



Does One Size Fit All? The Multiple Organizational Forms Leading to Successful Academic Entrepreneurship

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This paper offers an integrative theory, through the use of transaction cost theory principles, that attempts to match the attributes of university-held innovations with the specific organizational form that best supports the identified attributes in innovation commercialization efforts. Two commonly utilized organizational forms are considered: the spin-off and the technology license agreement. Additionally, innovation transfer is conceptualized as a transaction and each of the organizational forms is considered an alternate governance mechanism for the management of the commercialization transaction. It is further conceptualized that by minimizing transaction costs, through the proper selection of the organizational form, universities may increase the odds of successful revenue generation from their entrepreneurial efforts. The overall goal of the paper is to enhance our understanding of proper organizational form-innovation attribute alignment as a key driver of innovation commercialization success, so that universities and their industry partners can increase their effectiveness in commercialization activities.

Introduction

Universities in many regions around the world are being pushed to find alternative sources of funding to finance daily operations and research activities. One of the more promising sources for alternative funding is the commercialization of the university's research discoveries. As such, the role of the university is undergoing a transformation as their missions are being extended to incorporate a greater commercial orientation. The dual role of the modern academic mission now requires universities to not only serve society by educating students, but also to foster research that can be developed into commercially viable products and technologies (Kirby, 2005). Not surprisingly, the entrepreneurial movement within universities has been met with both enthusiasm and resentment as the scholarly community struggles with the ethical implications of such activities

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(Mowery, Nelson, Sampat, & Ziedonis, 1998). Despite philosophical objections, the entrepreneurial focus on innovation commercialization within research universities is an ongoing and growing reality as universities in the United States, Europe, Australia, and other developed nations face competitive funding pressures (Cano, 2007). This trend is highlighted by a recent report in *The Chronicle of Higher Education*, which informs that at least two dozen universities each earned more than \$10 million in fiscal year 2005 from licensing their rights to innovations developed through university research (Blumenstyk, 2007).

It would seem that the potential financial and economic benefits of university commercialization activities would be quite enticing to university and public policy administrators; however, university produced research is not currently flowing as quickly as it could to entrepreneurs and innovative companies who are eager to exploit new innovations. In fact, only a handful of universities consistently produce a steady stream of commercially viable innovations, and fewer still have a successful track record of working well with the business community in commercialization efforts (Schramm, 2006). Entrepreneurship researchers have recognized this trend, and as a result, have explored several issues related to the most commonly used commercialization avenues: the university spin-off and the technology license agreement (e.g., Agrawal, 2006; Shane & Stuart, 2002). A spin-off firm is an entirely new venture created solely for the purpose of commercializing the university's innovation, while a technology license agreement is a contract that gives outside entities the right to commercialize the university's innovation (Etzkowitz, 2000). In this paper, the term innovation is used to refer to any invention, new technology, idea, product, or process that has been discovered through university research that has the potential to be put to commercial use.

The widespread use of spin-off's and technology license agreements in university innovation commercialization activities has resulted in two separate, but highly related, streams of academic entrepreneurship literature, one focusing only on the technology license form and the other dealing only with the spin-off form (e.g., Agrawal, 2006; DiGregorio & Shane, 2003; Shane & Stuart, 2002; Thursby & Thursby, 2004). The outcome of these two distinct literature streams has been an increased understanding of the idiosyncratic issues associated with each form. However, the major disadvantage of this approach is that many universities utilize, or have the potential to utilize, *both* organizational forms in commercialization activities. Despite this limitation, a unified model that considers the differential effects of proper organizational form selection on the odds of commercialization success has not yet been introduced (Carlsson & Fridh, 2002). Hence, the purpose of this paper is to provide an integrative theory that identifies transaction costs as a major factor in the identification of the conditions under which one organizational form may be preferred over another for the commercialization of university-held innovations.

The theoretical model developed in this paper is based on an alignment principle that draws heavily on Williamson's (1981) Transaction Cost Theory (TCT) concept of asset specificity and opportunism, as well as on the work of Zander and Kogut (1995) who identify the attributes of innovation knowledge as codifiability, teachability, complexity, and system dependence. The Zander and Kogut innovation knowledge taxonomy provides a basis for the differentiation of innovations, while TCT allows the consideration of the costs associated with variations in the levels of asset specificity and the threat of opportunism that are a function of the attributes of the innovation. Thus, it is conceptualized that the knowledge associated with an innovation can be categorized according to its attributes and that these attributes directly impact transaction cost in commercialization activities. In this way, the magnitude of transaction costs becomes a key driver in the university's

selection of the appropriate organizational form for innovation commercialization. The theory also recognizes the idea that the proper selection of the organizational form leads to a reduction in transaction costs, and in so doing, increases the odds of commercialization success, which is defined as the generation of revenue for the focal university.

In addition to an integrative contribution, this perspective is also needed because it directly addresses another important deficiency within the literature. In a recent review of the academic entrepreneurship literature, O'Shea, Allen, O'Gorman, and Roche (2004, p. 22) note that, "many of the studies conducted to-date are based on theories that are actually atheoretical in nature, that is the research suggests relationships in the form of a model without providing a consistent explanation to account for those relationships. As a consequence, there is a need for more studies to systematically explain, from an organizational perspective, why some universities may be more successful than others." In keeping with this theme, the theory developed in this paper is based on the systematic logic of transaction cost theory. In this way, the paper represents a novel application of a well-developed organizational theory to explain relationships unique to the academic entrepreneurship context. The outcome of this application is not only the advancement of academic entrepreneurship theory, but also salient recommendations for the increased effectiveness of the practice of academic entrepreneurship. The paper is designed to generate insights, based on a normative model, for university technology transfer units, industry partners, commercialization-minded faculty members, and administrators. Such insights could be of value to these individuals, allowing them to evaluate the attributes of the innovation and associated transaction costs as an indicator of the organizational form that will best support the transfer of the innovation under development. Finally, it should be noted that in the process of developing the theory, a salient group of drivers that play an important role in the commercialization of university-held innovations are identified, as well as a set of potential organizational forms for commercialization. However, I do not pretend to have isolated all the variables or organizational forms that may impact university commercialization efforts.

Organizational Forms and Innovation Commercialization

In a broad sense, the term *organizational form* refers to the characteristics of an organization, or a set of organizing activities, that define it as a distinct entity and also identifies it as a member of a group of similar organizations (Romanelli, 1991). As such, this paper considers two distinct organizational forms for the commercialization of university-held innovations: the technology license agreement and the creation of a new spin-off firm. While there are many organizational forms that could potentially be utilized for the commercialization of university-held innovations, this paper considers only these two forms. The rationale behind the selection of these two forms is that these forms are widely accepted and utilized in global commercialization activities, which increases the generalizability and practical applicability of the developed theory (DiGregorio & Shane, 2003; Etzkowitz, 2000; Feldman, Feller, & Bercovitz, 2002; O'Shea et al., 2004; Thursby & Thursby, 2004). Although beyond the scope of this paper, an exploration of the potential applicability of additional organizational forms to the context of academic entrepreneurship is certainly a worthy theoretical endeavor. As such, the integrative model developed in this paper provides a foundation for the future exploration of the suitability of additional organizational forms in commercialization activities.

In the university innovation commercialization context, a spin-off firm is a completely new business venture that may be wholly owned by the university or created in

conjunction with outside investors (Shane & Stuart, 2002; Smilor, Gibson, & Dietrich, 1991); moreover, the faculty or staff of the originating university is usually heavily involved in new venture start-up activities (Feldman et al., 2002; O'Shea et al., 2004). Previous research has focused on the factors that contribute to the survival and success of university start-ups. For example, Saxenian (1994) discussed the influence of the founding university, while Shane and Stuart focused on the start-ups' social ties as an influential survival factor. Similarly, Holmstrom (1989) found that agency problems are less likely to become a factor in new ventures if the innovator is principally involved in the creation of the new firm.

The existing research on university spin-offs provides insights regarding the advantages associated with the use of this organizational form in commercialization activities. Principle among these is the form's ability to embed the innovator's tacit knowledge into the firm (Santoro & Bierly, 2006). This is important because previous studies of university spin-offs (Shane, 2001) assert that the form is more likely to succeed with the use of radical innovations, which are more likely to be highly tacit in nature. An innovation that is highly tacit in nature would require long periods of face-to-face learning in order to transfer the innovation knowledge to an outside entity. The required investment in learning by the university and the industry partner would be considered an asset-specific investment, which makes any disruption very costly for both parties. By imbedding the innovation knowledge into the firm, bilateral dependencies are greatly reduced. Therefore, the form's ability to effectively integrate tacit knowledge greatly reduces the transaction costs associated with the transfer of innovation knowledge. However, there are limitations associated with the spin-off form. The major limitations are the extensive resources required, difficulties achieving and maintaining innovator commitment, the lack of existing market ties, and the high-risk tolerance required (Nicolaou & Birley, 2003).

As an alternative to the creation of a new spin-off firm, many universities choose to commercialize their innovations via technology license agreements with entrepreneurs or existing firms (Carlsson & Fridh, 2002; Teece, 1986). Many existing firms base growth initiatives on rapidly changing technologies, the utilization of collaboration, and the use of property right protections, which has led to a proliferation of the technology licensing form in knowledge transfer activities (Kim, 2004; Kim & Vonortas, 2006; Powell, Koput, & Smith-Doerr, 1996). The incentive for a university to sell its technology to prospective partners is the revenue effect (Arora, Fosfuri, & Gambardella, 2001). The revenue effect is the returns that will accrue to the licensor in the form of licensing payments (i.e., a fixed licensing fee or continuing royalty fees) by licensees. The advantages, for universities, of technology licenses is a lower level of financial risk, greater speed to market, the ability to form relationships with multiple partners, and a high potential for long term revenue generation (Carlsson & Fridh; Zhao, 2004).

Of course, the use of the technology license agreement is not without its drawbacks. The major limitations of this form are the difficulties and complexities that result from imperfections in technology markets (Arora et al., 2001). As such, the factors that impact the success of university initiated license agreements have been recently explored (Benneworth, 2001; Thursby & Thursby, 2004). Agrawal (2006) conducted an empirical study exploring the effects of engaging the inventor on the success of technology license agreements. He reported that while engaging the inventor did affect success rates, less than half the firms that obtained a university-held license were able to successfully commercialize the innovation. Jensen and Thursby (2001) discovered that the majority of innovations licensed from universities are done so with the technology in a very early stage of development. These early stage innovations required substantial additional development in order to be successfully commercialized. Collectively, these studies indicate

that in order for a technology license agreement to hold a high potential for revenue generation, the innovation must be satisfactorily developed and the knowledge associated with the innovation must be organized (i.e., codified) in a way that makes it easily transferable.

Transaction Cost Theory and Innovation Commercialization

The previous organizational form discussion highlights the rather limited perspective that currently exists within the academic entrepreneurship domain. The majority of the existing research explores only one organizational form and looks at how outcomes can be improved within each form's independent domain. However, to the best of the author's knowledge, there has not been a focused consideration of the transaction cost associated with the transfer of university-held innovations to outside entities, such as entrepreneurs, existing firms, or university created spin-off firms. This research gap is most likely attributable to the fact that much of the existing literature treats the differential attributes of innovations as a black box or considers only a limited set of broad level dimensions, such as radicalness (e.g., Nekar & Shane, 2003). If there is little or no variation in the innovation and only one organizational form is considered, then there are no differential transaction cost issues (all transaction cost would be the same within that form). However, if this assumption is altered to more accurately reflect the true variable nature of innovations, the result is differential transaction costs both within and between each organizational form. Because the theory developed in this paper treats the characteristics of the innovation as a variable, TCT becomes the applicable theoretical paradigm and thus has been chosen as a foundation for the theoretical model developed in this paper.

TCT is an outgrowth of the seminal insights of Coase (1993) who identified the costs associated with using markets to govern economic exchanges. These insights have been further developed through the works of economist Oliver Williamson (1975, 1981, 1991), who emphasized that organizations seek to minimize the coordination costs accrued in economic exchanges with other organizations. As a result, the need to manage economic exchanges, or what is commonly referred to as transactions, becomes a major determinate of structural configurations in organizations (McKinley & Mone, 2003). A transaction is defined as occurring when a good, service, or knowledge is transferred across technologically separable interfaces (Williamson, 1981). In keeping with this definition, it is conceptualized that the university-industry innovation transfer is a transaction; furthermore, it has been argued that the key dimensions along which transactions differ is the degree of asset-specific investments required for the transaction and the threat of opportunistic behavior by transaction partners (Hill, 1990; Williamson & Ouchi, 1981).

The level of asset specificity required for transactions has been identified by Williamson (1981, p. 555) as "the most important dimension for describing transactions." Asset specificity deals with problems that arise when transaction partners make investment in site-specific assets, physical assets, or human assets that have a substantially lower value outside of the specific transaction relationship (Williamson, 1975). Essentially, asset-specific investments become sunk cost because they could not be as effectively utilized outside the specific transactional context. Thus, asset-specific investments create a dependency relationship that gives rise to a greater chance of opportunism. TCT posits that when asset specificity is high, the transaction should be moved from the market and brought under firm control. In the context of university-industry innovation transactions, this means that the drivers of asset specificity become an important consideration. Thus, it is conceptualized that the level of asset specificity required for successful innovation

commercialization is directly related to the attributes of the innovation being commercialized. In this way, TCT logic suggests that the innovation commercialization process should begin with a focus on the attributes of the innovation, which determines the level of asset specificity required, which in turn drives the selection of the appropriate governance mode (i.e., organizational form) for the commercialization of the innovation.

The second key dimension along which transactions differ in TCT is the threat of opportunistic behavior by the transaction partners (Williamson & Ouchi, 1981). Williamson (1981, p. 554) identifies opportunism as “self interest seeking with guile.” This might include such behaviors as lying, withholding or hiding valuable information, or other forms of prevarication. While the theory does not assume that all economic actors will conduct themselves in an opportunistic manner, it does contend that the potential is always present, and therefore it is a hazard that threatens the reliability of economic transactions. It is important to note the interaction effects between asset specificity and the threat of opportunism. The theory posits that the threat of opportunism is always there, but if asset specificity is low, it is not a problem because one can simply walk away from the transaction and readily find a new transaction partner. However, if the level of asset specificity is high, then the exchange partners experience a bilateral dependency and the threat of opportunism becomes much more problematic. In this case, transaction-specific investments mean that any opportunistic behavior that disrupts the transaction will require agents to engage in the difficult process of reallocating assets to the next best exchange relationship, where those assets are likely to have a much lower value. As such, TCT argues that when asset specificity is high markets “fail” and the transaction should be brought under firm control where any disputes regarding opportunistic behavior can be resolved by managerial fiat.

Differential levels in asset specificity and opportunism result in concerns over the way in which transactions are governed. Thus, TCT suggests that some transactions will be more cost effectively managed through arm’s-length purchases while others will be more effectively handled through integration into the firm. Williamson’s (1981) original conceptualization of TCT asserts that when asset specificity and the threat of opportunism are high, the transaction should be conducted using hierarchical governance, which means bringing the transaction within the boundaries of the firm. Alternatively, if the level of asset specificity and the threat of opportunism are low, then the transaction should be managed using market governance, which is the use of arm’s-length transactions with outside parties (Williamson, 1981). Since its original conceptualization, the theory has been revised to also include a hybrid form of governance. Hybrid governance mechanisms are ways of governing transactions that are neither pure market nor pure hierarchy (Williamson, 1991). Williamson (1991) describes hybrid governance as more elastic than pure hierarchal governance, but more legalistic than pure market governance. An example of hybrid governance is the application of inter-organizational trust as an effective governance mechanism for certain types of transactions (e.g., Reuer & Ariño, 2007). In this case, the transaction may be managed through a combination of contracts and trust-based agreements. In this way, the transaction would be managed by a hybrid form of governance.

The application of TCT to the academic entrepreneurship context leads to the conceptualization that spin-offs and technology license agreements can be considered alternate forms of governance. Admittedly, these organizational forms are neither pure market nor pure hierarchy forms of governance; rather they more closely resemble a hybrid form of governance. However, these two organizational forms are quite different in their ability to govern transactions with differential levels of asset specificity and opportunism concerns. The creation of a spin-off firm provides the university with a greater degree of

control over large asset-specific investments and related threats of opportunistic behavior. In contrast, the university's use of a technology license agreement makes the oversight and control of the issues associated with large transaction-specific investments much more difficult. Thus, conceptually speaking, each of these organizational forms fall at very different ends of the governance spectrum, with spin-off's falling closer to hierarchal governance and technology licenses falling closer to market governance. Because TCT posits that governance structures should be matched to the transaction in a way that minimizes the cost of managing the exchange, it is further conceptualized that the innovation commercialization transaction should be managed with the appropriate governance mechanism, which in this case is the organizational form. Following this logic, the differential characteristics of the transaction then become the source of variance in governance structures. However, each transaction is uniquely characterized by the level of asset specificity and the threat of opportunism, which are a function of the attributes of the innovation being commercialized. Thus, the variance in the governance structures between technology license agreements and the creation of a spin-off firm is (or should be) determined by the attributes of the innovation and the resultant transaction cost considerations.

Differential Attributes of Innovations

One of the key elements of this paper is the consideration of variation in innovation characteristics. As such, the theoretical model developed in this paper must consider the key dimensions along which innovations differ. However, this is a difficult task because innovations have been described, operationalized, and measured along many different dimensions in previous conceptual and empirical work (Downs & Mohr, 1976; Gopalakrishnan & Damanpour, 1997; Zander & Kogut, 1995). Hence, there is no formally agreed upon approach to the classification of innovations (Morris, Coombes, Schindehutte, & Allen, 2007). However, the work of Rogers (1980) is often cited as a significant contribution in this area. Rogers identified five dimensions on which innovations can be described: relative advantage, communicability, observability, complexity, and compatibility. The conceptualization of these innovation dimensions was subsequently refined by Winter (1987) and then adopted in a 1995 empirical study by Zander and Kogut. In this work the authors operationalize the work of Rogers and Winter by identifying, defining, and measuring five innovation differentiating constructs: codifiability, teachability, complexity, system dependence, and product observability.

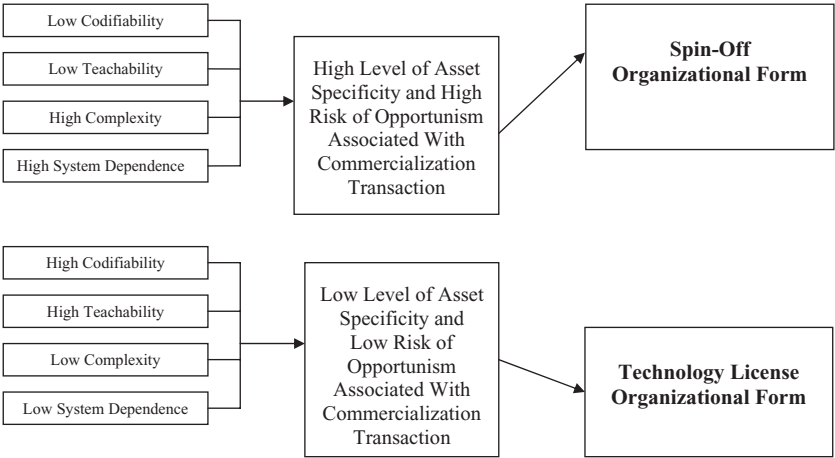
Zander and Kogut's (1995) five innovation attributes have been demonstrated to play a key role in the transfer and diffusion of innovation knowledge (Nieto & Perez-Cano, 2004; Roberts, 2000; Rogers, 1980; Kogut & Zander, 1992). Moreover, these attributes capture many of the different aspects that other researchers have used to differentiate innovations. For example, the differentiating characteristic of radical versus incremental innovations has been adopted in previous entrepreneurship and management studies (e.g., Damanpour & Gopalakrishnan, 2001; Nekar & Shane, 2003). While the adoption of these types of dimensions has proven to be theoretically useful, they have not been operationalized in a manner that provides a fine grained differentiation of innovations, which is a requirement for the theory developed in this paper. Alternatively, the Zander and Kogut framework provides dimensions that have been operationalized in a more precise and consistent manner. This allows for a more detailed conceptualization of the variation in innovations. The main advantage of this approach is the development of propositions that provide not only conceptual guidance, but also practical recommendations for the practice

of academic entrepreneurship. The major limitation of this approach is that there may be additional characteristics of innovations that are not captured by these five attributes. Despite its limitations, the Zander and Kogut framework offers a method of innovation differentiation that captures many of the salient dimensions of innovations and is highly applicable to the context of academic entrepreneurship, hence, the adoption of the framework in this paper.

It should be noted that the construct of product observability will not be considered in the development of the theoretical model. The product observability construct is not a direct outcome of the original conceptual work conducted by Rogers (1980) or that of Winter (1987). Rather, the dimension was developed by Zander and Kogut (1995) as an indicator of imitability. The degree of imitability was an important consideration for their study, as it focused specifically on the transfer of knowledge associated with manufactured products. In that context, reverse engineering issues are a key concern in the dissemination of product innovation knowledge and contribute heavily to the *involuntary* transfer of knowledge. However, in the academic entrepreneurship context and more specifically the context of the issues addressed in this paper, the focus is on voluntary innovation knowledge transfer only. Each of the other four dimensions of the framework speak directly to voluntary knowledge transfer whereas the product observability dimension focuses on involuntary knowledge transfers. In fact, Zander and Kogut (p. 79) implicitly state, “product observability is important for imitation by reverse engineering, but should not be important for voluntary capability transfer.” Another important consideration is that the theory developed in this paper is not focused on manufactured products as its sole domain. Rather, it is applicable to a wide variety of innovations. In short, the product observability dimension was created with a specific context in mind and thus does not generalize well. For this reason, the product observability dimension is considered to be limited in its applicability to the academic entrepreneurship context and specifically the theory developed in this paper; consequently, it has not been considered in the development of the theoretical model, which is illustrated in Figure 1.

Figure 1

TCT Based Model of Innovation Commercialization



Codifiability

The first innovation differentiating attribute considered in the model is codifiability. The codifiability of innovation knowledge is the extent to which a given knowledge item can be reduced to information by means of numbers, formulas, drawings, or words. Based on the degree of codifiability, two knowledge categories have emerged: explicit knowledge and tacit knowledge (Grant, 1996). The former category, explicit knowledge, is completely articulated and decipherable. Explicit knowledge is easy to transfer to others because it exists independent of the person. Examples of explicit knowledge transfer are the use of accounting information or statistical reports. In contrast, tacit knowledge can not be reduced to information and therefore can not be codified (Lane & Lubatkin, 1998). The body of tacit knowledge includes all things that one knows how to do, but can not articulate into words. Tacit knowledge is knowledge that arises as the result of personal experience, which makes it inherently difficult to transfer. Thus, tacit knowledge is often transferred by actually performing the knowledge related task. Examples of tacit knowledge transfer are the use of mentorship or apprenticeship programs.

The fundamental differences between codifiable and tacit knowledge means that there are very different requirements for the effective transfer of each type of knowledge. Codifiable knowledge is relatively easy to transfer and requires very little, if any, face-to-face interaction whereas tacit knowledge transfers require long periods of face-to-face contact and specialized training programs. As such, the codifiability of the knowledge associated with a university-held innovation is a key determinate of the type of commercialization transaction required for successful knowledge transfer. In short, the degree to which innovation knowledge can be codified determines how easily the knowledge can be transferred. This includes conveying the innovation knowledge to technology transfer offices and intellectual property right granting agencies. So, in the case of a highly tacit and difficult to codify innovation, it will be difficult to gain effective property right protection that captures the nuances of the tacit innovation and it will also be very difficult to transfer the knowledge to an outside entity. Alternatively, highly codifiable innovations that are based on explicit knowledge are much more likely to receive effective isolating mechanisms in knowledge transfer agreements. Patents, trademarks, and copyrights are all examples of isolating mechanisms that are commonly used in the commercialization process.

Interestingly, TCT authors have directly addressed the relationship between the effectiveness of isolating mechanisms and the mode of transaction governance. More specifically, it has been asserted that firms prefer market governance when isolating mechanisms are effective and hierarchal governance when they are not (Nieto & Perez-Cano, 2004). This means that transactions involving highly tacit innovation knowledge, which results in less effective isolating mechanisms, would be more effectively commercialized within firm boundaries. The model developed in this paper suggests that keeping this type of transaction within the university's boundaries would be achieved via the creation of a new spin-off firm. In contrast, transactions involving innovation knowledge that is more codifiable, which results in stronger isolating mechanisms, would be more effectively commercialized outside of university boundaries. As such, the TCT-driven model developed in this paper suggests that this type of transaction would be most effectively managed by a technology license agreement with an outside party.

In addition to the isolating mechanism problem, the innovation attribute of codifiability also drives the level of investment required to transfer the innovation knowledge

across the interface. Highly codified innovations would require both parties to make relatively small investments in the knowledge transfer process. Alternatively, innovations that are highly tacit in nature would require heavy investments in the knowledge transfer process, because the transfer of tacit knowledge requires human resource intensive learn-by-doing processes with large amounts of face-to-face contact. In TCT terms, highly tacit innovation transfers will require substantial asset-specific investments. Large asset-specific investments also lead to a greater threat of opportunism. As such, TCT logic predicts that the costs associated with a high asset-specific transaction are minimized when the transaction is brought under firm control, which is achieved via the spin-off organizational form. In contrast, innovations that are more codifiable in nature would be associated with lower levels of asset specificity and smaller threats of opportunism. TCT asserts that this type of transaction is best conducted outside the boundaries of the firm. As such, the transaction costs associated with the commercialization of codifiable innovations would be minimized within the technology license organizational form.

By integrating the innovation attribute of codifiability into the TCT framework, we see that there is a relationship between the codifiability of innovation knowledge and the choice of the governance mechanism used for the commercialization transaction. Proper selection of the appropriate organizational form results in lower transaction costs for the innovation transfer, which in turn increases the potential for greater revenue generation for the focal university. In this way, an increase in the odds of revenue generation is achieved with the proper match between the innovation attribute of codifiability and the appropriate organizational form as highlighted by the following propositions:

Proposition 1a: Highly codifiable (explicit) innovations have a greater revenue generating potential when commercialized through the creation of technology license agreements.

Proposition 1b: Difficult to codify (tacit) innovations have a greater revenue generating potential when commercialized through the creation of a spin-off firm.

Teachability

The next important innovation attribute explored is teachability. Teachability is the extent to which workers can be trained in schools or on the job and reflects the training of individual skills (Zander & Kogut, 1995). This attribute concerns the feasibility of communicating an item of technological knowledge (Winter, 1987). At first glance, it would seem that teachability and codifiability may be interdependent. However, these two dimensions of innovation knowledge are conceptually and empirically distinct. That is, each dimension captures a different aspect of the innovation knowledge transfer phenomenon (Nieto & Perez-Cano, 2004; Roberts, 2000; Rogers, 1980; Zander & Kogut). Conceptually, the independence of these constructs is represented by the idea that teachability and codifiability can move at differential rates. If the level of codifiability goes up, the level of teachability may also increase, but not necessarily at a proportional rate. For example, let us say that a university researcher has found a new way to formulate biofuel. Initially, the new formulation method is highly tacit in nature. Because the researcher wants to publish the outcome of his efforts and the university wants to seek property right protection, the researcher begins the process of documenting the steps and identifying the compounds used to formulate the new fuel. At the end of this process, a significant portion of the innovation knowledge has been codified.

If we go on to assume that the process and compounds described in the example above are new to the commercial sector, and the university wants to transfer the innovation to an

industry partner, then the industry partner's research team would have to be taught how to replicate the new fuel. The knowledge required is mostly codified, but a portion is still tacit. Since the process and compounds used are cutting edge, the recipient is unfamiliar with the innovative techniques and the codified knowledge cannot be readily assimilated. Thus, the resources required to teach the innovation to the industry partner are likely to be extensive. In this case, the availability of the codified knowledge may very well increase the teachability of the innovation, but the rate of that increase is proportionally small compared to the relatively high level of codifiability associated with the innovation. In this way, codifiability may (or may not) increase teachability and the ratio of that increase is dependent on additional factors, such as the complexity of the knowledge and the degree of prior related knowledge held on the receiving end; consequently, the teachability and codifiability dimensions are related, but independent dimensions of innovation knowledge.

The fundamental difference between innovations that are highly teachable and those that are less so, leads to very different requirements for the effective transfer of the knowledge. Highly teachable knowledge is relatively easy to transfer and requires only periodic face-to-face interaction whereas transactions involving difficult to teach innovation knowledge would require long periods of face-to-face contact and specialized training programs. As such, the teachability of the knowledge associated with a university-held innovation is a key determinate of the type of commercialization transaction required for successful knowledge transfer. If the university's innovation knowledge is highly teachable, it means that it can be more easily transferred across the interface to an existing firm. There would likely be only a small investment in teaching and learning resources by the university and its potential industry partners. Thus, the level of asset specificity required for the transfer of a highly teachable innovation would be relatively low. TCT suggests that the transaction cost would be minimized by using an arm's-length transaction, which in this case is the use of a technology license agreement. Alternatively, if the innovation knowledge is less teachable, then the commercialization transaction is likely to require major resource commitments to the teaching and learning process. As such, the level of asset specificity would be relatively high, resulting in a greater threat of opportunism. In this case, TCT asserts that the transaction costs related to the commercialization of this type of innovation would be lowest when managed within the firm via the creation of a university spin-off.

By integrating the innovation attribute of teachability into the TCT framework, we see that there is a relationship between the teachability of innovation knowledge and the governance mechanism used to effectively manage the commercialization transaction. Proper selection of the appropriate organizational form results in lower transaction cost for the innovation transfer, which in turn increases the potential for greater revenue generation for the focal university. In this way, greater odds of revenue generation are achieved when there is an optimal match between the innovation attribute of teachability and the appropriate organizational form as highlighted by the following propositions:

Proposition 2a: Highly teachable innovations have a greater revenue generating potential when commercialized through the creation of technology license agreements.

Proposition 2b: Difficult to teach innovations have a greater revenue generating potential when commercialized through the creation of a spin-off firm.

Complexity

Complexity is the next innovation attribute considered in the model. Complexity is the differential variation that results when different kinds of knowledge and competencies are combined. Zander and Kogut (1995, p. 79) assert that, “knowledge, no matter the level of the education of the worker, is simply more complex when it draws upon distinct and multiple kinds of competencies.” In simple terms, complexity captures the number of distinct skills or competencies required to apply the new knowledge. As such, innovations that are of a simple nature would require few distinct skills or competencies to be effectively transferred. In this case, the number of existing firms that would have the ability to integrate and exploit the innovation knowledge is likely to be great. Additionally, the university and its innovation transfer partner would not have to make large investments in developing distinct competencies for the transfer and commercialization of the university-held innovation. Therefore, the level of asset-specific investment required for the transfer of an innovation with low levels of complexity would also be low. TCT posits that in this situation the threat of opportunism is well controlled and the market is the best place for this type of transaction. In the developed model, the technology license form most closely represents market-based transactions, and thus, would be the recommended form for commercialization.

The commercialization path for innovations that are complex in nature, meaning many distinct competencies are required for successful transfer, is likely to look very different from the less complex innovations identified above. Complex innovations are much more difficult to transfer across the university-industry interface. When the innovation is complex, the distinct competencies or unique combination of competencies may not be held by any existing firm. For example, Cohen and Levinthal (1990) have shown that the transfer of innovation knowledge is dependent upon the degree of research and development (R&D) knowledge overlap between exchange partners. As such, a complex university developed innovation that may be radical and cutting edge, may have very little overlap with the R&D knowledge that is possessed by existing firms. The new innovation may also have very little in common with an existing firm’s product or service offerings, its marketing competencies, or its established distribution channels. In this case, the university and its external partner would have to make tremendous investments in developing the firm’s skills and competencies if the innovation is to be successfully transferred. A commercialization transaction of this nature would be characterized by its high level of asset specificity and a corresponding high threat of opportunism. TCT tells us that these types of transactions should be brought under firm control, which in this case is the creation of a new spin-off firm. The advantage of using the spin-off when complexity is high is the firm’s ability to embed knowledge into the new firm. If the researchers responsible for the development of the innovation are heavily involved in the creation of the new firm, the requisite skills and competencies become a readily available resource for the firm. In this way, the spin-off form effectively reduces the transaction costs associated with the transfer of an innovation that is characterized by high levels of complexity.

As highlighted above, the level of complexity associated with a university-held innovation has strong implications for the commercialization of university-held innovations. If the level of complexity is low, then existing firms are likely to possess the necessary skills and competencies required to commercialize the innovation, meaning a technology license agreement, is quite suitable. However, if the innovation is complex, then the necessary bundle of competencies is not likely to be held by existing firms and these competencies would need to be developed. However, the development of the required competencies within an existing firm would require a heavy investment and

represent a high risk of opportunism for the university. Thus, the creation of a new spin-off firm is likely to produce the greatest opportunity for revenue generation for complex innovations. Collectively, the effects of innovation complexity on the selection of the proper organizational form for innovation commercialization are reflected in the following propositions:

Proposition 3a: Innovations with a low level of complexity (requires few distinct competencies) have a greater revenue generating potential when commercialized through the creation of technology license agreements.

Proposition 3b: Innovations with a high level of complexity (requires many distinct competencies) have a greater revenue generating potential when commercialized through the creation of a spin-off firm.

System Dependence

The final differentiating innovation attribute is system dependence. System dependence is the degree to which a capability is dependent upon many different experienced individuals or groups of experienced individuals for its production (Zander & Kogut, 1995). It reflects the extent to which new knowledge is dependent upon the knowledge possessed by different individuals or groups within or outside the organization. In the industry setting, system dependence has been illustrated as a case where a new product is developed through collaboration between a subcontractor and employees in different departments. In the university setting, one could visualize a similar type of situation. An example would be an innovation that was developed through the collaborative efforts of several research scientists and a group of research assistants. Each individual may contribute a specific knowledge or skill that is required for the successful production of the new innovation. In this case, the innovation would have relatively high system dependence. Alternatively, a brilliant individual researcher may develop a new innovation primarily through their own research efforts, and thus the innovation would be much less system dependent than in the first example. In addition to the human capital aspect, system dependence could be a function of specialized equipment or unique technologies that are held by the university and are necessary for the production of the innovation.

Here again, concerns over the interdependence of system dependence and complexity dimensions may be raised. However, these two dimensions of innovation knowledge are conceptually and empirically distinct, in that each dimension captures a different aspect of the innovation knowledge transfer phenomenon. It has been conceptually argued and empirically demonstrated that the level of system dependence and the level of complexity can vary independently (Nieto & Perez-Cano, 2004; Roberts, 2000; Rogers, 1980; Zander & Kogut, 1995). Take, for example, a single researcher that possesses many different unique skills and competencies, which enable the development of a new innovation. In this case, the innovation is likely to be high in complexity, but low in system dependence. Alternatively, an innovation may be developed by a lead scientist and a large group of research assistants. In this case, the innovation relies on only a few distinct competencies, but requires a tremendous amount of lower skilled manpower. As such, this type of innovation would be characterized by its low level of complexity, but high level of system dependence. Both examples highlight the idea that system dependence and complexity may vary at rates that are not directly proportional. In this way, system dependence and complexity are related, yet distinct dimensions of innovations.

System dependence is an important consideration in the commercialization transaction. For the level of system dependence to be low, there would be few individuals or

departments involved in the innovation transfer process and there would also be a limited need for specialized equipment. These characteristics make transaction coordination for the university and its industry partner much easier and less costly. The less system dependent the innovation; the easier it is to transfer the innovation knowledge (Nieto & Perez-Cano, 2004), which means that the level of asset-specific investment required for a successful transaction is likely to be low. As previously discussed, TCT argues that in this situation, the threat of opportunism is minimal and the transaction is best governed outside firm boundaries, which is the use of the technology license organizational form in the theoretical model.

Alternatively, when the level of system dependence is high, the transfer of innovation knowledge becomes more difficult. The collection of individuals or unique technologies required for the production of the innovation must be assembled and coordinated for effective knowledge transfer. This may prove especially problematic in the academic environment where researchers are used to a culture of autonomy. Thus, the university will have to invest heavily in coordination and incentives to facilitate the knowledge transfer, and the industry partner will have to invest in an equally extensive system for effective assimilation of the innovation knowledge. The involvement of multiple individuals, especially the involvement of multiple departments from the university and the industry partner raise the stakes for the transaction in the form of high levels of asset specificity and a high threat of opportunism. As such, TCT asserts that this type of transaction is best managed within firm boundaries, which is the creation of a new spin-off firm in the theoretical model.

The innovation attribute of system dependence is a key consideration in the selection of the appropriate organizational form for the commercialization of university-held innovations. When the level of system dependence is high, there is likely to be a high level of investment in coordination and learning for the successful transfer of the innovation across the interface. In contrast, when system dependence is low, the transfer of the innovation is likely to be less problematic and would require far fewer investments in coordination and learning. Thus, the level of system dependence is a key factor in determining the level of asset-specific investments required for the innovation transfer, and in turn, the level of asset specificity determines the selection of the organizational form. The relationship between the level of system dependence and the selection of the organizational form is highlighted in the following propositions:

Proposition 4a: Innovations with a low level of system dependency will have a greater revenue generating potential when commercialized through the creation of technology license agreements.

Proposition 4b: Innovations with a high level of system dependency have a greater revenue generating potential when commercialized through the creation of a spin-off firm.

Conclusions and Implications

The overall goal of this paper is to enhance our understanding of proper organizational form—innovation attribute alignment as a key driver of innovation commercialization success, so that universities and their industry partners can increase their effectiveness in commercialization activities. To that end, transaction cost theory principles have been utilized to identify some of the conditions under which the proper selection of specific organizational forms, as driven by the attributes of the innovation and the level of

asset-specific investments required, may increase the odds of revenue generation in the commercialization of university-held innovations. Four distinct attributes of innovations have been identified as key determinates of transaction costs in commercialization transactions. The result of this theoretical effort is a set of propositions that identify the relationship between each innovation attribute, the level of asset specificity, and the selection of the appropriate organizational form. The proper alignment of these factors leads to a minimization of transaction costs, and in so doing increases the odds of success in university innovation commercialization efforts. The propositions and the associated theoretical arguments certainly do not capture all of the possible drivers of success in the innovation commercialization process, nor do they capture all of the possible organizational forms that may be considered for the commercialization of university-held innovations. However, they are intended to address some of the more salient issues associated with the organizational forms that universities most heavily utilize as they begin to view the outcomes of their research efforts in a more entrepreneurial way.

Research Implications

Academic entrepreneurship and technology transfer studies have advanced our understanding of innovation commercialization activities, but have done so primarily by examining the independent factors that affect performance outcomes in the creation of spin-off firms or the formation of technology licensing agreements (Agrawal, 2006; Nekar & Shane, 2003; Thursby & Thursby, 2004). This research departs from this approach to consider an integrative perspective that examines the conditions under which each organizational form is most appropriate. Moreover, transaction cost implications have been absent in the discussion regarding university innovation commercialization activities, which is a deficiency also directly addressed in this theoretical endeavor. As such, this paper provides a conceptual model and an associated set of propositions that effectively integrates transaction cost considerations and the unique attributes of the innovation as drivers of the selection of the appropriate organizational form for the commercialization of university-held innovations. One important implication of the theory is that determinates of successful outcomes in commercialization efforts are likely to include transaction cost considerations. Since these determinates demonstrate (1) interactive relationships between the attributes, (2) the level of asset-specific investment, (3) the probability of opportunistic behavior, and (4) the idiosyncrasies of each organizational form, it is unlikely that theorists can produce a more complete explanation of innovation commercialization activities by considering independent variables along one dimension or in the context of one organizational form.

The theory developed in this paper is intended to stimulate future research as we begin to conceptually move beyond the factors that affect performance in each organizational form and begin to consider the differential effects of proper organizational form selection. If the form selected for innovation commercialization is incompatible with the attributes of the innovation, then the odds of success are unnecessarily reduced. The theory developed in this paper reminds researchers that the organizational form is not an arbitrary artifact. Rather, it should be evaluated as an important choice, or in some cases a research assumption, that has significant theoretical and practical implications. Following this argument, future research should explore the possibility that additional organizational forms could be employed in the commercialization of university-held innovations. For example, joint ventures, an organizational form commonly utilized for research and development efforts in industry, could be explored as a viable organizational form in the university innovation commercialization environment.

It is also important to consider that this paper has not specifically addressed issues related to the amount of capital required, the role of the innovator, the impact of the external environment (i.e., industry or market factors), or the impact of administrative regulations in the selection of the organizational form chosen for commercialization. While there is literature exploring some of these issues, minus a specific focus on the organizational form or within the context of one form or the other independently (Agrawal, 2006; Benneworth, 2001; Chrisman, Hynes, & Fraser, 1995; DiGregorio & Shane, 2003), there is still much work to be done to integrate these issues into a more complete model of organizational form selection. As such, these issues provide numerous opportunities for future conceptual and empirical research in our efforts to increase our understanding of the drivers of success in the commercialization of university-held innovations.

Practical Implications

From the university and industry perspective, this paper provides some practical insights regarding the selection of the appropriate organizational form for the commercialization of university-held innovation. For example, the theory developed in this paper suggests that innovations that are very difficult to codify would result in a heavy investment by both partners in innovation learning during the transfer process. As a result, the high level of transaction-specific investments indicates that the university would be best served by governing this transaction with the creation of a spin-off firm. Likewise an innovation that can be easily codified is likely to involve a much lower level of investment in innovation learning in order to successfully transfer the innovation to an existing firm. In this case the university would be best served by governing this transaction via a technology license agreement.

Similar to the above discussion on the innovation attribute of codifiability, each of the developed propositions have direct practical implications for universities and their industry partners in the selection of the appropriate organizational form for commercialization efforts. Specifically the model suggests that technology transfer offices and potential industry partners should ask the following questions regarding each innovation commercialization transaction:

1. Can the knowledge associated with this innovation be codified (i.e., manuals, articles, video instruction, computer models, or other similar methods)?
2. How easily can the knowledge associated with this innovation be taught to an industry partner (will learning require intense close personal contact or practical hands-on training)?
3. What is the level of complexity associated with this innovation (how many different skills or competencies are required to assimilate the innovation knowledge)?
4. How system dependent is the innovation (how many individuals or groups of individuals are required to successfully produce this innovation)?

The key to success is the university and its potential industry partner's ability to recognize the attributes of the innovation and the governance advantages of each organizational form and use them to create a solid match between the innovation and the organizational form, as reflected by the propositions.

Overall, if universities are going to engage in entrepreneurial activities, they should consider the complexities, and associated transaction costs, that idiosyncratic innovation attributes create. As such, they should consider the different organizational forms

available for commercialization and seek to avoid an arbitrary predisposed disposition toward one organizational form. In addition, they should work to ensure that each innovation is commercialized using the organizational form that allows transaction costs to be reduced to the lowest possible level. Ultimately, the reduction of costs associated with the proper management of asset-specific investments and the threat of opportunism in the innovation transaction greatly increases the likelihood that the goal of revenue generation will be achieved. Finally, universities and potential industry partners should understand that achieving the successful commercialization of university research is a very difficult and risky endeavor; however, proper organizational form selection provides a higher probability of success in these endeavors, as suggested by the propositions developed in this paper.

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