" to "big reference labs...hospitals...and technicians." The machine requires the instruments and reagents to be optimized by Diagnostics Labs' own technicians to ensure that the stain color, shade, and amount of staining per slide are consistent. Even though a pathologist may be able to optimize these combinations after proper training techniques, Diagnostica Labs did not want these "new training costs" to impede the acceptance of its product and chose to do it all itself.

Similarly, Orthodyn Inc., the medical device manufacturer, chose to sell systems (including the anchors, the GPS-type device, the integrated proprietary software, the knee brackets, and braces) because the novelty of the technology would have required orthopedic surgeons to learn computer programming skills if they required to assemble the medical device without any assistance from Orthodyn.

Safeguarding. Safeguarding refers to the ability of the focal firm/venture to prevent the value derived from its innovation from being appropriated away by other known or unknown independent parties. From this point of view, the value of a particular product-form option depends on the comparative costs of safeguarding under alternative formats (Williamson 1985). In general, factors that make it comparatively more hazardous to protect the IP are likely to force the firm/venture to take greater effort in safeguarding the IP; in the context under investigation, it would mean selling the complete system. The protection of the firm's proprietary intellectual assets was a common concern among both managers and executives in these interviews, and they discussed the need to make product-form choices to protect this IP when the appropriability risks were high. For example, components manufacturers are at risk because the owner of the system architecture has the power to set interface protocols and decide which innovations are adopted and which ones are not (Pisano and Teece 2007). The key factor that emerged through the interviews that reflected these safeguarding concerns was the strength of the legal enforceability.

Arguably the most salient supply-side obstacle to the development and commercialization of technical knowledge is the risk associated with 'appropriability

hazards' (Teece 1986, Pisano 1989) that enable the value from the technology to be appropriated by other parties. One such appropriability hazard is the enforceability of IP protection. Enforceability refers to the degree to which legal agreements can be effectively enforced, with the emphasis being on the ability to protect IP and enforce contractual agreements on the part of one or more institutional constituents (Henisz 2000). The ability (inability) of the enforceability regime to protect intellectual know-how becomes critical when the focal firms consider alternative product-form modes. Greg, CFO of a Venture Capital Firm, mentioned that his firm is currently in the midst of a $100 million lawsuit with a larger firm regarding an intellectual property infringement dispute. He described *strong* intellectual property as an innovation with "good claims" and multiple product applications, preferably covered by multiple patents within a long development lead time. He finds that this is often the case when technologies are built as systems rather than components or licensed technologies. Greg also described varying industry norms as being an issue impacting his decision to enter alternative markets and technologies. For example, industries such as medical devices were largely reliant on legal intellectual property protections to recoup their large investments in research and development. Contrary to the needs of medical device technologies, informants in the software industry found legal protections such as patents to be a hindrance to the speed of innovation and an unfair monopoly in the marketplace. Bill, currently the co-founder of a software company and a former long-time product line engineer at a major Silicon Valley firm, believes systems are profitable when intellectual property is less enforceable, but in

the computer hardware industry, large Silicon Valley components' manufacturers are likely to have the strongest intellectual property.

> Intellectually property in Silicon (Valley) tends to be closely coupled with the component supplier.

My informants described in great detail their deliberations between alternative product-forms to secure the most economic value from their IP. Two themes emerged in a consistent fashion: when IP protections afforded by legal repercussions (e.g., a patent infringement suit) were sufficiently high, the desired product-form seemed to be one where it (the focal venture/firm) could secure the economic value without needing added resources. This often meant that these firms opted to sell their IP via licensing or sell intermediate components rather than total systems (when recouping investments in their IP was a consideration). In contrast, when technologies were to be commercialized in environments where legal protection was not adequate, the firm often chose to build-in its own fortifications around the core IP; i.e., by offering a system (Farrell 2002; Teece 1986, p. 287). For Keith and other informants, the opportunity to build multiple intellectual assets into one product provides an opportunity to ensure their intellectual property is better protected. For example, Keith describes Diagnostica Labs' strategy:

> We didn't produce products, or license products out to other people based on inventions, we just kept it all for ourselves, and essentially, filed IP like crazy. I mean we've got hundreds of patents. And so that's, part of why no one else can really build the instrument. (Laughs)

Keith, at Diagnostica Labs, described the medical devices sector as particularly susceptible to reverse-engineering and believed that the only way Diagnostica Labs could generate valuable returns to its investors was to build its instruments around a

"constellation of patents and trade secrets." The company specifically developed numerous patents and trade secrets around its core innovations to deter IP infringement. This description reveals the company not only chose to bundle IP to reduce the risks of appropriation by other channel members and competitors, but also opted to sell its product only as a complete system. The choice to sell systems is supported by theoretical arguments that tacit knowledge embodied within an innovation could provide sufficient protection and reduce appropriation hazards (Teece 1986 p. 287), whereas bundling IP may create a disincentive for appropriability by competitors throughout the channel because multiple IP offers stronger opportunities to recoup if infringement occurs (Farrell 2002).

In sum, the risk of appropriability had a significant influence on both the product-form and product design decisions. In particular, when appropriability risks were not a concern, the focal firms opted to sell the IP or make intermediate products. On the other hand, when appropriability risks were heightened, firms often opted for systems rather than components offerings. Informants also noted that the product form, once chosen, could be further bolstered against appropriation by taking specific measures to ensure multiple patents were bundled into the product and trade secrets were optimized to reduce the risk of reverse-engineering.

Firm Resources. The firm's resource profile refers to the skills/capabilities that the focal party and its partners possess which help it generate economic value from its innovation. One of the key tenets of the Resource Based View of the firm is that firm-specific and non-imitable resources have rent-generating value (Mahoney and Pandian 1992;

Wernerfelt 1984). Through my interviews, two sets of resources seemed to be most material to the product-form issue: product development resources and marketing/brand equity resources.

Product development resources. These resources refer to the procedural and structural assets the venture/firm has in place internally, or through its network of external partnerships, to design and develop products. These could take various forms including, involving marketing and technical people in product development, communicating with vendors early in the product design and development stages, organizing cross-functional teams to better translate market-level needs into products, etc. My informants referred to these set of assets as "customer-oriented resources" or as "procedural processes and mechanisms" to ensure a better dialogue with customers and to keep track of and operate on changing customer needs. Tracy, the co-founder of the software system company, suggested that the ability to offer a system required the company to have procedural mechanisms set in place to create relationships with customers and to specifically focus on customer problems.

> "… we have structured our processes to be client centric…going into custom software … requires a lot a communication, so there's a lot a complexities … through processes we've instituted internally."

Further, the meshing of internal marketing and relevant technical skills provided added advantages to understand technologies when they were particularly complex. As in many complex markets, having an internal sales and support team with a technical background provides final consumers with a more knowledgeable and effective liaison between the firm and its customers.

> " … we've hired people with interdisciplinary backgrounds and sales experiences (in product design) and that is our core value system"

Similar examples of enterprise-related processes, interdepartmental communication, internal sales teams, and active allocation of product development resources to the marketing department were provided by informants of the types of market and customer-oriented resources (Kohli et al. 1993) cultivated by their firms. For some investments, 'customer oriented' skills or resources was the pivotal factor leading investors to support a particular start-up. Often calling these resources part of the 'execution' of the commercialization process, investors evaluated potential deals based upon their belief that the technology could actually be successfully marketed to targeted customers. Examples of such resources include extensive technical as well as marketing educations; product market experience with specific access to distribution networks, well-trained and experienced sales teams, and managerial experience (at the divisional level) in the product market of interest.

Marketing/Brand equity resources. These resources refer to the brand and marketing channel equity of the firm that may influence the firm's product form choice. For example, Bill, a senior executive at EFX, a global manufacturing and technology company, said that even though the company was known in the market-place for its high-technology components like power supply units, automation devices, and motor technologies, it was seriously considering an entry into an "adjacent market" with a complete system that would convert solar energy into electric power. Asked to elaborate, he said:

> "They've [an upstream supplier partner] gotten very good at the cells and also very good at understanding the market. They really understand the market, and, but they don't have brand name, and they don't have manufacturing. So we come in and say okay, we've got a component, we'll marry up our component with yours. We have the manufacturing for all of our products, we've got the brand name, and you've got the, the market intelligence, and boy, that could be a very powerful combination."

In other cases, the firm had the technical skills to develop and sell the complete system, but did not have adequate levels of appropriate marketing resources. For instance, even though Dynamore Inc. has the technical skills to sell customized solutions to high-value clients rather than high-volume commoditized goods, it was considering an alternative product-form. This is what Ivan, at Dynamore, said:

> "… we're afraid we don't have the skills to sell products. We have the (technical) skills to sell and service … maybe we should brainstorm to see if it makes sense to (offer) a different business model. The key is how you support the product … we need to worry about how to sell it, how to market it, how to advertise for it and communicate its value."

He was emphatic that the company could not support its product effectively without these marketing resources and/or brand equity. Specifically, Ivan is concerned with offering an off-the-shelf type product because the company's closest competitor would then be Microsoft.

In contrast with Dynamore, EMP software described its marketing skills as one of the key factors that impacted its decision to sell systems in a market where data integration and storage could sometimes be purchased "off-the-shelf," i.e., like components. Tracy, the CEO said, "… we've people with marketing and business backgrounds, with sales experiences … marketing is our core advantage." Arguing that technical skills are often not enough, EMP intentionally hires employees with inter-disciplinary backgrounds in marketing and the relevant technical disciplines.

2.4 Discussion. My findings intersect with transaction cost analysis (Williamson 1985) and resource-based views of the firm (Barney 1991; Wernerfelt 1984), and provide empirical evidence of the determinants of product form choice. My informants discuss and deliberate over the product form decision in great length prior to committing to one commercialization alternative or another. John et al. (1999) argue that know-how transforms the business aspects of a market in profound ways because it is know-how that provides the fundamental concept that shapes scientific, technical, and commercial product offerings. Fundamental to the transformation of know-how to a revenue generating entity is the decision of 'what to sell.' My data reveal, however, that the transformation of know-how is specifically impacted by the underlying mechanisms associated with the coordination and safeguarding costs associated with the particular technology and its prospective market. Further, I find the firm-level marketing resources do not merely enhance a firm's competitive advantage in a particular market, but may also alter the product market itself. Likely, customers, value chain partners, and competitors are altered as a result of choosing to sell one product form alternative rather than another. Furthermore, I demonstrate that consistent patterns emerge across informants' accounts of the determinants of product form choice irrespective of the types of organizations they represent (i.e., early-stage ventures vs. Fortune 500 companies).

Our informants describe product-form as a critical decision across variable industry contexts, and this choice had key implications for a wide range of marketing decisions. Second, executives, mid-level product managers in established firms, and

entrepreneurs were all pro-actively involved in this decision and not only brought in deep, strategic thinking but also displayed a structured deliberative process in considering the factors that matter for commercializing their innovations and IP (Bhide 2008). This finding was universal among our informants. Third, a key theme to emerge, and central to the product-form decision, is that the venture/firm evaluated the "eco-system" of technical issues (Novak and Wernerfelt 2008; Henkel and Baldwin 2008), the marketplace of potential customers and competitors, and the legal environment relevant to the focal technology to decide where to participate in the value-chain with the aim of deriving higher value and extracting higher net benefits/profits from their know-how/IP (Pisano and Teece 2007; Henisz 2000). More specifically, two key rationales seemed to matter to their choice: a desire to generate the best economic value from their IP (coordination) conditional on their ability to secure their share of the returns from the IP (safeguarding) and their ability to design, develop, and market the desired product form (resource-profile). In essence, their choices are consistent with an integrated view of the organizational design (Williamson 1985; Wernerfelt 1994) and the RBV (Wernerfelt 1984) theories of the firm. These rationales manifest themselves in a variety of technological (e.g., modularity and complexity), customer (e.g., customer expertise), legal (e.g., IP enforceability), and firm-level (e.g., product development resources and marketing resources) factors that seem to impact their product-form decision.

By using project or technology-level accounts as a gateway to understanding the mechanisms driving this decision, I find themes supported by previous literature related to Transaction Cost Economics and Resource-based views of the firm. As Baldwin and

Clark (2000) found evidence that modular technologies were easier to interface with complementary technologies and could therefore be separated across modules, my findings reveal less complex and tacit technologies are better sold as less integrative goods comparatively (Kogut and Zander 1992). As such, technologies with highly-complex or radical departures from existing technologies were often difficult to sell as licensed agreements or contracts because their usefulness was limited by the codifiable knowledge within the contract and the ability to interface with other complementary technologies (Bhide 2008; Christensen 1997).

Further findings suggest technologies with highly enforceable intellectual property are relatively more conducive to less integrative goods (e.g., licensing, components) *ceteris paribus* because integrating multiple technologies is relatively more costly. However, when technologies were faced with the likely prospect of reverse-engineering, firms often built around the core innovation to bolster intellectual property protections. Examples include bundling multiple patents and patents with trade secrets (Farrell 2002). Further design efforts to ensure trade secrets were utilized rather than patents also provided opportunities to change the configuration of the product form without changing the product form itself. For example, scientists may choose to design the components of a technology to draw boundaries around technology at points of intellectual property, which allows firms to sell components between channel members with reduced risks of appropriation (Henkel and Baldwin 2009) and to hide their most valuable intellectual assets in software code rather than hardware devices (hardware was depicted as easier to reverse engineer) (Baldwin and Clark 2000). The redesign of a

technology is consistent with transaction cost analysis work considering the implications of weak intellectual property on the types of technologies trade among inter-firm exchanges (Oxley 1997).

With respect to firm-level resources, I find themes in my sample related to the functions of marketing resources (e.g., internal marketing processes, guidelines, and procedures) designed to better meet the needs of potential customers (Barney 1991). In particular, those firms with marketing and technical skills to understand the potential problems of likely customers and competitors as well as provide the technical expertise to devise possible solutions were more likely to sell integrative or more final goods. Findings suggest my informants did in fact alter how they chose to organize their product offerings or their product form choice as a result of these resources (Madhok 2002). Further, when the technology was plagued by likely reverse-engineering and unlikely to generate enough revenue to recoup the costs of investments, firms with the appropriate 'customer oriented resources' were in a better position to utilize those resources to integrate into more complete goods and build additional value into their product offering.

My informants also used their brand equity to actively construct and maintain relationships with channel members likely to be necessary for the development of a desired product form. For example, informants with high brand equity in the computer components market may utilize their reputation in that particular market to partner with other firms selling complementary components with the goal of selling a complete system. This was often the case when informants were considering entering an adjacent market with one of their established technologies combined with a technology not

currently offered by the focal firm. Like Jacobides and Winter (2005), my informants' motivations lie in the underlying mechanisms of Transaction Cost Analysis and the resource differentials associated with the firm; however, findings reveal these mechanisms were unique to the characteristics of a particular technology (e.g., product-line) rather than the circumstances of the firm.

Similar to Alvarez and Barney (2001), I explored how economic rents can be created and simultaneously organized to protect against appropriation as a result of commercializing new innovations. These researchers specifically consider value creation and value appropriation simultaneously as value creation without an isolating mechanism to protect it, is subject to no benefits (Porter 1996). However, unlike these studies, I find product form, itself, is a governance mechanism that must be managed to derive the most efficient outcomes for securing economic gains (Masten 1996, pg. 4; Coase 1937). Product form choice is argued to be a combination of transactions formulated as a product offering. This choice provides firms with the ability to make deliberate tradeoffs among the costs of coordinating the design and development of a technology, the costs of safeguarding against appropriability, and the opportunities associated with the firm's resources.

3. ESSAY 2: SCENARIO ANALYSIS OF EARLY-STAGE VENTURES

3.1. Study Overview. I use the term "product form" to indicate the type of offering the firm sells in the market. Product form determines the extent to which the firm internalizes the coordination of a technology and its complementary assets. Three alternative product offerings will be considered: licensed technology, components, and systems. A licensed technology is defined as the direct sale of intellectual property through a contractual agreement. This type of sale requires comparatively more coordination and development by the purchaser than the other product form alternatives. A component is defined as an individual constituent/element/ingredient of a larger composite product that needs to interact with other complementary constituent/element/ingredients in the composite product to facilitate/generate an output. A components offering means the firm is likely to be operating in a higher position in the supply chain. Written another way, selling a component suggests the vendor enters the market with an intermediate product that requires relatively more resources of the buyer to make the technology useful (as compared with a systems offering). A system is defined as "stand-alone plug-and-play products composed of complementary, inter-dependent elements that interact with each other to facilitate/generate an output." Systems are characteristic of a "finished" product composed of multiple components and an assembly architecture designed to ensure the product is ready for immediate use (John, Weiss and Dutta 1999). As such, a systems offering requires internal coordination by the vendor to ensure the interdependent parts interact appropriately (Sanchez and Mahoney 1996). Furthermore, systems offerings—as a result of the multiple components and architecture—embody tacit know-how stemming from the configuration of component

parts (Cohen et al. 2000; Bhattacharya and Guriev 2006). This is not to suggest that the vendor must assemble or manufacturer any or all of the components or architecture in-house. Instead, the product form decision requires the firm to consider the differential costs associated with coordinating additional complementary assets internally rather than allowing the market to be the coordinating mechanism. This is also not to suggest that the "system" offering—considered to be a final product by the vendor—will be used as a final product by its customers; however, my question pertains to whether and how the *vendor* chooses to coordinate complementary assets internally and how industry-level factors may impact that decision. My core thesis is that parties must strategically choose between product forms to efficiently embody technologies into tangible exchange offerings based upon the coordination and appropriability costs associated with the development and exchange of technologies. Thus, product form choice is a governance decision at the level of the technology or potential product-line.

I contend that in technology intensive markets, product form is influenced by the underlying currents associated with the transaction cost economics and resource-based views of the firm. Specifically, coordination, safeguarding, and resources impact how a firm chooses to transform its know-how into a saleable good. Of specific interest in this study is the manifestation of those mechanisms in the factors surrounding potential investments. Although coordination costs may manifest themselves in a variety of different aspects of the venture, I focus my hypotheses on the costs associated with coordinating the design and development of technologies with more or less modular designs. I consider how the ease of interfacing technologies with complementary

technologies will impact the investors' product form choice. Second, in order to understand how safeguarding costs impact this decision, I chose to explicitly examine the costs associated with variable levels of legal intellectual property protection. Finally, I chose to explore the impact of 'customer-oriented resources' as one type of resource impacting how firms choose to sell their technology.

3.2 Conceptual Framework in Practice: The Enclosed-Growing System. To illustrate these three mechanisms in the context of an early-stage technology, I start with a brief description of one entrepreneur's decision to enter the market with a *system (final good)* rather than another product form alternative (identifying information and specific details regarding the patentable technological mechanisms have been excluded to protect the informant and his intellectual property). I met Jason after his efforts to seek funding led him to an angel investor network. Jason is a CEO of an agricultural technology company. This company has invented an enclosed growing system designed to grow plants without light or soil in a cargo-like container divided into several trays spanning the length of the unit. This life-support system, as Jason calls it, provides a radical departure from the traditional greenhouse methods of growing agriculture and simultaneously allows for more manipulation of the plant itself. This type of controlled growth environment affords the grower complete control over lighting, temperature, plant nutrients, water, and even the characteristics of mature plants, fruits, and vegetables. For example, seedlings and nutrients can be altered in this environment to create juicier tomatoes with fewer seeds, sweeter, redder strawberries, saltier flavored vegetables, and denser herb plants. Heightened water-use efficiency, year-round growing cycles, the

benefit of reduced or possibly pesticide-free vegetation, and faster production cycles all contribute to the value proposition offered by this new technology. Amazingly, these preferences can be controlled by the software and growth materials specifically designed to operate in conjunction with the "farm-in-a-box." The capabilities of a fully-functional unit greatly improve both current growing methods and allow for customizable outcomes.

However, choosing to design, develop, and coordinate a multiple-component system was a technically complex and costly strategic decision for Jason and his co-founders. Specifically, selling a plug-and-play system required that the team coordinate the design and development of the container unit, consumable materials, sales, and marketing staff while ensuring their intellectual property was properly protected. With their decision to sell the complete system, the team needed to coordinate the unit, which consists of three primary components: the software, hardware (the off-the-shelf computer components running Jason's proprietary software), and the structural materials needed to build the shelving and the outer shell of the unit itself. The team also had to develop specialized nutrients to optimize the functioning of the growth system with precise tolerances (developed in conjunction with proprietary software algorithms).

Although Jason has considered how offering his technology as a license or a component would compare, he suggests that selling the entire farm-in-a-box is the only alternative that makes sense. First, he considers enclosed growing systems to be an infant industry with his primary competition being established growth practices—the greenhouse environment. He suggests that realigning an industry has constrained opportunities for offering components as the experts in current greenhouse growing

methods and, in particular, the local farmers and agriculture workers do not have the expertise to coordinate and integrate components into a growing system. If he sold the hardware/software unit, the system would suffer greatly from the lack of corresponding nutrients and the uncertainty associated with variable container designs. If he sold the containers separately, the optimization portion of the growth process would also suffer as the average worker in this industry does not have the skills to incorporate the technologies effectively. Alternatively, he could have chosen to license the technology to an established greenhouse firm and allow that firm to develop the end-product. However, the complexity within the design and the novel nature of the process would make the development extremely difficult and relatively incoherent to traditional growth method firms. Jason believes the coordination and development required of offering the entire enclosed growing system, although capital intensive is likely to be the best opportunity to generate value for the early-stage venture.

Protecting the team's intellectual property against reverse engineering also surfaced throughout our interview as a compelling consideration in their product form decision. In an effort to ensure that relatively larger and more established firms could not reverse-engineer the hardware by more efficient means, Jason patented the hardware combined with the growth process as a device patent. While Jason believes the patents provide some deterrent against infringement, the patents are unlikely to afford adequate and longstanding protections against reverse-engineering because the hardware components are largely off-the-shelf type components and the process could possibly be replicated by other highly-skilled individuals working in the field. Jason believed their

weak IP was a compounding factor indicating to him that they should sell the entire unit rather than one of their patented components.

With their decision to sell the entire "farm-in-a-box," Jason had more flexibility in the design and integration of the components, which meant he could be creative about how he incorporated their intellectual property in the final unit. As a result, the computer system was designed to instantiate much of their most valuable technology as software. Software provided Jason with the opportunity to protect their algorithms as trade secrets as opposed to patents. The enforceability of his intellectual property through trade secrets, and secondarily patents, provided Jason with the best opportunity to protect his proprietary assets against competitors since he was able to bundle multiple patents and patents/trade secrets throughout the unit.

Finally, although Jason was seeking additional capital to move forward into late-stage development, his founding team consisted of faculty with cutting-edge technologies and skills who have unparalleled technical and market expertise in the area of controlled growing systems. In particular, this group of scientists had been working on similar systems for several governmental agencies with great success. These individuals also had relatively extensive experience working with end-customers to implement and optimize the system to meet customer needs. As a result, Jason believed the technical and marketing capabilities of the founding members of the company provided him the edge necessary to ensure integrating multiple components as a final system was a milestone they could achieve.

The culmination of these three mechanisms: the difficulty associated with coordinating complex and radical technologies by customers with little expertise in enclosed growing system, the weak enforceability of the team's intellectual property when sold through licensing agreements or components, and their extensive technical and marketing resources and capabilities led Jason to believe the *system*, or "farm-in-a-box," in this case, is the most valuable product form for market entry. The decision to offer a license, component, or system is a governance decision influenced by the ease with which the vendor can coordinate the technology and its complementary assets, and the degree to which the institutional environment (i.e., industry) is associated with enforceable legal protections.

3.3 Hypotheses *Modular Technology.* The delineation of property rights is particularly problematic when the adequate specification of the technology is characterized by complex technological know-how (Teece 1986). The ease with which a technology can be communicated to suppliers and structured to interface with complementary technologies is paramount to market exchange. In general, the ability to communicate this accumulated know-how to ensure that the technology can be exchanged in the market is referred to as the "tacitness" of the technology (Kogut and Zander 1993). Composing a component for exchange in the market is more difficult when the tacitness of technology is high and, consequently, the extent to which technical knowledge and advice can be codified is low (Kogut and Zander 1992). The transferability of knowledge is critical because integrating component products with outside firms has differential costs under variable governance mechanisms (Baldwin and Clark 2000). First, it is relatively more

costly to organize under market exchange when the technology and its associated know-how are more difficult to make explicit and thus more costly to contract (Williamson 1992). Second, coordinating technology transfer in the marketplace, especially with arm-length contracts, can be extremely difficult when technologies require continued dialogue (Polanyi 1962). Third, prior research suggests contracting when the transfer of know-how is low is more efficient because tacit knowledge "almost requires face-to-face contact" (Arora 1996). More explicit definitions, processes, and instructions make the cost of coordinating the technology within the market relatively less costly than would otherwise be the case. The ease of specification and monitoring inherent in the technology and its complementary assets can make it more difficult for parties to construct and enforce contractual terms and thus make it less costly to coordinate and safeguard these types of technologies.

Alternatively, when technologies are designed to be easier to mix-and-match *at the beginning* of the development process, the technology is better suited to create product variations with differing bundles of functionalities, features, and performance levels (Baldwin and Clark 2000). Modularity refers to a particular design structure in which parameters and tasks are interdependent within units and independent across units (Baldwin and Clark 2000). Modular design enables components manufacturers to leverage a greater product variety, speed the introduction of new products, and lower the overall design and development costs (Sanchez 1996 p. 126). Because modularization requires less managerial authority and control, effective coordination of the development process may be achieved without the added costs of more hierarchical governance

(Sanchez and Mahoney 1996). As a result, manufacturers operating with standardized and interchangeable product designs face comparatively less production and development costs and fewer extensive compensating changes in the design of interrelated components. Stated another way, manufacturers operating in *modular* environments will offer fewer integrated product offerings because this technology is comparatively easier to mix-and-match with complementary technologies.

> H1: The higher the modularity, the lower the likelihood of choosing a more integrative product form.

Enforceability. Writing and executing a reliable contract for the use of technology requires the adequate specification of property rights, monitoring, and enforcement of contractual terms—any of which may be problematic, thereby increasing the potential for leakage of valuable intellectual property. Enforceability refers to the degree to which legal agreements can be effectively enforced within the industry. My emphasis is on the ability to protect and enforce intellectual property and contractual agreements on the part of one or more institutional constituents (Henisz 2000). Arguably the most salient supply-side risk to the development and commercialization of technical knowledge is that associated with 'appropriability hazards' (Teece 1986, Pisano 1989). The archetypal type of appropriability hazard studied in Transaction Cost Economics has been the cost of a "hold up," which is associated with firm specific assets (Williamson 1985). However, appropriability hazards may also arise from a variety of other factors. For example, appropriability hazards can also be influenced by how easily the rents from a technology can be appropriated by unscrupulous parties (Oxley 1997). Weak property rights

influence how easily technology transfer can occur between firms and the likelihood of leakage of valuable intellectual property (Teece 1986). As a result, several studies have examined how interfirm governance may be organized to ensure greater efficiencies in the market (Oxley 1999). Recent work in "Open Innovation" indicates this alternative, cooperative strategy can also lead to great success (Pénin, 2007, Harhoff, Henkel, & von Hippel, 2003; von Hippel & von Krogh, 2003); however, in the case of firms seeking to recoup their investments, openness is valued selectively (Henkel 2006).

My focus pertains to the enforceability of property and contract protections across differing market contexts and differing product forms. Specifically, I argue that the institutional environment defined as the political, social, and legal ground rules of an economy forming the basis not only for exchange, but also for production and distribution (Davis and North 1971) and has a significant impact on the cost of coordination within the market and, consequently, impacts the product form decision. Previous studies considering political risk, direct investments, and multinational technology transfer support that managers will clearly invest their firm's resources differently when they perceive the trading environment to be hazardous (Henisz 2000). Similarly, recent studies suggest the resource value is not independent of the specific environment in which the resources are deployed (Brouthers, Brouthers and Werner 2008; Priem and Butler 2001; Oliver 1997). The hazards of uncompensated technology transfer can be observed across and within industries (Henisz and Macher 2004). Providing further evidence of the variability of enforceability across industries, recent patent reform proposals have drawn heated debates between industry lobbyists arguing

for and against measures to increase enforceability; these debates suggest that some industry-level executives are dissatisfied with their current ability to protect innovation within their prospective industries. Furthermore, Grewal and Dharwadkar (2002) argue the institutional environment is a resource (industry-level) that must be managed much like other factors of production and should thus be considered for its value-adding ability. As such, I argue that these factors are the attributes of exchange considered in determining the proper product form alternative in the market.

Since regulatory institutions exist to ensure stability, order, and continuity of societies (Arndt 1979), their ability and power to impose direct constraints on channel members becomes critical when considering the costs of alternative governance mechanisms (Williamson 1985). Specifically, the enforceability of legal agreements (e.g., contractual and property rights) is vital to "efficient economic organization" and "encourages people to engage in [markets] at low cost" (North 1986, p 236). However, when the institutional environment and the attributes of the technology are particularly hazardous, more hierarchical governance structures are often adopted (Oxley 1997). As such, higher levels of enforceability are less costly environments to coordinate, develop, and implement technologies and their complementary assets.

H2: The higher the enforceability of intellectual property the lower the likelihood of choosing a more integrative product form.

Marketing Resources. Procedural processes and mechanisms designed to better meet customer needs are an inimitable advantage to ventures (Barney 1991). These resources can often be beneficial for direct customer interaction and dialogue. Madhok (2002) suggests firms will alter how they organize their transactions to best utilize their

resources. I argue that product form choice, a governance decision at the product level, will be impacted similarly when the firm has extensive marketing resources to execute their strategic marketing decisions. Since these resources are also costly to obtain and maintain, investors will choose to sell systems rather than less integrative product forms in an attempt to recoup the value of their resources.

H3: The higher the marketing resources of the venture, the higher the likelihood of choosing a more integrative product form.

Interaction Effects

Although the depth interviews and participant observation make some references to the interplay between the three underlying mechanisms, it is unclear how the effects of such factors as modularity in technology and the enforceability of intellectual property, for example, may influence the product form choice. As such the following hypotheses provide a brief exploration of the interactions between these factors. The logic associated with these effects is my own conjecture about their direction as it relates to the prior literature.

Interaction between Modularity and Enforceability H3 proposed that the higher the degree of modularity associated with the technology the more likely it would lead vendors to offer components in the market because components allow the vendor to leverage a greater product variety, speed the introduction of new products, and lower the overall design and development costs without the added governance costs of coordinating multiple components in-house. When the vendor is operating with highly modular technologies in an environment with low levels of enforceability, the ability to coordinate technologies via the market mechanism becomes more costly. Specifically, the vendor

faces increased governance costs associated with weaker intellectual property protection for a given technology. Williamson (1991) illustrates the shift parameter framework, which suggests that differences in the institutional environment changes the relative costs of alternative governance structures and, in particular, finds that the enforceability of property rights to be one such "shift parameter" that may influence the choice between market and hierarchy governance mechanisms. Consequently, because lacking enforceability shifts the cost parameters associated with that market upward, the costs of coordinating within the market also become relatively more costly than internal coordination (Oxley 1999). Thus, a systems offering is relatively more cost efficient when the enforceability of intellectual property is weak.

H4: For a given level of modularity, the likelihood of choosing systems over less integrative products will increase as the ease of enforceability because more difficult.

Interaction between modularity and resources

Consistent with my argument in H3, when firms have the procedural and managerial processes in place to better meet customer needs, they will utilize those resources to gain additional value through their product offering. I reason that the modularity will impact the decision, suggesting that firms sell components as it is less costly to coordinate these technologies with external partners. However, the ability of the firm to generate further value will temper the likelihood of selling less integrative product forms (i.e. licensed agreements or components). As such, investors will likely prefer systems rather than less integrative goods when firm-level resources are high compared with when resources are low.

H5: For a given level of modularity, the likelihood of choosing systems over less integrative products will increase as the presence of firm-level resources also increases.

Interaction between Enforceability and Resources

Consistent with the main effects proposed in H2 and H3, I propose that the interaction effect between enforceability and resources will create a more positive relationship between these factors and product form choice. An interaction effect, rather than independent main effects, is hypothesized here because enforceability would have a negative effect on product form choice. Investors would choose more integrative goods to bundle intellectual property protections when investors perceive IP enforceability to be weak (Farrell 2002). However, firm-level resources will have a positive effect on the likelihood firms will sell more integrative goods. As resources are a costly but inimitable competitive advantage, firms will be more likely to sell more integrative goods, especially when intellectual property protections are weak.

H6: For a given level of enforceability, the likelihood of choosing a system over a less integrative product will increase as the presence of firm-level resources also increases.

3.4 Context: Angel Investments. This study will provide a systematic investigation of these factors with real decision-makers—angel investors. These investors will evaluate fictitious proposals based upon product form choice and their perceived risk as a result of coordination, safeguarding, and resource factors present in the scenario. While it is noteworthy to mention that additional factors impacting product form choice were revealed less frequently throughout the qualitative study, coordination, safeguarding, and

resource concerns emerged with most frequency and consistency across the inductive study and will be the focus of my next study.

I chose to examine this question with early-stage ventures because startup firms have been surprisingly neglected, and yet early-stage ventures are particularly impacted by costs. It is often this stage in the firm's growth process where inter-firm relationships are required to advance an initial market offering (Evans and Leighton 1989). It is also typically one core innovation or technology and its potential for sales that are the primary factors impacting an investor's evaluation of a company (Sudek 2006/7), and the prospect of co-creating a company with this technology serves as a vital reason investors choose to participate in the deal (Landstrom 1998). As such, this type of organization is particularly focused on developing one core innovation, and as a result, provides a valuable opportunity for understanding a firm's decision of "what to sell" or which product form choice to offer in the market.

As a result, I examine how coordination and safeguarding costs act as the driving mechanisms behind the firm's choice of what product to sell in the market but is constrained by firm-level resources aiding in the execution of the final product. Specifically, I aim to answer the following research questions: (1) how do the three emergent mechanisms (from Essay 1)—*coordination*, *safeguarding*, and *heterogeneous resources*—impact product form choice, and (2) what functions do these mechanisms play in moving an early-stage venture toward selling a less or more integrative product.

From an investment standpoint, product form choice greatly impacts a firm's decision of where to enter the market, possible inter-firm relationships required for the

execution of the technology, and the variable opportunities to generate value through the innovation. Despite their importance, early-stage investors, particularly angel investors, are largely ignored by authors and academicians (Degannaro 2010). However, it is often this type of investor that is the first to evaluate a technology (Sudek 2006/7). It is also the early-stage investors that provide the network for entrepreneurs to obtain the necessary advisory board, management team, and network of channel members to generate valuable returns through the successful commercialization of the technology (DeGennaro 2010). Investors assist with business plans, bring in specialized advisors, research intellectual property rights, support lab and clinical studies to obtain regulatory certifications, and negotiate contracts with potential suppliers (Shane 2009). As a result, the success of the venture becomes a joint effort between skilled technologists, who understand the technology, and experienced investors, who understand the market.

3.5 Design and Method. In this study, I use a decision task to test the main effects of modularity (H1), enforceability of intellectual property (H2), firm-level resources (H3), as well as the interaction effect between modularity and enforceability (H4), modularity and resources (H5), enforceability and resources (H6) and modularity, resources, and enforceability (H7). In choice tasks, participants are given a number of options to rank or evaluate. Each option usually contains a combination of attributes (e.g., product features) presented at different levels. These options or factors can then be evaluated to determine the relative importance of each attribute (Part-worths). The use of choice tasks has been a growing method in business-2-business research (Wathne et al. 2001) to examine how different factors, individually and in combination, affect managers' decisions on issues

involving interfirm relationships. My decision task provided informants with scenarios for evaluation similar to those proposed by entrepreneurs seeking seed-funding in their early-stage technology. The use of scenarios can provide more realism to the task (Carroll and Green 1995); however, it also requires a significant level of sustained mental effort from the participants (Green and Srinivasan 1978).

I chose to examine the three core mechanisms driving investors' evaluations of product form choice—coordination, safeguarding, and resources—in this study. There are several reasons why I focus on these three mechanisms. First, my previous depth interviews and participant observations in both established firms as well as angel investor meetings reflect the significance and consistency of these mechanisms as drivers in informants' decisions. Second, established literature reflects the mindful and deliberate decisions firms make regarding their innovations, with the tradeoff between value creation and value claiming a long-standing area of interest for academics and practitioners. Third, these factors can be manipulated relatively unambiguously in scenarios. Fourth, fictitious scenarios rather than original proposals allow me to manipulate the factors of interest without the additional noise likely to come from actual investment proposals. Specifically, I had the freedom to remove industry-level factors, all details reflecting the potential market for the technology, competitors' information, and any preferences for technologies and brands. Last, this task design can effectively test the interactions among these factors that are formally hypothesized in my conceptual model.

I recruited approximately 100 participants from accredited angel investor networks in the Southwest region of the United States. Following the conjoint approach used by Wathne and Heide (2003), I employed a 2x2x2 full factorial within-subjects design. This full profile approach enabled the choice task to have maximum statistical power (Green and Srinivasan 1990). Thus, each participant was given a booklet containing background information regarding the same technology and eight hypothetical scenarios presented in random order. Each scenario listed the factors in variable orders but consistently presented my three factors of interest (coordination, safeguarding, and resources). Each factor was defined according to either a low or high level. In all conditions, the respondent was asked to consider these scenarios similar to those he or she evaluated in "real" screening meetings. Since these respondents were asked to evaluate approximately 20-30 proposals per month and these proposals, similar to my own, were based upon unknown truths, I felt confident these investors could respond appropriately to my evaluation questions.

After reading each "Venture" scenario, participants were asked to indicate which product form would be best for that venture to sell. Participants were also asked to evaluate each proposal for how integrative they believed the product should be upon commercialization[3]. Product form choice was measured by two items: (1) "As an investor, based on the levels of the three factors, which commercialization option would

[3] Although the product form choice decision has been depicted throughout my dissertation as a choice among three alternatives—licensing, components or systems—one can imagine how this continuum could also be evaluated as a continuous continuum of product form alternatives. For example, components are the broad category described by informants however sub components, components, subsystems, larger subsystems etc can be organized along a continuum of less to more integrative goods. As such, we wanted to offer an alternative but related opportunity for informants to evaluate the proposal for product form choice.

you prefer Venture A to choose? (1=License/Sell Intellectual Property, 2=Sell Component, 3=Sell System)," and (2) "Based on the levels of the three factors, please use the scale below to indicate whether the venture should sell/license the focal technology as opposed to sell the final product (i.e., systems)." Manipulations of the exogenous variables are embedded within each scenario.

For coordination costs, my depth interviews revealed several different situations that would impede coordination efforts and make it more costly for the venture to coordinate the design and development of the technology. I chose to manipulate the modularity (Baldwin and Clark 2000) of the technology since these ventures were high-technology companies, investors were familiar with the difficulties associated with interfacing technologies, and issues of modularity (although not termed modularity by most informants) were quite frequent in my early data collections. High level of modularity was manipulated as, "Design features make this technology easy to interface with other complementary technologies." The low level of modularity was manipulated as, "Design features make this technology difficult to interface with other complementary technologies."

Safeguarding was measured by manipulating the level of legal enforceability likely for the industry and legal environment in which the technology belonged. The high level of enforceability was manipulated as, "Industry and legal environments provide weak protections for the venture's intellectual property." Low level of enforceability was manipulated as, "Industry and legal environments provide strong protections for the venture's intellectual property." Note the safeguarding or

appropriability hazards issue was addressed only related to weak property rights (Oxley 1997) and did not address other appropriability hazards resulting from such factors as asset specificity (Williamson 1985).

My third factor, firm-level resources, was manipulated as the internal capabilities of the firm to market technology intensive products. The high level was specifically manipulated as, "The venture has extensive capabilities to collaborate, develop, and market technology intensive-products." The low level of resources was manipulated as, "The venture has few capabilities to collaborate, develop, and market technology intensive products." Operationalizing these rich concepts in this way was necessary to provide succinct scenarios and to prevent potential confounds.

3.6 Analysis and Results. Since a within-subjects research design was employed in this study, I used an ordered logit in JMP to analyze the data collected. Since each participant in this study provided responses to eight separate scenarios, their responses might not be independent of one another. The ordered logit model is appropriate for the data collected because the dependent variable of interest is the respondent's choice of which product form to sell based upon the factors presented in each scenario. Further, since the three alternatives—licensing, components, and systems—can be organized along the vertical positioning continuum (John et al. 1999) in order of least to most resource intensive for the focal firm, an ordered logit is the appropriate method. However, since ordered logit reports only the probability of the outcomes considered, I do not have actual estimations of their frequency of being chosen.

The findings are reported for two versions of the scenarios. One version represents the scenarios completed through online data collection, and the second version was provided through a booklet completed by investors and returned by mail. I will first report the data for the booklet data. Appendix I reports the logit model for product form choice. The full model shows a low fit with the data (Pseudo R^2=.08). The ordered logit results indicate that the effects of two of three independent variables are significant: modularity (= -.47; p <.05), enforceability (= -.24; p >.05), resources (= .56; p <.05). Consistent with the proposed directional support provided in H1, modularity is found to have a positive effect on product form choice, suggesting firms will choose to sell fewer integrative products when the ease of interfacing between complementary technologies is relatively less costly. Enforceability was insignificant. Firm-level Resources is found to have a negative effect on product form choice in support of H3. This suggests that firms with higher levels of resources are more likely to sell more integrative goods (e.g., final goods). Although H4 is insignificant, I find directional support to suggest that as the enforceability of intellectual property grows weaker, firms will sell more integrative goods even when the technology is modular (=.34; p >.05). Further, the interaction between modularity and resources (H5) is insignificant but is directionally consistent with our hypotheses (= .18; p >.05). The interaction between enforceability and resources is also directionally consistent but insignificant (= -.35; p > .05). Examining the 3-way interaction between modularity, enforceability, and resources (H7) did not find support in my data (=.07; p >.10), but are directionally consistent with the notion that firms with the ability to design and develop more

integrative goods will do so in an effort to protect their intellectual property even when technologies are modular. Among the control variables (e.g., years of investing, number of investments), results were insignificant.

Results for the online survey were conducted similarly with the full model containing the three-way interaction described above. However, the low number of responses from online data prevents a valid estimation of the model beyond my interaction terms. It is noteworthy to identify that directional consistency is found for all hypotheses between the two data sets except for the interaction between modularity and resources, which had a small but negative relationship with product form choice. Summary statistics are reported in Appendices J and K.

3.7 Discussion. The findings of this study show that in addition to the individual effects of modularity, enforceability, and resources, there is a two-way positive interaction between modularity and resources as well as directional support for the other hypothesized two-way and three-way interactions. This indicates that angel investors are making deliberate decisions about the product form choice they believe is best suited for a particular venture based upon the three underlying mechanisms revealed in my inductive study. Further findings specifically reflect that increased modularity in technology suggests that firms sell fewer integrative goods (Sanchez 1999; Novak and Wernerfelt 2008). In addition, the directional support for the booklet data, as well as the significant findings in the online data, reflect that investors are more likely to choose more integrative or final goods when ventures are operating in an environment lacking intellectual property enforceability. Next, the impact of firm-level resources on the

investors' evaluations of potential investment proposals reflects their willingness to sell more integrative goods when the firm has the capabilities or resources to actually execute the commercialization through a final good. In the case of modularity, weak intellectual property protection moderates the relationship with product form choice such that firms are less likely to sell a licensed technology when the enforceability of intellectual property is weak. The three-way interaction between modularity, enforceability, and resources is insignificant but reflects a positive relationship with product form choice, suggesting that firms will also choose to sell systems rather than less integrative products in the presence of modular technologies, lacking IP enforceability and firm-level resources. Note that this data set would have benefited from additional respondents to better examine the relationship between these factors and the investors' decision about product form. Overall, the findings underscore the directional support for the hypothesized relationships between these factors and product form choice, but would benefit from additional data to substantiate the directional support for these findings.

4. ESSAY 3: INDUSTRIAL SURVEY OF ESTABLISHED FIRMS

4.1 Study Overview. The emergent framework developed in Essay 1 provides a rich tapestry of motives and factors that matter when firms/ventures choose their product-form. This study investigates a core subset of the issues that arise from that framework. Specifically, the study focuses on the joint impact of difficulty to enforce IP and the firm's product development resources on its product-form choice for two key technological factors – ease of mix-and match (i.e., modularity), and complexity of technology was investigated with established firms within one primary industry. Given the novelty of the research question, all of these factors were considered exogenous. In the context of this study, the two product-form options investigated are components and systems. I deliberately chose to investigate this phenomenon with established firms to systematically test the three mechanisms emergent in my initial study without the possible conflicting factors arising from an examination across industries, broad areas of technical expertise, and philosophical views of intellectual property protections. My desired goal in this study is to identify whether and how these factors impact product form choice with established firms with relatively large and stable resources and interfirm relationships.

4.2 Hypotheses. Consider the case when the core technology has features that enable it to be mixed-and-matched with a variety of system configurations. This modularity, or mix-and-match compatibility, enables the focal firm to create product variations with differing levels of functionalities, features, and performance levels (Sanchez 1999; Sanchez and Mahoney 1996). Modularity enables the firm to leverage its technology through a greater variety of products while simultaneously increasing the speed of new product

introductions and lowering the overall design and development costs (Sanchez 1996 p. 12). Because modularization requires less managerial authority and control, effective coordination of the development process may be achieved without the added costs of more hierarchical governance (Sanchez and Mahoney 1996). Stated otherwise, firms operating in more modular technical environments are likely to offer less integrated product offerings (i.e., components) because this technology is comparatively easier to mix-and-match with complementary technologies, and coordination of the end-products is generally achieved through the "invisible" market (Somaya and Teece 2001).

This "open architecture" offered by a modular technology, however, becomes problematic in environments where the enforcement of IP protection becomes more difficult. This enforcement is usually provided by a "set of legal ground rules that establish the basis for production, exchange, and distribution" (Davis and North 1971, pg. 6-7; Henisz and Williamson 1999). Variation along this legal enforceability, and hence the hazards from weak enforcement, exist not only at the country-level (Henisz 2000), but also within a country at some industry or market level. For instance, researchers (e.g., Nunnenkamp and Spatz 2004; Nicholson 2003) have identified a variety of factors, including the level of technological intensiveness and speed, the duration of IP protection, and variation in human capital intensity, as being determinants of IP enforceability at the industry level. Many industry-specific regulations (e.g., the Semiconductor Chip Protection Act of 1984) point to differing criteria for IP enforcement across industries. Furthermore, many complex industrial products (e.g., Computerized Numerical Control or CNC manufacturing machines, which gets classified as belonging

to industry sector 35) and their sub-system/components themselves are composed of a dizzying array of mechanical, optical, electronics hardware, software and instrumentation technologies. Essentially then, there are large market-level variations in the ability of the firm to enforce and secure its IP.[4]

Firms operating in environments where it is more difficult to enforce or protect IP face risks because other agents (e.g., not only trading partners like vendors or customers, but also non-trading partners operating in other market sectors) can appropriate a large share of the economic value generated from the focal party's innovations and IP (Henisz and Williamson 1999). Such firms might then seek to organize their trading arrangements under a more hierarchical mode of governance (Oxley 1999). In my context, "selling systems" constitutes a more hierarchical form of governance over "selling components" because the systems manufacturer has control not only over the architecture of the system but also over the design and development of the constituent parts. A systems manufacturer can hence bundle a variety of IPs and technologies that make it difficult for an outside party to reverse-engineer. Thus, we would expect that in environments where IP is difficult to enforce, even firms that have highly modular technologies that have relatively clear-cut definitions and boundaries are vulnerable to appropriation hazards; as a result, they are likely to choose to sell systems rather than components.

[4] The congressional hearings on the Patent Reform Act of 2010 show such variation in industry and market-level norms quite clearly. There was a clear divide between firms operating in the electronics/software sector (e.g., Microsoft, Intel, Cisco) that preferred a weaker enforcement regime as against firms operating in the pharmaceutical/medical device sector (e.g., Merck, Pfizer), which demanded more stringent patent enforcement and infringement penalties.

However, it is contended that the need to protect and secure the economic value from a firm's IP is not sufficient; firms need to have the appropriate levels of product development skills and resources to design, develop, and market a system that not only masks the core IPs but also provides a meaningful and effective solution to customer needs in some particular markets. These resources would come in many forms, including (a) having formal structures to involve marketing and technical personnel in product development and having R&D teams, (b) having routines to involve key vendors early in the product design and development stage as well as developing solutions to customer-market needs, (c) having established procedures to understand customer needs and translate them into meaningful product features, and (d) having technical expertise to extend the boundaries of research and knowledge to provide customer solutions. Compared to firms with low levels of product development resources, firms with high levels of these resources are more likely to be able to successfully create and market products that enable them to protect and safeguard their investments in innovation. Hence, it is hypothesized that:

H1: If, the technology is modular and the IP is difficult to enforce, firms are likely to sell systems (over components) when the firm's product development resources are high (instead of low).

A similar argument can be made for complex technologies. Here, even though the complexity of the technology might make it inherently difficult for outside agents to successfully appropriate the value, the focal firm would still like to seek hierarchical safeguards (i.e., design and sell systems) as the difficulty of enforcing IP increases. Again, however, only firms with high levels of the appropriate product

development resources would be successful in designing and marketing these systems. Hence, it is hypothesized that:

H2: If, the technology is complex and the IP is difficult to enforce, firms are likely to sell systems (over components) when the firm's product development resources are high (instead of low).

4.3 Context: Electronics Firms in Industrial Markets. The hypotheses were tested in the context of complex industrial equipment and products that are sold by industrial OEMs/component manufacturers and used by industrial buyers in their manufacturing, logistical, and/or administrative operations. Settings where the product being supplied was a part/component into the customer's products/services and sold downstream were excluded. The data was collected from sales managers at firms drawn from four industrial sectors, namely non-electrical heavy machinery (SIC 35), electrical and electronic machinery (SIC 36), transportation equipment (SIC 37), and instrumentation devices (SIC 38)[5]. The context of complex industrial sales has many appealing features for the research purpose. First, my field interviews revealed that components versus systems were indeed the two most prevalent product-form alternatives in these markets. Second, these firms operated in a large variety of market sectors; this assured me that adequate variation in IP enforceability norms as well as product development resources would be found in the data. The key dependent variable is whether the most important product line of the focal firm, in terms of revenues, was either a system or a component (definitions in

[5] The U.S. Standard Industrial Classification (SIC) system was replaced by the North American Industry Classification System (NAICS) in 2002. However, most information vendors still classify most of their mailing list data using the SIC codes.

Table 1). Thus, the unit of analysis is at the *product-line level* and not the industry, firm, or customer level.

4.4 Design and Method. The key informant methodology (Campbell 1955) was used to identify individuals who were closely involved in the decision making and knowledgeable about the context being investigated. I used a two-stage procedure to reach my survey participants. I first obtained a list of sales managers of manufacturing firms in the industrial sector in the United States with sales exceeding $100 million from two list brokers – the American List Council, and Dunn and Bradstreet. These 1470 individuals were then contacted by phone to qualify them as key informants. To qualify, they had to be centrally involved in managing the sales for their division/firm in a well-defined customer, product, or geographic market, and be knowledgeable about the customer and competitive environment faced by the firm. Four telephone calls on average were required to qualify each informant. To elicit cooperation, each participating manager was offered a customized report that summarized the findings from the survey and compared their profile to the average patterns across all firms in the data. Of the initial 1470 individuals, 869 agreed to participate in the survey. In the second stage, questionnaires were mailed to these 869 respondents. After two reminders, I received 264 responses. Four of these were discarded for missing data, for a final sample of 260 responses (or a response rate of 30%).

4.5 Analysis and Results. Table 1 details the operational measures for each of the constructs. To the extent possible, I relied on past measures in this study. A set of items was constructed de novo to measure the product development resource construct. This

construct was conceptualized as a formative scale. To test my hypotheses, I created a binary variable for low versus high product development resource regime as follows: For each observation, I noted the number of items (minimum = 0; maximum = 6) for which the informant marked a value higher than the mid-point of the scale (which is 4). If the number of items with marked value higher than 4 was less than 3, I coded that firm to have "low levels of product development resource." In contrast, if the number of items with marked value higher than 4 was greater than or equal to 3, I coded that firm to have "high levels of product development resource." This binary variable was then used in my hypotheses test.

Assessing Non-Response Bias

To assess non-response bias, I used the Armstrong and Overton (1977) technique of contrasting early responses against late responses. I received 68% of the responses within 3 weeks of mailing the initial survey; these were classified as early respondents and the rest as late respondents. The two groups were compared on various demographic characteristics, including the sales revenues for the business unit and the number of employees using a one-way MANOVA. The tests (Wilks' Lambda (λ^*) = 0.94; F (2, 260) = 0.98) indicated no significant differences between the two groups, suggesting that non-response bias is not a serious concern in the data.

Measure Reliability and Validity

I used standard procedures to purify the multi-item scales and evaluate their psychometric properties (Anderson and Gerbing, 1988). I first computed item-to-total correlations for each multi-item scale and dropped items with estimates below 0.30. Then, using LISREL

8.1, I estimated congeneric (single-factor) models for each set of items and used the Werts et al. (1978) formula to compute the scale reliability estimates shown in Table 1. All the factor loadings were significant, and the fit indices (Normed fit index – NFI; Non-normed fit index – NNFI; Confirmatory fit index – CFI; Root mean squared error of approximation – RMSEA) met the fit requirements, suggesting a satisfactory level of internal consistency and unidimensionality.

To assess discriminant validity, I used the Fornell and Larcker (1981) procedure, where I calculated the average variance extracted for each multi-item scale and compared its square root (SQAVE) with the inter-construct correlations. These are reported in Table 1. I found that SQAVE exceeds the inter-construct correlations in all cases; hence, each construct shares more variance with its own measures than with other constructs. I conclude that the traits are sufficiently discriminant from each other. Finally, to test for common method bias, I conducted Harman's one factor test by loading all the items of my scales on a single latent factor. The fit indices (RMSEA = 0.29, CFI = 0.32, IFI = 0.26, NFI = 0.27) were significantly lower than acceptable levels, suggesting that one factor cannot adequately account for the observed variance in the measures. Overall, my tests revealed no evidence of significant response bias in my data. Given the adequacy of my measures, I now turn to the tests of the hypotheses.

Hypotheses Test

Table 2 reports the probit model for the product-form choice. The model shows reasonably good fit with the data (Pseudo R^2 = .24). Examining the 3-way interaction between modularity, difficulty in enforceability, and the firm's product development

resources (H1), I find a positive estimate for the relevant coefficient ($\hat{\beta}$ = .09; p < .05), which supports my prediction. The 3-way interaction between complexity, difficulty in enforceability, and the firm's product development resources (H2), however, did not find support in my data ($\hat{\beta}$ = .06; p > .10), though it was directionally consistent with my hypothesis.

Among the lower-order effects, I find that ease of mix-and-match (i.e., modularity) makes it more likely that firms are in component markets ($\hat{\beta}$ = -.31; p < .05), complexity makes it more likely that firms are in systems markets ($\hat{\beta}$ = .23; p < .05), and the interaction between complexity and resources makes it more likely that firms are in systems markets ($\hat{\beta}$ = .15; p < .05). All other lower-order effects were insignificant. Among the control variables, I find that log (Firm sales) has a marginally significant effect ($\hat{\beta}$ = .35; p < .10) and that firms classified as operating in industry sector 35 (heavy engineering and machinery) are more likely to be selling systems ($\hat{\beta}$ = .19; p < .10) compared to those classified as operating in industry sector 38 (instrumentation). All other effects were insignificant.

To shed further light on my hypothesized 3-way interactions, I split the observations into two regimes characterized by low (=0) versus high (=1) levels of product development resources. This is to test my argument that even in a weak appropriability regime (where difficulty of IP enforceability is high), only firms with high levels of such resources are capable of offering systems. Table 3 shows the results for this two-regime model. The last column in Table 3 shows the results for the Chow test for

difference in parameters across the two regimes. As this split test essentially investigates the interaction of the resource measure with other variables, I include only those terms from Table 2 with this interaction.

Consistent with H1, I find that the coefficient for the 2-way interaction between modularity and difficulty to enforce is significantly lower in the low resource regime ($\hat{\beta}$ = .05; p > .10) compared to the high resource regime ($\hat{\beta}$ = .17; p < .01), suggesting that only firms possessing high levels of these resources are likely to offer systems even when they might desire to seek safeguards. I again find no differences between the regimes in the coefficients for the 2-way interaction between complexity and difficulty to enforce. At the same time, note that the coefficient for complexity is significantly lower in the low resource regime ($\hat{\beta}$ = .16; p > .10) compared to the high resource regime ($\hat{\beta}$ = .39; p < .01), suggesting that at high levels of complexity, firms with high levels of resources can coordinate the design and development of systems.

One conceptual argument raised in the literature on IP enforceability is that in environments where it is difficult to enforce IP, firms might seek safeguards not only through their choice of governance mechanisms but also by changing the product/technology attributes to lower appropriation hazards (e.g., Oxley 1999). Applied in my context, this would suggest that technology features – modularity and complexity – are endogenous to the difficulty of enforceability variable; if so, my analysis would suffer from an estimation bias because I assume these technology features to be exogenous in my hypotheses and in Tables 2 and 3. To investigate this, I regressed independently the two technology variables on difficulty to enforce. In both cases, I find that difficulty to

enforce does not significantly impact the technology variables, giving me confidence in my analysis where I assume these variables to be exogenous to the appropriability environment.

4.6 Discussion. The contributions from Study 3 can be summarized as follows. First, I find that mix-and-match compatibility, product complexity, strength of IP enforceability, as well as the level of a firm's product development resources are drivers of product-form choice. Second, the product-form decision seems to be composed of two major components: the need to create the most-valued product-form (as evinced by the need to coordinate and, simultaneously, the need to safeguard) and the ability to create that product-form (as evinced by the possession of appropriate levels of product development resources). Finally, I find a fascinating inter-play between the coordination and safeguarding motives. Even when technology is modular (which makes economic value generation through external coordination easier), firms seem to seek the protection provided by internal coordination (i.e., sell systems) when the strength of the IP enforceability is poor, but only if they have high product development resources. In contrast, when technology is complex (which makes economic value creation through external coordination, as well as appropriation of IP by external agents difficult), firms chose to coordinate internally (sell systems), but again only if they have high product development resources. The IP enforceability and safeguarding effects are moot in this latter case.

5. GENERAL CONCLUSIONS

5.1 Theoretical Implications. Making a choice of what technology to sell in the market is impacted by three key underlying mechanisms: coordination, safeguarding costs, and the resources of the firm. This decision of what to sell, which I term "product form choice," augments our understanding of the applications of transaction cost economics (TCE), as well as Resource Based Views (RBV) of the firm in situations where decision makers must choose among alternative formulations of a product. Essay 1 identifies the three aforementioned mechanisms driving this choice and provides an emergent pattern of factors suggesting whether and how practitioners choose one product form alternative rather than another. Specifically, I identify how environmental, firm, technology, and customer level factors may impact the product form decision. Essay 2 confirms some of the relationships between those underlying mechanisms and product form choice (as described by informants in Essay 1). Essay 3 provides further support for my framework through an empirical analysis of established firms. Findings reveal that the increase in coordination costs leads practitioners to sell more integrative goods comparatively. Heightened safeguarding costs are also suggestive of selling systems rather than components; however, without the resources to successfully execute the more integrative good, firms were less likely to actually sell the system rather than the component.

The results of this work establish a framework for understanding how the underlying mechanisms associated with transaction cost economics and the resource-based views of the firm impact product form choice. Prior to this research, I could classify the literature related to product form choice as, 1) scope of the firm; 2) product or vertical architecture; and 3) vertical positioning. Most relevant here is the product

formulation continuum presented by John et al. (1999) to examine the alternative "vertical positioning" options or, as I suggest, "product form" alternatives available to practitioners. The conceptual work of John et al. (1999) organizes the alternatives along a continuum of resource outputs by the focal firm and suggests a multitude of various factors that may impact this decision. My results extend this work by identifying a theoretical lens for understanding this choice, and by predicting and testing how these factors may lead practitioners to choose one alternative over another.

In so doing, this dissertation extends the work in transaction cost economics and the resource-based views of the firm to early-stage ventures. This context is considered under-studied and, sometimes, a contentious area of exploration for transaction costs as well as resource-based theorists. Berger and Udell (1998) find that the Organizational Design literature lacks understanding regarding early-stage ventures, particularly the strategic importance of angel investors. Alvarez and Barney (2007) argue that there is great turmoil among leading scholars as to whether organizational theories can be extended to entrepreneurial ventures. While numerous organizational theorists have conducted studies in a similar context, much of their focus has been on the social exchange of the relationship between the angel investor and the entrepreneur (Sengupta 2011; Steier and Greenwood 2000: Uzzi and Gallespie 1999). For example, study results reflect the importance of mutual trust and reciprocity on the performance of the venture (Shane and Cable 2002). Related work considers information asymmetry between entrepreneurs and potential investors. Shane and Cable (2002) utilized in-depth fieldwork and a survey of angel investors to explain the financing of new ventures, while

drawing on concepts outside of social obligations and influence. Specifically, their studies considered the financial impact of information asymmetry between entrepreneurs and potential investors. More recent work by Shane and Ventakaraman (2005) reflects continued sentiments of academicians' neglect regarding such critical issues as understanding the process of exploiting an idea through commercialization in favor of understanding the importance of networking and social relationships. Interestingly, my examination of the product form decision revealed it is a vital and frequent choice made by decision makers in established firms, entrepreneurial ventures, and investment firms. Decision makers are mindful and deliberate, and spend exceptional amounts of time and labor to study the alternative paths to commercialization and their implications for the product and the firm.

Considering the product-line level decision bestows researchers with a new level of analysis to expand our understanding of transaction cost economics. This study of the factors impacting the commercialization of a technology illuminates the underlying mechanisms of transaction cost economics beyond the typical micro-analytic analysis. Instead, the process of choosing one product formulation over another exemplifies how transactions between channel members occur not in isolation but as bundles intertwined within one potential product. For example, consider a simple system requiring components A and B, typically it is evaluated for sale by considering component A (in isolation) and also component B (in isolation) and their relationship to the final product. Our study suggests considering how the two components interact together may provide a better indication of the transaction costs associated with the final good and may suggest

how the final product is sold (as separate components or combined as a more integrative product).

Being among the first to look at the empirical effects of these attributes at the product-level, my findings both support and contradict the results of Adjustment Cost Theory (Novak and Wernerfelt 2008) and the "mirroring hypothesis" put forth by Cabigiosu and Camuffo (2011). Novak and Wernerfelt (2008) argue that the requisite activities of a product, namely their production processes, should parallel that of the activities occurring within the firm. As such, their work suggests that the production processes that require more adjustment frequency (i.e., dialogue, modifications) are more likely to be produced internally rather than in the market. Single component or multi-component goods would then be manufactured based upon whether it was more efficient to utilize the market or the firm for producing a product. Findings reveal that increased frequency of adjustment costs leads to the development of more internal products and, thereby, suggests a greater likelihood of selling more integrative products. Although this work is suggestive of an underlying coordination mechanism similar to the coordination costs I uncover in Essay 1, it suggests that the production processes necessary of a product dictate the boundaries of the firm. This is inconsistent with my analyses for two primary reasons. First, the work of adjustment cost theorists limits the scope of the analyses to production processes, whereas my work considers the coordination, design, and development of the technology as additional processes required of the product. Second, this research suggests that the processes necessary to develop a product internally are consistent or parallel with the firm's boundary decisions. For example, a

firm choosing to sell a system consisting of component A and component B must produce component A and component B. Otherwise, the firm will choose an alternative product form. My analysis, although not limited to production processes, reveals this is often not the case. Firms frequently utilize the marketplace for some components while manufacturing others. This is not reflective of their decision of what to sell. Instead, the decision of what to sell is a result of the three aforementioned mechanisms—coordination, safeguarding, and resources.

Finally, this work also builds upon governance value analysis (Ghosh and John 1999) in marketing by further illustrating the relationship between transaction cost analysis and resource profiles at the firm-level. The governance value analysis (GVA) framework was developed to explicitly incorporate firm-specific interests and resources in the design of inter-organizational exchanges. This framework transforms the traditional economizing calculus of TCA into a strategizing calculus by specifically considering the interactions among firm-level resources, positioning strategy, transactional attributes, and governance structures. This framework sheds light on how firms make tradeoffs between claiming and creating value in their channel relationships. In sum, governance value analysis argues that governance decisions are made not only through efficiency concerns arising out of economizing transaction costs, but also strategic motives related to exploiting and protecting valuable resources and capabilities. I provide empirical support for GVA by showing that firm-level resources and transactional attributes (e.g., technological factors) have a crucial impact on the chosen product form. Findings reveal that firms operate differently based upon the specific

characteristics of the technology and its complementary technologies assets. This further substantiates the claims of Ghosh and John (1999), which suggest that transactional attributes, such as technology factors, have a significant impact on the strategizing calculus and, thereby, provide direction for product form choice.

5.2 Managerial Implications. The product form choice framework provides practitioners and investors with a framework for understanding the product form alternatives and the mechanisms impacting the efficiency of one alternative rather than another. Specifically, the findings may impact the way practitioners determine how to take a technology in the early development stage and map[6] the progression of the technology through development and commercialization with alternative paths for likely product form alternatives. Further, these insights may suggest which components of a technology should be pursued for manufacture internally or acquired within the market, a timeline for commercialization related to all potential product form alternatives sought, likely competition and potential customers, a recommendation for the best alternative, and a formulation for an implementation plan.

Second, a critical aspect of sales strategy is developing an understanding of the specific needs of potential customers. Often, sales teams have the opportunity to create only one pitch to a prospective customer. During this pitch, a salesperson must be prepared to discuss the alternative product forms available to a potential customer. My

[6] Technology roadmapping is a needs-driven technology planning process to help identify, select, and develop technology alternatives to satisfy a set of product needs (Garcia and Bray 1997).

framework is suggestive of the types of factors impacting product form choice and indicates opportunities for sales personnel to tailor their pitches to the specific market environment, to identify the likely resources of the customer and to alleviate any safeguarding concerns when potential customers are looking to integrate a technology in a market with weak intellectual property rights.

Third, the results of this study suggest that the enforceability of intellectual property rights has an impact on the types of technologies sold in the market. When technologies are to be sold in an environment with less than adequate property rights, firms will choose to sell more integrative products. As such, technology management can be proactively determined by managers and investors to ensure that firms profit from their innovation. This study also suggests that without the necessary firm-level resources to execute the coordination of the design, development, and commercialization of a technology, the lack of intellectual property protection may not be rectify appropriation risks in markets for technology.

5.3 Limitations. There are several limitations in this dissertation. First, I gathered data to test my conceptual model with active angel investors. The scenario analysis, in particular, took each investor approximately 20-30 minutes to complete. As a result, I was unable to obtain the response rate necessary to conduct an adequate analysis of the factors (in the case of the three-way interaction for the online data) and also include some of the demographic variables asked of the informants. The data analysis in its current form suffers greatly from the low response rate. Further data collection must be completed to provide a more accurate account of the impact of these mechanisms on

product form choice. Further complicating the scenario analysis, I removed any identifying details related to the technology, the likely product market, and industry factors to alleviate noise within the data. While this did alleviate some of the biases mentioned in my depth interviews, it also made it difficult for some informants to evaluate the proposals.

Second, the scenario analysis focuses on only one factor related to the underlying mechanisms in my emergent framework. For example, I measured only the impact of modularity (representing coordination costs); however, other forms of coordination costs could have been included in the study and may have generated different results.

Third, this dissertation considers product form choice as three discrete product form alternatives for Essay 2 and considers only components and systems in Essay 3. My informants noted that product form alternatives could also be considered along a continuum, similar to the vertical positioning continuum (John et al.) and thereby may provide additional information as to the types of products firms choose to sell. For example, I consider licensing only as an agreement by the seller to give an exclusive or nonexclusive license to the buyer for its intellectual property. However, in some licensing agreements, companies will sell the technology along with a consulting agreement designed by the parties to ensure that the tacit intricacies of the technology are made useful by the buyer. In some ways, this arrangement is not purely a licensed agreement for the sale of exchangeable property because the buyer of the technology is also buying continued support provided by the know-how of the seller. Similarly, I consider components as one broad alternative; however, subcomponents, components,

and subsystems may be more or less integrative and should therefore be categorized along a continuum of integration among complementary technologies.

Fourth, the focus of this dissertation is on the focal firm's perspective of what to sell. I do not directly consider how the buyer may impact this decision, but instead assume the focal firm is attempting to meet the needs of the customer by selling one product form alternative rather than another. Further, since the product form choice continuum is based upon the comparative costs between utilizing the market versus conducting the design and development of the technology internally, I assume this has some implications for the firm's perception of its potential customer and the market in which the technology would likely enter. However, my assumptions are about customers aggregately; I do not specifically consider the individual needs of potential customers in any of my studies. Customer characteristics such as their brand equity or technical expertise may have a large impact on how the focal firm chooses to sell the technology to an individual customer.

Finally, although I ask my informants about their resources in Essay 1, I am not explicit nor do I extensively probe how they could obtain additional resources if a particular product form were desired but the resources necessary to coordinate and design the technology were not available within the company. However, my informants did mention that there are a multitude of different opportunities for obtaining relevant resources or capabilities through partnerships, mergers, acquisitions, and licensing agreements. I do not consider resources as endogenous and therefore ignore the many

possibilities available to the firm to make strategy decisions regarding a particular technology.

5.4 Future Research. The findings within this dissertation provide sufficient evidence that the product form decision is a critical strategic decision in marketing and that practitioners make deliberate and consistent choices among product form alternatives. By documenting and exploring product form choice in both early-stage ventures and established firms, I identified several theoretical and managerial implications and opportunities for future research. Theoretically, this work revealed the three key underlying mechanisms associated with product form alternatives. Further, these mechanisms were revealed through careful analysis of the factors impacting the informants' product-line level decisions. Similarly, from a practical perspective, the product form choice framework can not only lead to better indications of what formulation of a product to sell, but also may lead to more effective supply chain relationships and sales force strategies.

The product form choice outcomes that result from the impact of coordination costs, safeguarding costs, and firm-level resources have been identified throughout this dissertation; however, the question of why some firms choose to sell one formulation of the product rather than another as it relates to their vertical coordination strategies remains unanswered. Specifically, it is unknown whether and how the vertical coordination decision may relate to product form choice. It may be that the product form decision provides a foundation for the firm's sourcing or integrating decisions. Alternatively, the firm may consider alternative value chain positioning strategies and the

probable channel relationships required to sell alternative product forms simultaneously. As a result, product form choice may be jointly determined with the vertical coordination decision. This is not to suggest firm and product-level scope are synonymous but that sourcing decisions at the product level may be impacted by the likelihood of building or enhancing channel relationships. A systematic examination of the patterns of vertical coordination decisions and product form choice will provide a better indication of this early-stage strategy decision and thus could provide an interesting extension of this current research.

Sourcing strategies are common for high-technology companies looking to commercialize their technologies with state-of-the-art components. One opportunity to acquire technology outside of the focal firm is through acquisition. However, acquisition strategists often neglect to consider the technology or innovation acquired until post-acquisition. A growing literature has begun to explore the impact of technology acquisition in the merger and acquisition decision making process (James et al. 1998). Specifically, this work suggests that M & A discussions have long been dominated by finance and business managers which may be problematic since these managers are not experts in the technological field of interest nor do they understand the necessary post-acquisition strategies required to successfully market the newly acquired technology. This can be detrimental for the acquiring firm, which may not realize the value of its new technological assets, as well as for the acquired firm whose technology is undervalued. As such, my framework may provide a foundation for future studies focusing on the acquisition of technology through acquisitions, mergers or joint alliances. It is

particularly important to understand how to most efficiently acquire requisite complementary technologies and how the choice of product form may impact this decision and how to best structure that arrangement.

A third opportunity for extending my current research is to explore how the technological design of an innovation may impact the product form choice. Many technologies are designed as a "platform" technology with multiple applications across industries. These technologies may be marketed to several potential customers for very different applications. For example, a 3-dimensional imaging device tested and marketed for the diagnosis of cervical cancer may also provide the platform for additional disease diagnoses as well as for cell testing in plants. Alternatively, a firm could choose to sell one narrow product build specifically for one product market. Further examination of the commercialization of these types of technologies and, in particular, a longitudinal analysis of their evolution may provide insights into the factors impacting this decision and product form choice. For example, in what circumstances would one product form alternative be better than another based upon radical versus incremental nature of the innovation? Also, other questions such as when to sell a platform technology versus a narrowly focused technology and how the evolution from one product form alternative versus another may have implications for success is of critical significance.

Fourth, an examination of product form choice across international contexts would provide us with the opportunity to study the impact of factors such as political stability, distribution channel reliability, and variable levels of enforceability for intellectual property. Prior studies in transaction cost economics have suggested that

firms operating in environments with political instability are more likely to choose more internal governance structures comparatively because the risk of operating in the market is more costly (Henisz 2000). I believe a similar impact on product form choice may exist in environments with less than adequate IP, property, or contractual rights. I suggest an examination of variable levels of environmental risks may lead companies to sell more integrative goods; however, more integrative goods are also more costly to design and develop. Therefore, a more nuanced understanding of these risks and product form choice may reflect when it is most appropriate to sell fewer or more integrative goods across different countries or regimes.

A final theoretical consideration is the relationship between the decision-maker and the potential recipient. In order to study product form choice from the perspective of the focal firm, participants were primarily asked about retrospective accounts of a technology commercialization decision at the product level. I presume firms are acting on behalf of their potential customers in an effort to generate value in the market. However, the chosen product form may have been different if the focus of this dissertation were on the choices made by the buyer. Further, it is possible that the underlying mechanisms associated with product form choice may be different if our study had focused on the perspective of the buyer rather than the seller of the technology.

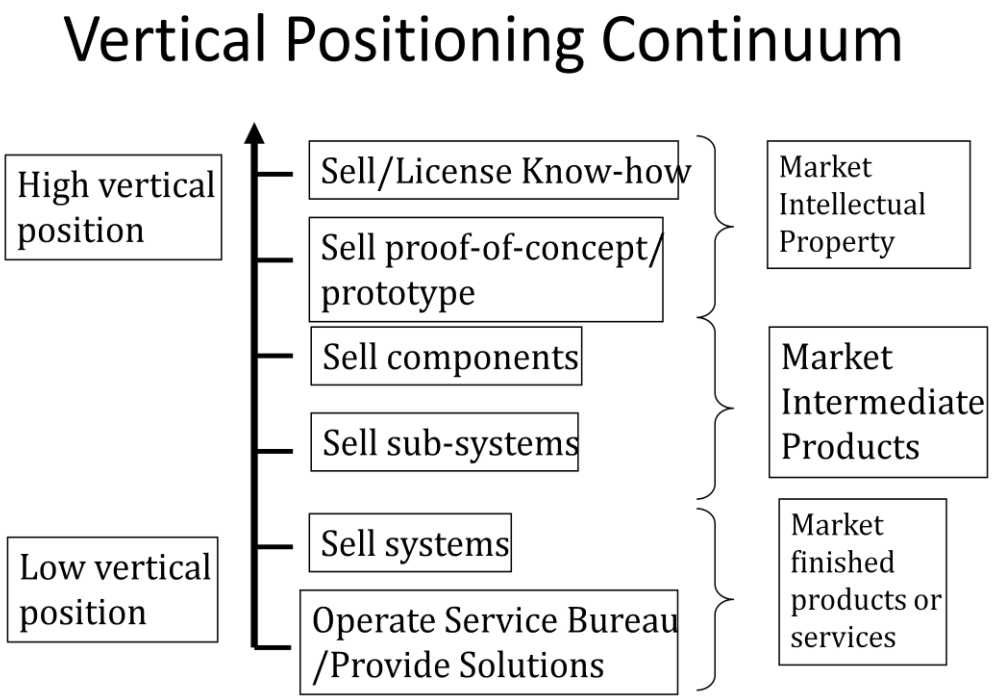
APPRENDIX A: PRODUCT FORM ALTERNATIVES: BONE-ANCHOR DEVICE

Component:
GPS device

System:
GPS and anchoring bracket

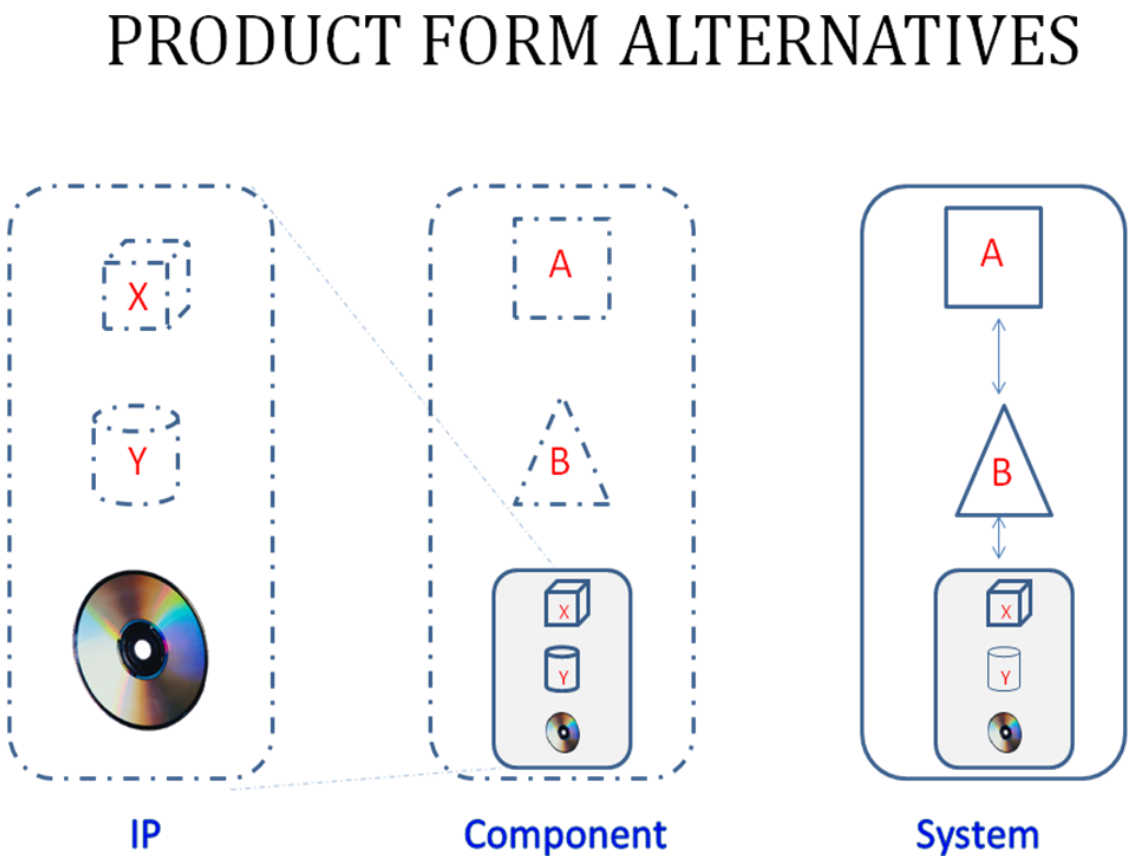
APPENDIX B: PRODUCT FORM CHOICE IN ADVERTISING

APPENDIX C: VERTICAL POSITIONING CONTINUUM



(Adapted from John, Weiss, Dutta 1999)

APPENDIX D: PRODUCT FORM ALTERNATIVES



APPENDIX E: PRODUCT FORM CHOICE: INTERVIEW EXCERPTS

Decisions impacted by Product Form Choice	**Supporting Data Excerpt**
Potential Customers	"Is ours a direct sell? Who is our customer? If we sell something to an IBM, we're not selling directly to the end-customer, we're selling to an IBM … they are our customer."-Tracy, CEO, Software Company
Potential Competitors	Her competitors are large service companies such as IBM but also noted that the company's recent decision to offer customized "back-end functions for their [customers'] database integration" has made ad agencies her primary competitors.-Field Notes
Advertising Strategy	"The question is more about how to market the product, how you sell the product, how you advertise for it."-Ivan, Co-Founder, Software Company
Time-to-Market	"But if you get behind a company in its series A round and it's secured away from actually having a product that's going to market, which means it's 10 years away from any kind of real market traction, you're looking at a really long lifecycle. "-Peter, CEO and Angel Investor
Product Design	"… focusing primarily on helping the product architect figure out what are the drivers; how's the market changing, what are the important features that should be getting into the next version of the product"-Bill, Co-Founder, Software Company
Component Sourcing	"It's a whole combined system ... we learned our lesson years ago by outsourcing certain parts of the process. We had, I mean, like, 10 vendors externally. But, one of the key tolerances was specified with one of the vendors, they made on the high-end, and then one [vendor] made a tolerance of something else on the low-end, and then these things just leaked like crazy"-Keith, Marketing Director, Medical Device Company

APPENDIX F: INTERVIEW PROTOCOL (INVESTORS)

1. How would you describe _____as a company? How would you describe _____ unique or differential advantage? What firms do you compete with or are most similar to your firm?"

2. What types of attributes are you looking for when considering which innovations to support?

3. Can you describe to me any unique aspects of the decision-making process that _____and similar companies need to make in investing in a technology or science? It appears that your company invests in early-stage and later-stage technologies. Please describe some of the challenges associated with varying stage technologies and the commercialization process?
    a. Technology (end-product diversity, tacitness, complexity)?
    b. Industry norms?
    c. Regulations/obtaining federal approval/enforceability of IP?
    d. Consumer-needs?
    e. Supply-side relationships?

4. One particularly critical aspect of determining which proposals are most promising seems to be gaining an understanding of the market space this innovation hopes to infiltrate? Please describe how you evaluate and strategize regarding the choice of market?

5. In your experience, when do companies or individuals seek out venture capitalists, private equity, or angels, and when do they not?

6. In addition to financial resources, what other types of resources do you offer the innovator?
    a. Managerial?
    b. Marketing?

7. In doing some background research on investment proposals, I have found that equity or venture capitalists often prefer to see that the innovators have consulted with marketing or managerial advisors. What role do they play in your decision to invest?

8. Please describe an example of a recent proposal you agreed to fund. What were some of the defining attributes that led you/your firm to accept this proposal?

APPENDIX G: INTERVIEW PROTOCOL (MANAGERS)

Product Market Entry Strategies:

1. How would you describe _____as a company? How would you describe _____'s unique or differential advantage? What firms do you compete with or are most similar to your firm?"

2. What types of factors are you looking for when considering which innovations to support (through commercialization)?

3. Can you describe to me any unique aspects of the decision-making process that _____and similar companies need to make in investing in a technology or science?
    a. Technology?
    b. Industry norms?
    c. Regulations?
    d. Intellectual property?
    e. Customer needs?
    f. Upstream suppliers? (are they skilled, costly, even available?)

4. Please describe how your/your firm's marketing skills have impacted the decision to enter the market with this form of product? Why didn't your firm enter the market at a different (give example) position in the supply chain?

5. You have undoubtedly seen research/innovation projects being projected as future successes. What are some of the factors that are used to determine a priori whether one market space may be a more successful strategy for entry rather than another?

6. It is my understanding that many times innovations are brought to market with the assistance of outside firms. In your experience, when do companies or individuals seek out other parties?
    a. Please describe an example of one such situation and how the relationship with this party influenced your ultimate market entry strategy.

7. Please describe some of the challenges associated with varying stage technologies and the commercialization process.

APPENDIX H: SCREENING PROPOSAL

Kimberlite Industries, LLC

Deal Room Email:
kimberlite@gmail.com

One Line Pitch: Precision Solar-Conversion Process for converting solar energy into electricity power.

Business Summary: Our unique **Photovoltaic** process is a more efficient method of converting solar energy into electricity. For example, our method requires relatively half the solar energy for the conversion process to be efficient.

Management: Kimberlite's team members have a successful track record of starting manufacturing companies in electronics related industries.

Customer Problem: 1. Consumers (both residential and corporate) want functional and practical technologies for converting solar energy into electricity.
2. Because the sun doesn't deliver that much energy to any one place at any one time, a large surface area is required to collect the energy at a useful rate.
3. The amount of sunlight that arrives at the Earth's surface is not constant. It depends on location, time of day, time of year, and weather conditions.

Product/Services: Our unique process causes energy to be collected exponentially more quickly and with relatively more consistency than other technologies on the market. This technology is relatively complex to design and manufacture. However, we have top notch experts working on the product.

Target Market: The EPIA (European Photovoltaic Industry Association expects that market to grow 9-fold to 7,500 Megawatts by 2014. That is possible if Asian governments implement policies supporting solar use such as giving preferential rates for solar energy or offering cash subsidies to builders of huge ground-mounted solar facilities. Until recently, Japan and Australia were the only markets for solar energy in Asia, with solar cells and panels being manufactured Japan, China, South Korea, and Taiwan.

Customers: Presently, Kimberlite has scheduled discussions with local and International government entities and large corporations in Los Angeles and Phoenix. Potential customers include corporations, government entities, and residential consumers

Kimberlite

Company Profile:
URL: ww.kimberlitecorp.com
Industry: Other
Employees: 10
Founded: 1997

Contact:
Name Aaron James
Email: kimberlite@gmail.com
W: 602-555-1000
F: 602-555-1001

Financial Information:
Funding Stage: Prototype Ready
Previous Capital: $250,000
Monthly Burn Rate: $15,000
Pre-Money Valuation: $700,000
Capital Seeking: $1,000,000

Additional Information:

Management:
Sally Collins, President
Frank Lloyd, CEO
Charles Wynn, CMO
Monica Salas, Dir. Ntl. Sales
James Avery, CSO

Advisors:
Lawyer: Scott Smith
Accountant: Robert Larkes

Investors:
Sally Collins- primary
Electronics Inc.

Referred By:
Website

Sales/Marketing Strategy: Kimberlite leverages longstanding relationships to first secure commitments from retail partners and then approaches distributors with retail business in hand. Kimberlite's marketing is focused largely on quality brand/product design and development. The company builds a brand following at street level with grassroots marketing efforts. Quality design, packaging, and merchandising further improve consumer pull for Kimberlite's brands.

Kimberlite Industries, LLC 123 Fake St.	Financials* ($)	2008	2009	2010	2011	2012	2013
	Revenues						
	Expenditures						
	Net						

Business Model: Kimberlite's core business model centers on first developing the technology, securing the intellectual property, and aligning with proven brands prior to investing in development and marketing its products.

Competitors: Kimberlite competes with EvolutionSolar, Solarqwest, and Ecosolar. However, there are presently two companies selling solar converter systems in the US market but with less advanced technologies.

Competitive Advantage: Our team is unmatched in solar conversion industry. No other solar conversion process can match the capabilities of our technology. We have strong intellectual property protection for this technology.

What are the factors that investors tend to overlook? : One factor sometimes overlooked is the progress that this group has made in just one year with a fraction of the capital invested to achieve comparable progress by similar groups. The other factor would be the value of the business model, the team driving it, and the discipline surrounding it. This model and our approach to the market are designed to minimize risk to capital and allow Kimberlite to achieve scale efficiently.

What will capital be used for (you may attach a Schedule of Use of Proceeds)?:
Working Capital: 200,000
Production: 200,000
Sales and Marketing: 50,000
Corporate Expansion: 15,000
lT Systems: 35,000
Total: $500,000

- Physical infrastructure expansion - Company is currently expanding its office space to accommodate growth. $50,000
- Technology Upgrade - Company is currently $75,000
- Marketing - $100,000
- Working capital - $275,000

What milestones will be accomplished with this funding that will enable you to secure additional capital or achieve liquidity? Use of Proceeds: 30% R and D, S & M 60%, G & A 10%

Indicate your expected future funding needs and your expected exit vehicle (lPO, acquisition, etc.).: Near Term - 3 to 6 Months

1. Secure Production Line of Credit in December to allow for more efficient use of capital for production.
2. Secure Equity Round of $500,000 in 2 months to provide working capital, production, and marketing.
3. Secure additional $1,000,000 to $2,000,000 in 6 - 18 months to provide growth capital and ability to pursue new and larger product opportunities.

Has anyone directly associated with the company made a personal financial investment? lf so, how much? When? Who?:

- Founding partner group invested $200,000 of initial $250,000 seed equity raise
- Sally Collins, President, $100,000 personally
- Frank Lloyd, CEO, has agreed to secure $100,000 credit line

Has your company applied for and/or been approved for the State of Arizona Angel Tax Credit?: No

APPENDIX I: STUDY 2 EXPERIMENTAL BOOKLET

EIGHT VENTURE SCENARIOS:

VENTURE ALPHA

1. Product Integration Features
Design features make this technology **easy** to interface with other complementary technologies.

2. Capabilities of the Ventures
The venture has **extensive** capabilities to collaborate, develop, and market technology intensive products.

3. Intellectual Property Protection
Industry and legal environments provide **strong** protections for the venture's intellectual property.

VENTURE BETA

1. Product Integration Features
Design features make this technology **easy** to interface with other complementary technologies.

2. Capabilities of the Ventures
The venture has **extensive** capabilities to collaborate, develop, and market technology intensive products.

3. Intellectual Property Protection
Industry and legal environments provide **weak** protections for the venture's intellectual property.

VENTURE GAMMA

1. Product Integration Features
Design features make this technology **easy** to interface with other complementary technologies.

2. Capabilities of the Ventures
The venture has **few** capabilities to collaborate, develop, and market technology intensive products.

3. Intellectual Property Protection
Industry and legal environments provide **strong** protections for the venture's intellectual property.

VENTURE DELTA

1. Product Integration Features

Design features make this technology **difficult** to interface with other complementary technologies.

2. Capabilities of the Ventures

The venture has **extensive** capabilities to collaborate, develop, and market technology intensive products.

3. Intellectual Property Protection

Industry and legal environments provide **strong** protections for the venture's intellectual property.

VENTURE EPSILON

1. Product Integration Features

Design features make this technology **easy** to interface with other complementary technologies.

2. Capabilities of the Ventures

The venture has **few** capabilities to collaborate, develop, and market technology intensive products.

3. Intellectual Property Protection

Industry and legal environments provide **weak** protections for the venture's intellectual property.

VENTURE ZETA

1. Product Integration Features

Design features make this technology **difficult** to interface with other complementary technologies.

2. Capabilities of the Ventures

The venture has **few** capabilities to collaborate, develop, and market technology intensive products.

3. Intellectual Property Protection

Industry and legal environments provide **strong** protections for the venture's intellectual property.

VENTURE ETA

1. Product Integration Features

Design features make this technology **difficult** to interface with other complementary technologies.

2. Capabilities of the Ventures

The venture has **extensive** capabilities to collaborate, develop, and market technology intensive products.

3. Intellectual Property Protection

Industry and legal environments provide **weak** protections for the venture's intellectual property.

VENTURE THETA

1. Product Integration Features

Design features make this technology **difficult** to interface with other complementary technologies.

2. Capabilities of the Ventures

The venture has **few** capabilities to collaborate, develop, and market technology intensive products.

3. Intellectual Property Protection

Industry and legal environments provide **weak** protections for the venture's intellectual property.

APPENDIX J: STUDY 2 OPERATIONAL MEASURES OF CONSTRUCTS

Descriptive and Confirmator Fit Statistics	Item Description and Response Format
Product Form Choice	**Systems** are defined as "stand-alone plug-and-play products composed of complementary, inter-dependent elements that interact with each other to facilitate/generate an output.". **Components** are defined as an "individual constituent/element/ingredient of a larger composite product that need to interact with other complementary constituent/element/ingredients in the composite product to facilitate/generate an output." **Licensing**/Intellectual Property means to sell or license the technology of know-how. This choice is furthest from deriving the actual benefit from the focal technology. 1. As an investor, based on the levels of the three factors, which commercialization option would you prefer for Venture A to choose? (Choose only one option)
Product Integration Features: ***Modularity***	1. **HIGH**: Design features make this technology easy to interface with other complementary technologies. 2. **LOW**: Design features make this technology difficult to interface with other complementary technologies.
Intellectual Property Protection: ***Enforceability***	1. **HIGH**: Industry and legal environments provide strong protections for the venture's intellectual property. 2. **LOW**: Industry and legal environments provide weak protections for the venture's intellectual property.
Capabilities of the Venture: ***Resources***	1. **HIGH**: The venture has extensive capabilities to collaborate, develop, and market technology intensive products. 2. **LOW**: The venture has few capabilities to collaborate, develop, and market technology intensive products.

APPENDIX K: STUDY 2 DETERMINANTS OF PRODUCT FORM CHOICE: ORDINAL LOGIT WITH BOOKLET DATA

Variables	**Hypotheses**	**Base Model (1)**	**Main Effects Model (2)**	**Main Effects and Interactions (3)**	**Full Model (4)**
Modularity (ease of mix and match)	-		-0.41(.18)**	-0.46 (0.18)**	-0.47(0.19)**
Enforceability (ease of protecting IP)	-		-0.27(0.17)	-0.23(0.18)	-0.24 (0.18)
Resources (firm-level)	+		0.45(.017)**	0.54 (0.18)**	0.56 (0.19)**
*Modularity*Enforceability*	+			0.34(0.18)	0.34 (0.18)
Modularity Resources*	+			0.19 (0.18)	0.18 (0.19)
Enforceability Resources*	+			-0.36(0.18)**	-0.35 (0.19)
Years of investing		0.002 (0.003)	0.004 (0.003)	0.003 (0.003)	0.003 (0.003)
Number of Investments		0.002 (0.003)	0.002 (0.004)	0.004 (0.004)	0.004 (0.004)
RSquare (U)		0.006	0.04	0.08	0.08
-2 Log Likelihood		1.62	13.1 (0.02)*	21.93 (0.00)*	22.09 (0.00)*

Standard errors in parentheses.
**p < 0.05; *; p <0.01

APPENDIX L: STUDY 2 DETERMINANTS OF PRODUCT FORM CHOICE: ORDINAL LOGIT FOR ONLINE DATA
[Systems =3]

Variables	**Hypotheses**	**Base Model (1)**	**Main Effects Model (2)**	**Main Effects and Interactions (3)**	**Full Model (4)**
Modularity (ease of mix and match)	-		-0.35 (.29)	-0.33 (0.31)	-2.33 (356)
Enforceability (ease of protecting IP)	-		-0.70 (0.30)*	-0.83 (0.34)*	-2.69 (356)
Resources (firm-level)	+		1.39 (0.32)*	1.56 (0.37)*	3.41 (356)
*Modularity*Enforceability*	+			-0.01 (0.32)	1.91 (356)
Modularity Resources*	+			0.30 (0.32)	-1.61 (356)
Enforceability Resources*	+			-0.57 (0.34)	-2.33 (356)
Years of investing		-.01 (0.01)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)
Number of Investments		0.15 (0.11)	0.23 (0.13)	0.23 (0.13)	0.23 (0.13)
RSquare (U)		0.01	0.23	0.27	0.29
-2 Log Likelihood		2.09 (0.35)	28.36 (.00)*	32.69 (0.00)*	35.37 (0.00)*

Standard errors in parentheses.*: $p < 0.05$

APPENDIX M: STUDY 3 OPERATIONAL MEASURES OF CONSTRUCTS

Descriptive and Confirmatory Fit Statistics	Item Description and Response Format
Product Form Choice	**Systems** are defined as "stand-alone plug-and-play products composed of complementary, inter-dependent elements that interact with each other to facilitate/generate an output.". **Components** are defined as an "individual constituent/element/ingredient of a larger composite product that need to interact with other complementary constituent/element/ingredients in the composite product to facilitate/generate an output.. Would you characterize this product-line as a system or a component? System: _____ Component: _____
Modularity **Reliability = 0.85** $\chi^2(2) = 4.98$; CFI = 0.96 NFI = 0.96 SQAVE = 0.75	1. The composition of this end-product can be easily altered without triggering compatibility concerns. 2. The configuration of this end-product is based on standard interfaces. 3. The composition of this end-product is perfectly modular. 4. The composition of this end-product can be chosen without holding into account other aspects (e.g., components, design, standards) of the product.
Complexity **Reliability = 0.90** $\chi^2(2) = 6.04$; CFI = 0.98 NFI = 0.96 SQAVE = 0.78	1. The inter-linkages between different components and sub-systems in our product are very sophisticated. 2. Our product is primarily composed of state-of-the-art engineering content. 3. Deriving quality output from our machines requires precise understanding of engineering technologies. 4. The configuration of our product necessitates frequent adjustments in accordance with the specific task requirements.
Difficult to Enforce **Reliability = 0.79** SQAVE = 0.68	1. Contractual violations are difficult to establish in this industry. (reverse coded) 2. Legal agreements can be effectively enforced in this industry. 3. This industry has strong norms for protecting intellectual property
Product Development Resources (Formative scale)	1. We have in place procedures to involve marketing and technical personnel in product development. 2. We have routines in place for involving our suppliers early on in our product design and development stage. 3. We have set-up procedures to co-opt with our suppliers in designing the best solutions for our customer's' needs. 4. We have cross-functional teams to enable the translation of customer needs into product features. 5. We have established procedures to integrate our customer-oriented facilities with other essential aspects of our business. 6. Our research team has the means to extend the boundaries of our technological capabilities to provide customer solutions.
Sales Revenues	In dollars the business unit's sales revenue across all product lines
Potential Competitors	The number of potential competitors for this family of product-lines/equipment (suppliers)

Unless otherwise indicated, the anchors for the scale points are 1 = strongly disagree and 7 = strongly agree.

APPENDIX N: STUDY 3 PROBIT MODEL ON PRODUCT FORM CHOICE
Dependent Variable: Systems (=1); Components (=0)

Independent Variables	**Hyp**	**Main Model**
Key Hypotheses		
Modularity * Difficult to Enforce * Resources	+	0.09 (0.04)**
Complexity * Difficult to Enforce * Resources	+	0.06 (0.04)
Lower Order Effects		
Ease of Mix-and-Match (Modularity)		- 0.31 (0.11)**
Complexity		0.23 (0.10)**
Difficulty of IP Enforceability (Difficult to Enforce)		0.11 (0.12)
Firm's Product Development Resources (Resources)		0.09 (0.14)
Modularity * Difficult to Enforce		0.08 (0.05)
Complexity * Difficult to Enforce		-0.04 (0.06)
Modularity * Resources		-0.10 (0.09)
Complexity * Resources		0.15 (0.07)**
Difficult to Enforce * Resources		-0.06 (0.08)
Control Variables		
Log (Firm Sales)		0.35 (0.18)*
Log (Competitive Intensity)		-0.04 (0.16)
Industry Dummy for SIC35		0.19 (0.11)*
Industry Dummy for SIC36		0.04 (0.15)
Industry Dummy for SIC37		0.06 (0.23)
Constant		-1.72 (0.56)***
Wald χ^2(df)		33.07 (16)
Pseudo R^2		0.24
n		260

Standard Errors in parentheses.
***: $p < 0.01$; **: $p < 0.05$; *: $p < 0.10$

APPENDIX O: STUDY 3 SPLIT SAMPLE ANALYSIS FOR LOW AND HIGH RESOURCE REGIMES

Dependent Variable: Systems (=1); Components (=0)

Variables	**Low Resources Regime (n = 141)**	**High Resources Regime (n = 119)**	**Chow Test of Difference in Coefficients**
Modularity	-0.28 (0.13)**	-0.34 (0.11)**	-0.06 (0.17)
Complexity	0.16 (0.10)	0.39 (0.10)***	0.27 (0.11)**
Difficult to Enforce	0.10 (0.12)	0.04 (0.11)	-0.07 (0.14)
*Modularity * Difficult to Enforce*	0.05 (0.04)	0.17 (0.04)***	0.12 (0.06)**
*Complexity * Difficult to Enforce*	0.03 (0.04)	0.07 (0.06)	0.04 (0.08)
Constant	-2.67 (0.61)***	-1.48 (0.53)**	1.19 (0.67)
Wald χ^2 (df)	8.62 (5)	16.59 (5)	
Pseudo R^2	0.10	0.19	

Standard Errors in parentheses.
***: $p < 0.01$; **: $p < 0.05$;

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