THREE ESSAYS ON ENTREPRENEURSHIP: THEORY, MEASUREMENT, AND ENVIRONMENT

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by

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THREE ESSAYS ON ENTREPRENEURSHIP: THEORY, MEASUREMENT, AND ENVIRONMENT

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ABSTRACT

This dissertation identifies three sets of issues regarding entrepreneurship research and addresses them correspondingly in three separate but related essays. The first issue is about the economic basis in which the role or function of entrepreneurship can be explained from the perspective of economic theory; and it is the subject of *Essay One* of this dissertation. The second issue concerns finding new ways to select appropriate measures of entrepreneurship and is the objective of *Essay Two*. The third issue regards the empirical test of hypotheses on regional environmental factors that may be important to promoting the emergence and performance of entrepreneurship and is the main purpose of *Essay Three*.

In *Essay One*, while questioning the conventional wisdom that economic transactions are either coordinated by the market price mechanism or directed by the authority of the firm, I argue that there exist economic transactions that do not totally

conform to these two alternative means of governance. Specifically, the exchange of information and knowledge for innovative production, in many circumstances, is neither governed by the price mechanism nor controlled by the authority of the firm because the exchange, utilization, or production of information and knowledge takes place inside the human mind. I term such exchanges *hidden transactions*. Considering entrepreneurship as the intrinsic force that initializes the hidden transactions, I further argue that firms, social networks, and institutions such as freedom and equal access to education which facilitate and enlarge hidden transactions are important to entrepreneurial and economic development.

In *Essay Two*, by classifying entrepreneurship as *conceiving entrepreneurship* and *performing entrepreneurship*, I argue that while conceiving entrepreneurship as ideas of doing business is largely unobservable performing entrepreneurship as actual execution of these ideas can be reasonably measured by tracing the trail or footsteps of entrepreneurs. This essay demonstrates that multiple indicator measures of performing entrepreneurship (in the case of technology entrepreneurship) can be chosen plausibly by using the confirmatory factor analysis under the framework of latent-variables modeling.

Essay Three focuses on empirical investigation of regional factors that promote technology entrepreneurship. Although the entrepreneurial vision is a unique individual phenomenon, the fact that entrepreneurial activities are geographically concentrated suggests that there must be something in the region facilitating the emergence of entrepreneurship. By defining what is termed “an entrepreneur’s opportunity set,” the study hypothesizes that performing entrepreneurship depends on the opportunity set that the region provides to entrepreneurs. A full structural equation with latent variables

model is proposed and described, but because of inadequate information and the requirement of large sample size, an OLS model is alternatively employed for empirical testing of hypothesis.

Important policy implications can be drawn from this dissertation in terms of entrepreneurial development in the age of technology and globalization.

INTRODUCTION TO THE THREE ESSAYS

Throughout human history, entrepreneurs have been the most active players in areas of technological, economic, and social development. Since Richard Cantillon's 1755 work, *Essay on the Nature of Commerce in General (Essai sur la Nature du Commerce en general)*, the words, "entrepreneur" and "entrepreneurship" have been increasingly used in the economics and business literature. Today, entrepreneurship research involves many disciplines such as economics, management, cognitive science, and sociology. Acknowledging that there are distinct objectives and approaches of entrepreneurship research in these fields of study, this dissertation research mainly addresses the problems of entrepreneurship research from the perspective of economics.

In the economics literature, many characterizations of entrepreneurs and explanations of the roles or functions of entrepreneurship can be found. Nevertheless, there is no consensus and no clearly agreed upon economic theory of entrepreneurship. Such ambiguity in the understanding of entrepreneurship can be mainly ascribed to the dynamic and complicated nature of entrepreneurship. Consequently, there are many unresolved issues in entrepreneurship research. In this dissertation, I identify the following three sets of research problems and address them respectively in three related essays.

The first set of problems concerns the economic theory of entrepreneurship. It is commonly known that entrepreneurs perform very important economic functions. However, contemporary economic theory has largely neglected entrepreneurship. Despite some serious theoretical inquiries such as Schumpeter (1912, 1934), Knight (1921), and Mises (1949), entrepreneurship research has not been in the central stage of mainstream economics. That is, it is unclear where entrepreneurs should stand in economics or what is the economic basis in which the role of entrepreneurship can be logically explained. In *Essay One* of this dissertation, *Hidden Transactions, Entrepreneurship, and Economic Development*, I argue that the economic basis of entrepreneurship can be explained in the process of innovative production, in which individual entrepreneurs play a pivotal role in initializing the exchange of information and knowledge, thus, the reallocation of resources. In this theoretically orientated essay, while recognizing that the production and utilization of knowledge initially take place inside the individual human mind, I question the conventional wisdom that economic transactions are governed either by the price mechanism or by the authority of the firm. I point out that the market price mechanism and the authority of the firm, in many circumstances, may not be the ultimate governing forces of the allocation of resources because of existence of types of economic transactions that take place outside the market price mechanism and the authority of the firm. I term them *hidden transactions*, which largely consist of the exchanges of information and knowledge among individuals.

The underlying reason for the existence of hidden transactions is that the knowledge or innovative production takes place essentially inside individual minds, and individuals' willingness, desire, and action to initialize the exchange of information and knowledge constitute what is called entrepreneurship. As the role of individual entrepreneurship in initializing hidden transactions is realized, in the essay, I also argue that firms, social networks, and institutions such as freedom and equal access to education which could facilitate and enlarge hidden transactions are critical to the emergence of entrepreneurship, and thus, economic development.

Second, while many studies have attempted to define entrepreneurship from different perspectives, economists have been struggling to find appropriate measures of entrepreneurship, making empirical research on entrepreneurship in many circumstances infeasible. Being aware of the dynamic and complicated of entrepreneurial functions and activities, in *Essay Two* of this dissertation, *Can Entrepreneurship Be Measured* ? *The Case of Technology Entrepreneurship in the United States*, I classify entrepreneurship as "conceiving entrepreneurship" and "performing entrepreneurship." Acknowledging that the former, as ideas of doing business, is largely unobservable, I argue that the latter as actual execution of the ideas can be feasibly observed by tracing the trail of entrepreneurs. Since entrepreneurs may leave multiple footprints, I adopt the latent variable approach in finding measures of performing entrepreneurship. Using this method, I treat performing entrepreneurship as a latent variable, and choose multiple observable indicators as indirect measures of the performing entrepreneurship. A confirmatory factor analysis (CFA) under the framework of latent-variables modeling is used in the case of performing technology entrepreneurship in the United States. In such an analysis, four indicator variables, including number of technology patents, number of small business innovation rewards, venture capital disbursements, and number of high technology firm establishments, are chosen to manifest performing technology entrepreneurship. Data on these variables are collected from all 50 U.S. states. The results of the analysis indicate that the measurement model of performing technology entrepreneurship fits the data plausibly. The study demonstrates that measures of entrepreneurship can be reasonably developed by careful classification and tracing of entrepreneurial activities. The latent variable approach can be a conceivable method in selecting measures of entrepreneurship, and potentially, for further empirical testing of hypotheses in entrepreneurship studies.

Third, while a large body of literature in entrepreneurship research has primarily treated entrepreneurial vision as an individual phenomenon, the literature in the economics of geography has indicated that entrepreneurial and industrial activities mostly cluster in just a handful of regions. This has certainly suggested that there must be some regional factors that promote the emergence and performance of entrepreneurship. However, entrepreneurship research has not paid enough attention to investigating such factors. In *Essay Three* of this dissertation, *The Region as an Entrepreneur's Opportunity Set: an Empirical Analysis in the Case of Technology Entrepreneurship in the United States*, I argue that "performing entrepreneurship" in a region depends largely on what I termed "the entrepreneur's opportunity set" that the region can provide. I further argue that the entrepreneur's opportunity set has four major components, including the availability of strategic resources, the ease of recombining resources, the ease of founding the firm, and the security of doing business. A conceptual model is developed linking entrepreneurship in a region to these four components of the entrepreneur's opportunity set. Because each of the variables in such a conceptual model can not be directly observed or measured, I originally proposed a full structural equation model with latent variables for empirical testing. Multiple indicator variables were chosen to manifest each of these latent variables in the case of technology entrepreneurship in the United Sates. I have attempted to test the proposed model using the data I collected from 265 U. S. metropolitan areas. Unfortunately, such an empirical model did not converge and produce admissible output due to inadequate information, including the use of proxies and estimation of missing data, on these indicator variables. While the U.S. state level data are complete and reliable on these elected indicator variables, however, the sample size is not large enough for running the full structural equation model with latent variables. Therefore, the OLS model is employed alternatively in testing the proposed conceptual model using the state level data since the successful selection of indicator measures of performing technology entrepreneurship in *Essay Two* makes the formation of a single measurable dependent variable possible.

In the actual test of the OLS model, I use the results on four indicator variables, including number of technology patents (PATENT), number of small business innovation rewards (SBIR), venture capital investment (VC), and number of technology firm establishments (NTE), to form an index, called the performing technology entrepreneurship index (PEI) as a dependent variable. The PEI for each individual state is calculated as: PEI = sum [(data on indicator variable / sample average) * factor score], in which, the factor score is the factor loading obtained from the CFA analysis in *Essay Two*. The independent variables in the OLS model are chosen corresponding to each component of the entrepreneur's opportunity set, including the number of scientists (NOS) and R&D investment (RD) for the availability of strategic resources; the number of anchor universities (ACU), number of anchor firms (ACF), and "labor market freedom" measured by the Freedom Index area 3 (FI-III) for the ease of recombination of resources; the number of technology consultants (NCO), the number of business incubators (BICB), and the "size of the government" measured by the Freedom Index area 1 (FI-I) for the ease of founding a new firm; and the number of intellectual property lawyers (NOL) and "takings and discriminatory taxation" measured by the Freedom Index area 2 (FI-II) for the security of doing business. The results show that while most of the independent variables have the correct sign, only R&D investment (R&D), the number of anchor firms (ACF), and the size of government (FI-I) are statistically significant, while the number of intellectual property lawyers (NOL) is very near to the level of statistical significance.

While *Essay One* of this dissertation makes important theoretical effort in explaining the economic basis of entrepreneurship, *Essay Two* and *Essay Three* explore new ways of measuring entrepreneurship and of empirical testing of important factors that encourages the emergence and performance of entrepreneurship. Important policy implications can be drawn for economic development in the age of technology and globalization.

ESSAY ONE: HIDDEN TRANSACTIONS, ENTREPRENEURSHIP, AND ECONOMIC DEVLEOPMENT

Introduction

A focal point of economic theory about the reallocation of resources is how economic transactions are organized or governed. From the perspective of mainstream economic theory, economic transactions are organized or coordinated by the market *price mechanism*, known as Smith's invisible hand. While indicating that there are costs associated with market transactions, Coase's (1937) seminal work of transaction cost economics has considered the *hierarchical authority of the firm* as an alternative to the market price mechanism in terms of the governing of economic transactions. It is very true that we observe both types of economic transactions - the exchange of economic goods through priced-market transactions and the coordination of factors of production by direct orders of the authority of the firm. However, one could consider these two alternatives to be the only means of governance of economic transaction if all necessary economic transactions totally conform to them. An immediate question may follow. Is there any type of economic transaction that is neither governed by the price mechanism nor directed by the authority of the firm?

In this essay, I argue that the transaction of certain economic goods, at the moment of exchange, and in many circumstances, are neither coordinated by the price mechanism nor directed by the authority of the firm. Such a characterization is especially applicable to the exchange of information and knowledge for innovative economic production. That is, the exchanges or transactions of information and knowledge, to a certain extent, are hidden from both the market and the authority, but they are necessary and critical for economic production and development; the governance or coordination of them largely relies on means other than the market price mechanism and the authority of the firm. Therefore, I term this type of economic transactions, basically the exchanges of information and knowledge for innovation or futures innovative economic production, as "hidden transactions."

I maintain two underlying reasons by which the exchanges of information and knowledge in many circumstances are hidden from both the market mechanism and the authority of the firm. One is that information and knowledge, as economic goods, have many properties which are quite different from that of ordinary goods (Arrow 1996); and the other is that knowledge or innovative production initially takes place inside the individual human mind. In this essay, I try to emphasize that individual human entrepreneurship is the fundamental force which initializes the exchanges of information and knowledge for innovative production, especially, in those circumstances when there is no existence of futures market for economic goods (Arrow 1974) and when there is no way for the authority of the firm to gain total control of such exchanges.

Realizing the role of individual entrepreneurship in initializing hidden transactions for innovative production, I argue that the firm, social networks, and various institutions, such as education, freedom, and openness policies, all have an important role to play in expanding an individual's entrepreneurial activities by not only enlarging the scale, but also increasing the frequency and relevancy of hidden transactions. Acknowledging that there are many underlying reasons for the existence of the firm, I maintain that the firm also provides geographic, social, and technical proximities to individuals, and therefore, facilitates hidden transactions. Given the limitations of the firm’s knowledge pool, social, professional, and industrial networks are also argued as critical for expanding hidden transactions among individual entrepreneurs. In addition to networks, I contend that regional institutions that allow free movement of individuals may have an important impact on the magnitude of hidden transactions, and thus, the scale of entrepreneurial production, especially, in technology industries. This essay attempts to provide theoretical explanation on important factors that encourage the emergence of entrepreneurship. From the basis of hidden transaction, the dynamic nature between individual entrepreneurs, the firm, and the region can be revealed. Meaningful implications for firm strategy and regional development policies can be drawn from this study, especially, in the age of technology and globalization.

The Exchanges of Information and Knowledge as “Hidden Transactions”

Information and knowledge are considered vital economic goods because they are used pervasively in the processes of innovation, economic production and exchange, as well as the functioning of the entire economic system. First, throughout human history, in order to make use of a natural material, information and knowledge about its properties have to be revealed and known to consumers no matter they are generated by experimental or observational means. Second, the production of any man-made product or service, even the simplest ones, is instructed by information and knowledge. In the age of modern technology, many sophisticated new products, such as computers and medicines, are produced with much complicated and newly created information and knowledge. Third, the making and the functioning of the economic system is very much guided by information and knowledge, including the functioning of the firm and the market. Furthermore, the idiosyncratic nature of products, organizations, markets, or economic systems is explained by unique combinations of different bits of information and knowledge.

Despite their critical importance, information and knowledge have not been in the center of economic theory until the last half of the twentieth century (Stiglitz 2000). According to Stiglitz, economic theory that concerns information and knowledge can be divided into two distinct branches, the economics of information and the economics of innovation. In the economics of information, two major arguments can be found from literature: (1) information is necessary to discovering price and quality of commodities to match consumer preferences, but it incurs significant cost of acquiring in market transactions, thus, giving to the rise of certain institutions or the existence of the firm (e.g., Coase 1937; Stigler 1961); and (2) the nature of "informational inequality" (Arrow 1963) or "asymmetrical information" (Akerlof 1970) between sellers and buyers gives the rise of unexpected economic behaviors, causing market failure and the emergence of certain institutions. In the economics of innovation, literature has mainly focused on under investment in research and development or market failure of innovation. For example, Arrow (1962) has argued that under investment in innovation would probably occur because of the following problems: indivisibility of information (zero marginal cost of information), inappropriability (improbability of inventors' fully appreciation of the economic value of their invention while diffusion of information is inevitable), and uncertainty of innovation (the unpredictability of the outputs for given inputs). Both branches of literature have largely advanced our understanding of the role and impact of information and knowledge in economic production, the functioning of the market, the rise of certain institutions, and thus, the allocation of many economic resources.

Nevertheless, how information and knowledge themselves as critical resources are allocated has not been in the forefront of discussion.

Regarding the allocation of resources, a dominate view is that market price mechanism governs or coordinates the exchange of economic goods through market transactions. While questioning the wisdom of mainstream economics and introducing the concept of “transaction cost,” Coase (1937) argued that, to save transaction costs at the margin, market transactions can be internalized within a firm and directed by the authority of the firm, suggesting that organizational authority works as an alternative to market price mechanism in terms of governing of economic transactions. For ordinary economic goods, it is probably true that the exchange or transaction of them is governed either by the price mechanism or by the authority of the firm. However, given that many properties of information and knowledge are quite different from that of ordinary economic goods (Arrow 1996), does the exchange of information and knowledge conform only to these two alternative means of governance as ordinary goods do? The answer is, to a certain extent, yes, but it is not merely confined to these two alternatives. Information and knowledge can certainly be exchanged at market transaction if they are about existing products or services whose utilities are known to consumers. Still, this does not keep one from getting information and knowledge from other ways such as casual conversations in which the cost of exchange is negligible. Moreover, even if there is very low or negligible cost of transaction, the exchange of information and knowledge may not necessarily take place. Of course, the authority of the firm has the power to direct some exchange of information, but it may never have total control of the exchange of information and knowledge among individuals in both within and across firms.

Therefore, one may conclude that, to a certain extent, the exchange of information and knowledge is *hidden* from both the market price mechanism and the authority of the firm. In this essay, I would like to term such exchanges as *hidden transactions*.

The way that the exchange of information and knowledge is hidden from the market and authorities lies in the unique nature of the distribution of information and the production of knowledge. Hayek (1945) argued that "the knowledge of the circumstances of which we must make use never exists in concentrated or integrated form, but solely as the dispersed bits of incomplete and frequently contradictory knowledge which all the separate individuals possess" (p. 519). He further pointed out that "the economic problem of society is thus not merely a problem of how to allocate 'given' resources …," and "it is rather a problem of how to secure the best use of resources known to any of the members of society, for ends whose relative importance only these individuals know." (pp. 519-520). While his characterization of knowledge has been widely used to explain the relationship between the existence of local knowledge and the call for decentralization, it also suggests that: (1) knowledge largely resides in individual minds, and (2) the reallocation or exchange of information and knowledge is necessary to further utilization or new production of knowledge. In his article, Hayek pointed out that the decentralized free market system may work in securing society's best use of knowledge. However, how the market works to reallocate knowledge and to secure society's efficient utilization or production of knowledge is still largely unknown.

Information and knowledge about the existing ordinary products and services may be pertinent to the price mechanism because the value of such information and knowledge is generally comprehensible to economic agents and consumers. However, for future goods production, as Arrow (1974) has argued, there is “nonexistence of futures goods markets” (page 6), and “there will be no price at which transactions in future goods will take place” (page 9). According to Arrow, expectation may help the price mechanism work its way for market transactions of future goods. I argue that the fundamental distinction between the futures market of an existing commodity, such as soybean, and the futures market for an innovative product, for instance, some sort of device that is never imagined to cure cancer in the future. For the former, the soybean, we know its utility, and the expectation of its future production, and the prediction of its future market price is practical. Conversely, for the latter, the future innovation of the medical device, we do not know its utility and whether it is to be produced at all in the future. Market expectation would not be realized for at least a period of time until enough information or new knowledge about such a device is available. However, the basic fact of innovation is that the exchange of information and the production of new knowledge have to take place before such expectation is built. Obviously, the market price mechanism could not function, and the authority of the firm would have no way to direct those exchanges until innovative production reaches a certain stage. Then, what would be the forces to initialize and coordinate these necessary hidden transactions of information and knowledge for innovative production in the first place?

Entrepreneurship and the Governance of Hidden Transactions

The major reason that current economic theory has not provided a complete picture of the governance of economic transactions is that it has largely ignored a very basic fact – while ordinary economic goods, generally tangible goods, are produced in the firm and mostly exchanged in the market, the creation of new knowledge or innovative production initially takes place inside individual human minds. Though, cognitive science has revealed very little on how the human brain functions, we can still make an educated guess on the process of knowing and knowledge production. Putting into the context of knowing or knowledge production, we may consider data and information as the "inputs" and new knowledge as the "output." *Data* is simply some recorded or restored symbol of "facts." *Information* are certain signals of these data, sent out by a sender (can be a human or non-human object) and received by sensible human organs (the receiver), and then processed by the human brain (the processor). *Knowledge*, however, can be considered as human conclusion about a specific matter based on the given information or signals previously and currently received. Knowledge as human conclusion derived from the process of knowing can be recorded and put into some sort of memory (including the human brain) as data, and then, be transformed into informational signals and sent out for the next round of new knowledge production. Because existing knowledge can be transformed into bits of information as inputs for new knowledge or further innovative production, there is interchangeable use of "information" and "knowledge" in economic literature. Since the process of knowing or innovative production is also a cumulative process (Nelson and Winter, 1982; Rosenberg, 1976), technological breakthrough, innovation, or a new way of problem solving only occurs at a certain point in time in the process when a right combination of information or knowledge is realized, even by accident.

In such a production process, people exchange information and knowledge with each other and their environmental surroundings. There are many ways people can engage in these exchanges. For example, formally arranged exchanges, such as education, meetings and interviews, are very common; casual conversations take place in many occasions; readings allow people to exchange information and knowledge indirectly with others across space and time; and through observational means, people can acquire information from certain phenomenon or events happening daily in their environment. In the case of formal education, although students pay for the classes in which the transaction of information and knowledge arise mainly between teachers and students, how much students learn (the actual amount of information and knowledge is actually transacted) is usually not represented by the price of education. People are engaged in conversation or observation in numerous occasions, but they may or may not uniformly extract the same relevant information for purposeful production or utilization. Even in the case of knowledge spillovers (the diffusion of useful knowledge), people exposed to them may not absorb relevant information and knowledge automatically and equally. One should be noticed here is that there are fundamental differences between the concept of “knowledge spillovers” and the term of “hidden transactions.” Although the former has been long and frequently used in economic literature, it is assumed that useful information or knowledge can automatically and equally distributes among individuals who expose to them. However, the latter emphasizes that any exchange of information or knowledge has to be among individual parties; and parties in exchange may not receive it automatically or make the same use of it even it is in the public domain because that vigorous individual action or ability to code information or knowledge is required. These all suggest that some sort of quality of individual human-beings may have an impact in the process of exchange of information and the production of new knowledge.

To further understand the role of individuals, I consider the exchange of information and knowledge with respect to parties of exchanges as the follows. In the case of formal and informal "person-to-person" exchanges, we usually have "more-than-one-party transactions," including two-party and multi-party transactions; however, in the case of individual reading or other observational learning activities, there is only "one-party transaction," in which the party or parties in another side may be unseen or inhuman. No matter what type of transaction, the outcomes that the party or parties may obtain from the moment of exchange could be outlined as follows: (1) the information or knowledge has no meaning to the party or parties; (2) the information or knowledge is relevant but not enough to make a breakthrough in problem solving so that it can only be accumulated or added to an individual's knowledge domain as "prior knowledge;" and (3) the information is enough for the party or parties in exchange to make a breakthrough in problem solving or innovation. In addition, parties who receive the same information and knowledge may obtain different outcomes. That is, individuals engaged in the same transaction may or may not get the same output for innovative production, and a positive outcome may not always be possible. The following factors could determine the outcome of the transaction of information and knowledge. First, the genetic make-up of a human-being may affect an individual's ability to code information and produce new knowledge. Second, the prior knowledge that an individual accumulated may have an influence on the individual's rate of new knowledge production. Third and most importantly, an individual's active engagement or alertness at the moment of exchange of information could be the key to reaching a positive outcome in the case of hidden transactions.

Moreover, the access of an individual to relevant information and knowledge also defines the individual's rate of innovative production and actual utilization of knowledge.

While there is little to say about the impact of genetic make-up of an individual on innovative production, one could still conclude that there is something both intrinsic and extrinsic in determining the rate of exchange, reproduction, and utilization of information and knowledge. I contend that the intrinsic part is the kind of human quality, such as ability, desire, and willingness, to initialize the exchange, production, and utilization of information and knowledge. Therefore, entrepreneurship can be viewed as such a human quality to initialize the hidden transactions in which the price mechanism and the authority of the firm may be absent. Although there is no consensus on the definition of entrepreneurship, this view still aligns well with other perspectives of entrepreneurship. For instance, in the world of Knight's uncertainty, there is "the possibility that 'mind' may in some inscrutable way originate action" (Knight 1921/1957, Page 221), suggesting the role of entrepreneurship in putting up with uncertainty in economic production. Other characterizations of entrepreneurship such as Kirzner's "alertness" to discovering opportunities to profit (Kirzner 1979), Casson's "imagination and foresight" (Casson 1982), and Witt's "cognitive leadership" (Witt 1999), have all ascribed entrepreneurship to individual's intrinsic motives in initializing economic actions. I argue that this is especially true in the exchange of information for innovation, utilization of knowledge, or new knowledge production.

In addition to entrepreneurship as the intrinsic force to initialize the exchange of information and knowledge, many extrinsic factors may also have an impact on the allocation of these critical resources for the production and utilization of knowledge.

Even though entrepreneurial vision and willingness to take actions are largely an individual phenomenon, physical, social, and institutional means are also important for entrepreneurial development. These extrinsic factors have critical importance in entrepreneurial development because they allow and expand individual entrepreneurial activities by facilitating hidden transactions for innovative production in society.

Having realized that there are both intrinsic and extrinsic factors of entrepreneurial production, now, I would like turn to the economic basis in which the individual entrepreneurial function and external factors may have a role to play from the perspective of hidden transactions. As previously mentioned, since an individual or individuals could obtain different types of outcomes from a single transaction, I argue that the rate of innovation or productivity of entrepreneurial activities for individual entrepreneurs depends on both the frequency and the relevancy of the latent transactions pertinent to a particular innovative production. Before a viable innovative product is accepted in the market, individual's engagement in hidden transactions is necessary. Any intrinsic quality of an individual and extrinsic factors that could increase the frequency and relevancy of the latent transactions are critical to innovative or entrepreneurial production.

The Role of the Firm, Social Capital, and Institutions in Entrepreneurial Development

Given the fact that knowledge production takes place in the human mind, the role of individual entrepreneurship seems indisputable in initializing the exchange, production, and utilization of knowledge. Yet, it only indicates the importance of intrinsic human motives. Literature in economics of geography and innovation has suggested, not only that many new technologies are produced and utilized in firms and organizations, but also that entrepreneurial and industrial activities have largely clustered in certain regions (Porter, 1990; Feldman, 1994). These all indicate that there must be some extrinsic promoting factors in the firm and the region for entrepreneurial and industrial activities, especially for innovative production. From the perspective of hidden transaction, I would like to further discuss how the firm, social capital, and certain institutions have roles to play in the exchange, production, and utilization of information and knowledge.

Hidden Transactions and the Role of the Firm

While the production and utilization of knowledge originated in the human mind, and individual entrepreneurship is required to initialize the exchange of information and knowledge, the interaction and cooperation among individuals are necessary conditions for such exchanges. The effect of the interactions and cooperation can be represented in the frequency and relevancy of the hidden transactions. There are many alternative theoretical explanations for the existence of the firm. For example, the division of labor and specialization of production (Smith, 1776) and the transaction cost theory of the firm (Coase, 1937). Given the importance of hidden transactions, I argue that the firm is also a physical place and a social device that provides geographic, social, and technical proximities to individuals, and thus, increases the frequency and relevancy of the exchange of information and knowledge. Even though the exchanges may not be totally directed by the authority of the firm in terms of hidden transaction, such an explanation still aligns well with Coase's notion of transaction cost since these proximities that the firm provides also reduce transaction cost for exchanges of economic goods, including hidden transactions, within the firm. Also, the reason that technical proximity increases the relevancy of the hidden transaction is consistent with the view of specialization of production.

The Function of Social Capital in Hidden Transactions

Despite the advantages to facilitate hidden transactions, the firm has limited pools of knowledge and information. That is, relevant information or knowledge for particular innovative production may reside outside the sphere of the firm. Under such a circumstance, an individual entrepreneur has two ways to acquire relevant information and knowledge. One is by using social capital; and the other is to make direct contact, usually, by moving to where the relevant information may reside. To scholars from different areas of studies, social capital may be defined slightly differently. In socioeconomic literature, social relations or social networks are often characterized as social capital. Granovetter (1985) argued that "most behavior is closely embedded in networks of interpersonal relations," or "economic action is embedded in the structure of social relations," indicating that social capital is very important in economic development. Burt (1992) has also argued that the rate of return to investment is positively related to social capital, which he defines as human relations within and beyond the firm. I argue that social capital has an important role in economic development because it facilitates hidden transactions. The extensive and unique use of social, professional, and industrial networks in various Japanese industries (e.g., Dyer and Nobeoka, 2000; Chuma 2003) and inside industry clusters in the United States (e.g., Saxenian 1994) have all exemplified the role of social capital in the production and utilization of knowledge in society.

Freedom, Education, and the Scale of Entrepreneurial Innovation

Besides the use of social relations or networks, individuals enlarge their knowledge pools and access to new information and knowledge also through moving from one firm to the next, and from one place to another. Nevertheless, individual mobility may be confined by many factors. Human institutions are one of the factors that define the constraint of individual mobility, and thus, the size of the knowledge pool and individual's access to information. In the history of mankind, individual mobility has been restricted at times and in places by certain institutions. However, institutional change that lifts these restrictions on individual mobility may have a positive effect in facilitating the exchange of information and knowledge, and thus, the advancement of technological innovation. Typical examples of positive institutional change may be found in the following: Europe's industrial revolution after the Renaissance, Japan's accomplishment after Meiji Restoration, the leading of the West in technology accompanied by persistently granting freedom in society, as well as China's recent economic development after her reform and openness policy.

In addition to social networks and freedom in society, one of the most important man-made institutions that grant individuals access to information and knowledge is education. While individual entrepreneurs can learn from experiences other than formal education, granting equal access of education to individuals in society would not only allow all potential entrepreneurs opportunities, but also provide individuals a platform for the exchange of information and knowledge, including both formally arranged transactions and hidden transactions. Of course, very few people may disagree with providing individual human beings freedom and equal access to education; and some studies have suggested high economic returns to education for individuals (e.g., Beck 1964). Taking hidden transactions as an economic basis, one may visualizes how freedom and education enlarge the scale of entrepreneurial activities, and thus, the base of society's economic development.

Implications

In this essay, "hidden transactions" have been identified as necessary exchanges of information or knowledge for innovative productions, in which the conventionally recognized means of governance of economic transactions, including the market price mechanism and the authority of the firm, are absent. The identification, characterization, and discussion of such type of transactions have some meaningful implications. First, mainstream economic theory, particularly, the neoclassical framework, largely focuses on the firm and the market, but ignores the role of individuals as economic agents. From the perspective of hidden transactions, individual entrepreneurship is seen as the fundamental force that initializes necessary economic transactions for innovative production. That is, the individual is treated as an economic entity or a basic production unit in the case of innovative production. Second, the dynamic alignment of individual entrepreneurship, the firm, and the region could be more precisely depicted on the basis of hidden transactions. While the initializing of hidden transactions for innovative production happens inside individual human mind, the firm is a collection of individuals, and the region contains both individuals and firms. Since hidden transactions among individuals could take place inside the firm and across firms and regions, how the firm and the region could increase both the frequency and relevancy of the latent transactions and internalize possible hidden transactions may be important in the age of telecommunication and globalization. Vigorous outsourcing of multinational firms (particularly, those technology giants), allowing spin-offs in the first place but finding ways to internalize them later, and recruiting potential talents may all exemplify the dynamics of entrepreneurial activities on the basis of latent transactions. Important regional institutions, for instance, Silicon Valley's "high velocity labor market" (Hyde 2003) constructed by a variety of institutional means, that enhance the frequency and relevancy of hidden transactions may be the key to the clustering of entrepreneurial activities. It suggests that the "region" as a larger but more diversified place contains individuals and firms, but only those in which the exchanges of information and knowledge, including hidden transactions, are facilitated by wisely devised institutions would have sizable emergence of technology entrepreneurship and substantial innovation-based economy.

Unlike the term "hidden actions" used by other literature (Miller 1992) to describe shirking behaviors of individuals for team production inside a firm, "hidden transactions" have been seen as the nexus where productive force of innovation can be explained. Although Schumpeter's "creative destruction" (1934) suggests that "hidden transaction" may not always be beneficial to an economy, that regional competitiveness rests upon innovation has been well revealed by evidence of industry clusters in technologically advanced nations (Porter 1990). In the age of telecommunication and globalization, firms and regions that could not only facilitate the exchanges of information and knowledge from within but also internalize potential positive outcomes of hidden transactions from outside would gain competitive advantages.

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ESSAY TWO: CAN ENTREPRENEURSHIP BE MEASURED? THE CASE OF TECHNOLOGY ENTREPRENEURSHIP

Introduction

Since the first use of the word, “entrepreneur,” in Cantillon’s 1755 work, *Essai sur la Nautre du Commerce en general* (Kirzner, 1979; and Casson, 1982), entrepreneurship has gradually become an important subject of research in several academic fields, such as economics, management, and sociology. Although the importance of entrepreneurship in technological, economic, and social development is commonly perceived, entrepreneurship research has not produced consistent results on either the impact of entrepreneurial activities or the factors that may encourage the emergence and performance of entrepreneurship. It is well-known that economics is a field with a rich set of mathematic tools. Ironically, economists have not been very successful in electing effective measures of entrepreneurship. In existing literature of entrepreneurship studies, a very few studies have focused on developing measures of entrepreneurship. The failure of adopting appropriate measures of entrepreneurship is one of the obstacles in conducting impact analysis and testing hypotheses of those factors. It seems that the very nature of entrepreneurship has somehow contributed to the difficulty of measuring entrepreneurship. A legitimate question still remains. Can entrepreneurship be reasonably measured?

While acknowledging that the dynamic and idiosyncratic nature of entrepreneurial functions and activities may have caused the complication of measuring entrepreneurship, I argue that plausible measures can still be chosen by further classification of entrepreneurship and careful tracing of the trails of entrepreneurs. Classifying entrepreneurship as “conceiving entrepreneurship” and “performing entrepreneurship,” I argue that the former is largely unobservable, but the latter can be logically traced and measured. Also, considering the distinct nature of the types of entrepreneurial practices, this study advocates that measures of entrepreneurship and means of comparison should be made carefully.

In this study, I explore the latent variable approach to measure performing entrepreneurship in the case of technological entrepreneurial practice. Using such a method, performing entrepreneurship is treated as a latent variable in which a single direct measure is unobservable or infeasible, but a set of indirectly observable indicator variables can be chosen to manifest it. A so-called confirmatory factor analysis (CFA) is employed and the plausibility of the proposed model construct for measuring high technology entrepreneurship is tested. In the study, performing technology entrepreneurship is manifested by four indicators, technology patents, small business innovation rewards, venture capital disbursements, and technology firm establishments. Data from all 50 U.S. states are collected and used in the empirical testing of the hypothesized model. The results of the analysis show that the proposed measurement model fits the data well in the level of statistical significance. This study suggests that although direct measuring of entrepreneurship is very difficult and, in many circumstances, impossible, reasonable indirect measures of entrepreneurship can still be found with clear classification and careful distinctions of the types of entrepreneurial practices. The latent variable approach is demonstrated as a proper method in choosing measurement of performing entrepreneurship in the case technology industries. It may be similarly applied to the studies of other categories of entrepreneurship. In addition, possible ways of conducting further empirical research using these selected measures of entrepreneurship are suggested.

The Dynamic and Idiosyncratic Nature of Entrepreneurship

In the economics literature, many scholars have made attempts to define entrepreneurship. Each of them has characterized entrepreneurship from a unique perspective. For instance, Knight (1921) suggested that individual entrepreneurs are willing to take actions or perform certain economic functions in circumstances of risk and uncertainty. As Kirzner (1979 and 1997) placed emphasis on an entrepreneur's "alertness to discovering opportunities to profit," Casson (1982) highlighted on an individual entrepreneur's "imagination" and "foresight." While Hagen (1962), McClelland (1961 and 1987), and Khilstrom and Laffont (1979) considered entrepreneurship as certain unique psychological traits of individuals, Witt (1999) argued that entrepreneurship is an individual's cognitive leadership in the firm. Given the view of neoclassic economics in which entrepreneurs are treated as passive decision makers, Schumpeter (1912/1934) argued that entrepreneurship is an individual's carrying out of the new combinations of means of production marked with innovative ideas. Such distinctive views have all advanced our understanding of the nature of entrepreneurship. However, a commonly acceptable measure of entrepreneurship may not be found in such wide spectrums of definitions. Further classification may be needed to select appropriate measures.

In this essay I argue that, in order to develop appropriate measures of entrepreneurship, clear distinctions or classifications should be made regarding the stages of entrepreneurial function and the idiosyncratic nature of entrepreneurial practice in different areas of businesses. First, no matter how entrepreneurship is defined, entrepreneurs must first have an idea of doing business to begin with and then to carry out the idea when certain conditions are met. Therefore, I classify entrepreneurship as "conceiving entrepreneurship" and "performing entrepreneurship." The former can be imagined as an individual's creation of a business idea, and the latter may be seen as an individual's actual execution of that idea. Generally, having a business idea is very much an individual phenomenon. That is, the idea is conceived inside the individual's mind. In such a circumstance, the direct observation of the conceiving entrepreneurship is probably impossible given the current level of human knowledge about cognition. Although business ideas of individuals may not be all carried out, once individuals actually execute their business ideas, they perform certain entrepreneurial functions in business practice and must leave some trails behind. Performing entrepreneurship can then be largely observed and possibly measured if one traces these trails of entrepreneurs.

In addition to the classification of conceiving entrepreneurship and performing entrepreneurship, I also argue that appropriate measures of entrepreneurship may be established while different categories of entrepreneurial practices are taken into consideration. Although we may not find clear classification of different types of entrepreneurship in the literature of entrepreneurship research, in reality, institutions have been established and named according to different types of entrepreneurial practices. For example, technology entrepreneurship centers have been built in many prestigious universities and places in the United States such as Harvard University Technology Entrepreneurship Center, MIT Technology Entrepreneurship Center, and California Technology Entrepreneurship Center and so on. We can also find many centers for rural entrepreneurship, such as these in Kansas and Nebraska. Apparently, the missions and entrepreneurial practices in the technology entrepreneurship centers are quite different from that of the rural entrepreneurship centers. By the same token, we would not expect the objective of economic entrepreneurs to be the same as that of social entrepreneurs. Furthermore, entrepreneurs in different countries or cultures may leave distinct trails of unique business practices. Therefore, I argue that uniform measures of entrepreneurship may not be found across different sectors, business practices, or cultures. This study suggests that appropriate measures of entrepreneurship may be adopted within a single category of entrepreneurial practices. In this particular study, I restrict the choice of appropriate measures of performing entrepreneurship to only the entrepreneurial practices in high technology industries in the United States.

A Latent Variable Approach in Measuring Entrepreneurship

Having made distinctions between different stages of entrepreneurship and differences among various types of entrepreneurial practices, I next discuss a methodological approach that may be suitable to entrepreneurship research. In behavioral and social sciences such as psychology, sociology, and management science, scholars have often come out with many concepts that cannot be directly observed or measured, such as intelligence, self-esteem, democracy, and so on. Although these concepts are unobservable and immeasurable, statisticians have forcefully adopted a framework called latent variable modeling to deal with vaguely defined concepts. In such a framework, those concepts that cannot be directly observed are termed latent variables, and multiple, indirect, but observable measures can be used as indicators to manifest these unobservable concepts. For example, human intelligence can not be directly observed and measured, but SAT score and G.P.A. can be used as indicator variables to manifest intelligence. Similarly, I argue that entrepreneurship is one of these unobservable concepts which could be treated as a latent variable. Under the framework of latent-variables modeling, multiple observable indicators can be found to manifest it in the same fashion.

Although entrepreneurial activities are numerous and many of them are untraceable, there are still major footsteps or milestones left behind by entrepreneurs. Based on Harwley's (1907) view of entrepreneurship as depending on ownership rights, Gartner and Shane (1995) have adopted the number of organizations per capita as an indicator of entrepreneurship. Such an indicator can be used as a measure of entrepreneurship because not only that the birth of the firm is a distinctive milestone of new business venture, but also that the firm, according to Foss and Klein (2004), is an important organizational means for entrepreneurs to perform their function. Acknowledging the important contribution made by Gartner and Shane (1995) in measuring entrepreneurship, I argue that the number of organizations per capita as the indicator of entrepreneurship may not be enough to manifest it because entrepreneurs perform important economic functions before as well as after the firm is established.

According to Schumpeter (1912/1934), entrepreneurs perform multiple functions in the carrying out of "new combinations of means of production," including

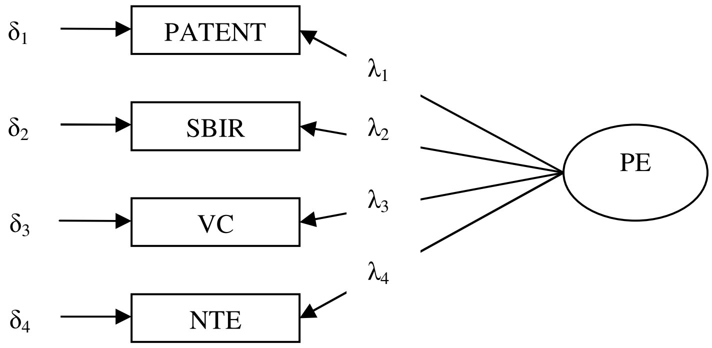
> (1) The introduction of a new good – that is one with which consumers are not yet familiar – or of a new quality of a good. (2) The introduction of a new method of production, that is one not yet tested by experience in the branch of manufacture concerned, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially. (3) The opening of a new market, that is a market into which the

> particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before. (4) The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created. (5) The carrying out of the new organization of any industry, like the creation of a monopoly position (for example through trustification) or the breaking up of a monopoly position. (Schumpeter 1912/1934, p.66)

Therefore, I strongly advocate adopting multiple observable indicators as indirect measures of performing entrepreneurship. In this study, I particularly explore the latent variable approach to develop measures of performing entrepreneurship in the case of technology entrepreneurship in the United States. I use four indicator variables, including the number of technology patents (PATENT), the number of small business innovation rewards (SBIR), venture capital disbursements (VC), and the number of technology establishments (NTE) to manifest the latent variable, performing technology entrepreneurship (PE). Ideally, I would also like to include the number of new products and services created as another indicator variable. However, data on such a variable are unavailable.

Based on Gartner and Shane's (1995) measure of entrepreneurship by the number of organizations per capita, I propose the number of technology establishments per capita as one of the indicators of performing entrepreneurship. The number of technology establishments may be more probable than the number of organizations because multiple entrepreneurial efforts and different applications of technologies within a single firm are possible. For example, the Monsanto Company has transformed itself with several technology establishments such as agricultural biotechnology, pharmaceuticals, and agricultural chemicals. The number of technology establishments according to industrial classification may represent performing entrepreneurship in all high technology areas. In addition to the number of technology establishments, while patent registration serves as a way to protect intellectual property rights of innovators, it also symbolizes a major footstep of technology entrepreneurs towards the development of new products, services, or processes. Hence, the number of patents granted can be seen as another indicator for performing technology entrepreneurship. Likewise, the small business innovation rewards endowed by many branches of the United States government mostly signify the actual steps of starting a new technology business by entrepreneurs, and thus, is an indication of performing technology entrepreneurship. Since venture capital investment is the well-known and particular way of founding new technology ventures in start-up firms or new technology projects in an existing business, it can also be counted as a very important indicator for performing technology entrepreneurship. Based on these chosen indicator variables, I conduct an empirical test of the measurement model to assess performing technology entrepreneurship by using the confirmatory factor analysis (CFA) under the framework of latent variable approach. The model construct is demonstrated by Diagram 2.1. PE inside the oval is the latent variable which stands for performing technology entrepreneurship; the four variables within a rectangle are indicator variables chosen to measure the latent concept, performing technology entrepreneurship. The arrows between the latent variable, PE, and its indicator variables signify the causal relationship; in this case, they imply that because there are presences of performing technology entrepreneurship we can observe these indicators. λ_1 to λ_4 are called factor loadings or factor scores, representing the strength of the relationships between each indicator and the latent variable; and δ_1 to δ_4 denote measurement errors. Such a

Diagram 2.1: Confirmatory Factor Analysis (CFA) Model for Performing Technology Entrepreneurship:



measurement model construct can also be specified and expressed mathematically via the following set of equations:

$$PATENT = \lambda_1 \, PE + \delta_1 \tag{1}$$

$$SBIR = \lambda_2 \, PE + \delta_2 \tag{2}$$

$$VC = \lambda_3 \, PE + \delta_3 \tag{3}$$

$$NTE = \lambda_4 \, PE + \delta_4 \tag{4}$$

Unlike traditional statistical analysis, the purpose of empirical testing of the latent variable model is to reveal how well the hypothesized model construct fits the data. That is, the plausibility of the proposed model is to be tested based on sample data of all indicator or observable variables. Such plausibility is determined by a set of statistical measures called goodness-of-fit between the hypothesized model and the sample data. In such a procedure, a researcher imposes the structure of the proposed model on the sample data, and then tests how well the observed sample data fits the restricted model structure (Byrne 1998). While the discrepancy between the model and the data is denoted by the residual, the model-fitting procedure can be described as:

$$\text{Data} = \text{Model} + \text{Residual}$$

Mathematically, the estimation procedure in latent variable modeling is derived from the relation between the covariance matrix of the observed variables and the covariance matrix of the structural parameters (Bollen 1989). Let S denote the sample covariance matrix of the structural parameters, Σ represent the population covariance matrix, θ be a vector that consists of the model parameters, and $\Sigma(\theta)$ is the restricted covariance matrix implied by the specified structure of the hypothesized model and expressed as a function of the parameter vector. As such, then, the null hypothesis (H_0) should be $\Sigma = \Sigma(\theta)$, meaning the postulated model holds in the population. Unlike the conventional statistical method, the researcher hopes not to reject the H_0. The primary focus of the actual estimation is to produce parameter values that minimize the discrepancy between the sample covariance matrix of S and the population covariance matrix expressed by the model parameters $\Sigma(\theta)$. The most commonly used fitting function for latent variable modeling is the maximum likelihood (ML) function (Bollen 1989, Page 107), denoted by equation (5) below:

$$F_{\mathrm{ML}} = \log | \Sigma(\theta) | + tr\, (S\, \Sigma^{-1}\, (\theta)) - \log | S | - \text{constant} \tag{5}$$

For such a function to be minimized, $\Sigma(\theta)$ should be as close as possible to S. More detailed statistics of such an analysis are available in the next section of this essay.

Data and Analysis

Data for the indicator variables are collected at the U.S. state level in technology industries and sectors. Since the information and communication technologies (ICT) and the biotechnology (Biotech) largely represent new technologies, data on these two areas are particularly extracted. The number of technology establishments (NTE) is based on the North American Industry Classification System (NAICS) codes to define both the ICT industries and the Biotech industries (see Table 2.1). For information and telecommunication industries, the following codes are included: 334 (Computer & Electronic Product Manufacturing), 333295 (Semiconductor Machinery), 5112 (Software Publishers), 516 (Internet Publishing and Broadcasting), 517 (Telecommunications), 518

Table 2.1: Definition of ICT and Biotech Industries (by NAICS code)

NAICS	Industry Description
ICT Industry	
334	Computer & Electronic Product Manufacturing
333295	Semiconductor Machinery
5112	Software Publishers
516	Internet Publishing and Broadcasting
517	Telecommunications
518	Internet Service Providers, Web Search Portals, and Data Processing Services
5415	Computer Systems Design and Related Services
Biotech Industry	
3254	Pharmaceutical and Medicine Manufacturing
54171	R&D in the Phys. Engineering & Life sciences
ICT & Biotech	
54138	Testing Laboratories

Source: U.S. Census 2002

(Internet Service Providers, Web Search Portals, and Data Processing Services), and 5415 (Computer Systems Design and Related Services). For biotechnology industry, 3254 (Pharmaceutical and Medicine Manufacturing) and 54171 (R&D in the Physical Engineering & Life sciences) are included. In addition, the NAICS code 541380 (Testing Laboratories) is also counted for both the ICT and Biotech industries. The number of establishments on these codes is collected from the American Fact-Finder, United States Census Bureau, 2002 Census; and the data is scaled on per capita basis.

The number of technology patents (PATENT) is based on 32 technology patent classes which largely cover both the ICT and Biotech industries, and detailed class codes are listed in Table 2.2. The data are provided by the U.S. Patent and Trademark Office, and the average number of patents from 2000 to 2004 on a per capita basis is used in empirical testing. Data on venture capital investment (VC) for both information technology and biotechnology are collected from the SDC Database, managed by Thomson Financial Inc., for the period of 2000 to 2004. The average amount of venture capital disbursement over the period is calculated in million of dollars per capita. Data on the number of small business innovation rewards (SBIR) are extracted from the TECH-*NET* Database, managed by the Office of Technology, Small Business Administration (SBA), and the average number of small business innovation rewards over the period of 2000 to 2004 is also calculated on a per capita basis.

The descriptive statistics of the data are summarized in Table 2.3. Based on such data defined above, the LISREL program is used to run the model and the results of the model outputs can be seen from both Diagram 2.2 and Table 2.4. To judge the

Table 2.2: Definition of Technologies in ICT and Biotech Areas by Patent Classification:

Patent Class	**Patent Description**
ICT Technologies	
345	Computer Graphics Processing
375	Pulse or Digital Communications
398	Optical Communications
438	Semiconductor Device Manufacturing Process
455	Telecommunications
700	DP: Generic Control Systems or Specific Applications (Data Processing)
701	DP: Vehicles, Navigation, and Relative Location (Data Processing)
702	DP: Measuring, Calibrating, or Testing (Data Processing)
703	DP: Structural Design, Modeling, Simulation, and Emulation (Data Processing)
704	DP: Speech Signal Processing, Linguistics, Language Translation, and Audio Compression/Decompression (Data Processing)
705	DP: Financial, Business Practice, Management, or Cost/Price Determination (Data Processing)
706	DP: Artificial Intelligence (Data Processing)
707	DP: Database and File Management or Data Structures (Data Processing)
708	Arithmetic Processing and Calculating (Electrical Computers)
709	Multicomputer Data Transferring or Plural Processor Synchronization (Electrical Computers and Digital Processing Systems)
710	Input/Output (Electrical Computers and Digital Processing Systems)
711	Memory (Electrical Computers and Digital Processing Systems)
712	Processing Architectures and Instruction Processing, e.g., Processors (Electrical Computers and Digital)
713	Support (Electrical Computers and Digital Processing Systems)
714	Error Detection/Correction and Fault Detection/Recovery
715	DP: Presentation Processing of Document, Operator Interface Processing, and Screen Saver Display Processing (Data Processing)
716	DP: Design and Analysis of Circuit or Semiconductor Mask (Data Processing)
717	DP: Software Development, Installation, and Management (Data Processing)
718	Virtual Machine Task or Process Management or Task Management/Control (Electrical Computers and Digital Processing Systems)
719	Interprogram Communication or Interprocess Communication (Ipc) (Electrical Computers and Digital Processing Systems)
720	Dynamic Optical Information Storage or Retrieval
725	Interactive Video Distribution Systems
Biotechnology	
424	Drug, Bio-Affecting and Body-Treating Compositions
435	Chemistry: Molecular Biology and Microbiology
530	Chemistry: Natural Resins or Derivatives; Peptides or Proteins; Lignins or Reaction Products Thereof
800	Multicellular Living Organisms and Unmodified Parts Thereof and Related Processes

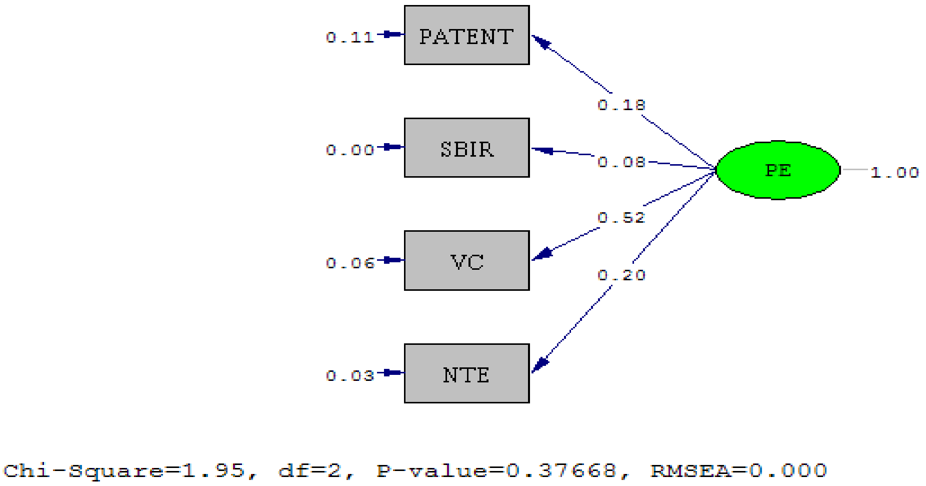
Source: U.S. Patent and Trademark Office plausibility of the model from LISREL outputs, one needs to look into both the estimates of model parameters and the overall goodness-of-fit statistics. First, the parameter estimates have to be meaningful based on what was proposed. From Diagram 2.2 and Table 2.4, one can see that the estimates for all factor loadings, λ_1 to λ_4, are positive, a correct sign as proposed; and the measurement errors or error variances, δ_1 to δ_4, are all relatively small as one may expect. Noticeably, the difference between Diagram 2.2 and Table 2.4 in terms of parameter estimates is due to rounding.

Table 2.3: summary of descriptive statistics of the data

Variable	N	Minimum	Maximum	Mean	Std. Deviation
PATENT	50	.020473	2.213117	.30930654	.378467702
SBIR	50	.016615	.586684	.09393636	.099163712
VC	50	.000000	3.206873	.36024500	.578126853
NTE	50	.339456	1.413815	.72130275	.256365579

From Table 2.4, one can see more accurately. The estimated scores for these four factor loadings, λ_1, λ_2, λ_3, and λ_4, are 0.18, 0.085, 0.52, and 0.20 respectively; the estimates for measurement errors, δ_1, δ_2, δ_3, and δ_4, are 0.11, 0.0027, 0.062, and 0.026 correspondingly. The standard errors (inside parentheses) for all these estimates are very small; and *t* – statistics (Z-scores) below each corresponding parentheses are all greater than 1.96 at the 0.05 level. Additionally, R-squares for measurement equations (1) to (4) are 0.24, 0.73, 0.81, and 0.60 respectively. These all suggest that the estimates of these

Diagram 2.2: LISREL Path Diagram with Output for the CFA Model



```
Chi-Square=1.95, df=2, P-value=0.37668, RMSEA=0.000
```

parameters are not only meaningful but also, to a large extent, statistically significant.

In addition to the adequacy of these estimates and the statistical significance of these measurement models, the overall model goodness-of-fit statistics also have to be

Table 2.4: LISREL Estimates (Maximum Likelihood) of the CFA Model

```
  PATENT = 0.18*PE,  Errorvar.= 0.11,   R2 = 0.24
            (0.053)             (0.023)
             3.46                4.77

  SBIR = 0.085*PE,  Errorvar.= 0.0027,   R2 = 0.73
          (0.012)              (0.00085)
           7.10                 3.12

  VC = 0.52*PE,  Errorvar.= 0.062,   R2 = 0.81
        (0.068)             (0.028)
         7.68                2.24

  NTE = 0.20*PE,  Errorvar.= 0.026,   R2 = 0.60
         (0.032)             (0.0065)
          6.19                4.03
```

acceptable or plausible. There are many criteria with which the goodness-of-fit can be assessed. Table 2.5 below contains statistics of some selected goodness-of-fit indices which are developed by statisticians. In general, a small Chi-Square (χ^2) value relative to its degree of freedom is indicative of good model fit (Byrne 1998); however, it is affected by sample size. Given χ^2 limitation, other goodness-of-fit indices have been commonly used to judge overall model fit or plausibility with suggested values. For example, the Root Mean Square Error of Approximation (RMSEA) proposed by Steiger and Lind (1980) and the Root Mean Square Residual (RMR) (Jöreskog and Sörbom, 1989; Hu and Bentler, 1995), with a value less than or equal to 0.05, are indicative of good fit;

Table 2.5: Goodness of Fit Statistics for the Overall CFA Model:

Degrees of Freedom = 2
Minimum Fit Function Chi-Square = 2.10 (P = 0.35)
Normal Theory Weighted Least Squares Chi-Square = 1.95 (P = 0.38)

Root Mean Square Error of Approximation (RMSEA) = 0.0
90 Percent Confidence Interval for RMSEA = (0.0 ; 0.28)
P-Value for Test of Close Fit (RMSEA < 0.05) = 0.42

Normed Fit Index (NFI) = 0.98
Comparative Fit Index (CFI) = 1.00
Incremental Fit Index (IFI) = 1.00
Relative Fit Index (RFI) = 0.94

Critical N (CN) = 216.13

Root Mean Square Residual (RMR) = 0.0026
Standardized RMR = 0.028
Goodness of Fit Index (GFI) = 0.98
Adjusted Goodness of Fit Index (AGFI) = 0.90

---

according to Byrne (1998), other indices such as Normed Fit Index (NFI), Comparative Fit Index (CFI), Incremental Fit Index (IFI), Relative Fit Index (RFI), and Goodness of Fit Index (GFI) with a value equal or greater than 0.90 are also indications of good model fit. In addition, Critical N (CN) with a value that exceeds 200 suggests that a model adequately represents the sample data. Since the actual statistics from the model output in table 2.5 have met the criteria of these suggested values of good fit, I conclude that the proposed confirmatory factor analysis (CFA) model in measuring performing technology entrepreneurship is plausible.

Implications

This study has indicated that, although the nature of entrepreneurship to a certain extent contributes to the difficulty of measuring entrepreneurship, entrepreneurship can still be reasonably measured with appropriate classifications and careful tracing of the trails of entrepreneurial activities. Confirmatory factor analysis under the framework of latent variable modeling has been demonstrated to be a conceivable way for selecting indicator measures of performing entrepreneurship. With such selection of measures of entrepreneurship, empirical test of hypotheses on factors that may contribute to the emergence and performance of entrepreneurship becomes possible. Two ways of conducting such empirical tests may be suggested. One is to test hypothesis using a full latent variable model that incorporates both the measurement model and the structure model, including dependent and independent variables. While incorporating both unobserved and observed variables into one model structure as an advantage, a full latent variable model requires a large sample of data; however, in many cases, the availability of data can be a restriction. In such circumstances, one could still form a single dependent variable based on the standardized factor loading scores obtained from a similar confirmatory factor analysis, and then, a traditional multivariate procedure may be used in hypothesis testing.

In addition to forming dependent variable for empirical test of important promoting factors of entrepreneurship, the measures developed in this study can also be used as a benchmark of entrepreneurial activities in regions. For such a purpose, I calculate the performing technology entrepreneurship index (PEI) based on the results obtained from the CFA model estimates as the following:

PEI = sum [(data on each indicator variable / sample average) * factor score]

Table 2.6 below demonstrates the difference between the PEI index developed in this study by using multiple indicators and the Entrepreneurial Activity Index developed by Kauffman Foundation. The latter is calculated as the percentage of the population of

Table 2.6: Comparison between PEI and Kauffman Index:

PEI		**Kauffman Index**	
Top 5 states	***Bottom 5 states***	***Top 5 states***	***Bottom 5 states***
Massachusetts (6.060112)	Arkansas (0.040582)	Vermont (550/100,000)	Delaware (160/100,000)
California (4.140776)	Mississippi (0.033788)	Colorado (530/100,000)	West Virginia (170/100,000)
Colorado (2.852286)	West Virginia (0.020473)	Montana (490/100,000)	Alabama (170/100,000)
New Jersey (2.211533)	Louisiana (0.038827)	Wyoming (480/100,000)	Kentucky (180/100,000)
New Hampshire (2.153740)	Alaska (0.029625)	Idaho (470/100,000)	Pennsylvania (180/100,000)

adult non-business owners who start a business each month (the actual fraction inside parenthesis in table 2.6 under the Kauffman Index is taken from Kauffman Index of Entrepreneurial Activity State Report 2005 by Robert W. Fairlie). From Table 2.6, one can see a huge difference between the two measures of entrepreneurship. Since each measure may have its pros and cons, comparison should be made with great caution, and future research is much needed.

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ESSAY THREE: THE REGION AS AN ENTREPRENUER’S OPPORTUNITY SET: AN EMPIRICAL ANALYSIS IN THE CASE OF TECHNOLOGY ENTREPRENEURSHIP IN THE UNITED STATES

Introduction

In entrepreneurship studies, the entrepreneur’s vision is often considered a unique, individual phenomenon (e.g., Hagen 1962; McClelland 1961, 1987; Khilstrom and Laffont, 1979; Kirzner 1979, 1997; Casson 1982). However, recent literature in economic geography (e.g., Porter 1990, 1998; Feldman and Francis 2004) indicates that entrepreneurial and industrial activities tend to cluster geographically, suggesting that the ability to convert entrepreneurial ideas into entrepreneurial action varies systematically across regions. After all, entrepreneurs choose a “region” to start their businesses. This is especially true for entrepreneurial activities in innovative or technological production (Feldman 1994; Audretsch and Feldman 1996). The fact of geographic concentration of entrepreneurial activities has certainly suggested that there must be something in the “region” facilitating the emergence of entrepreneurship and the formation of industry clusters.

In this study, based on the classification of entrepreneurship as “conceiving entrepreneurship” and “performing entrepreneurship,” I argue that the “performing entrepreneurship” in a region depends largely on what I term the “entrepreneur’s opportunity set” that the region can provide. I further argue that the entrepreneur’s opportunity set has four major components, including the availability of strategic resources, the ease of recombining resources, the ease of founding the firm, and the security of doing business. A conceptual model is developed and states that performing entrepreneurship in a region is a function of the region’s availability of strategic resources, ease of combining resources, ease of founding the firm, and security of doing business. Because each of the variables in such a conceptual model can not be directly observed or measured, I originally proposed a full structural equation model with latent variables for empirical testing. Multiple indicator variables were chosen to manifest each of these latent variables in the case of technology entrepreneurship in the United Sates. Data on these indicator variables were collected from both 50 states and 265 metropolitan areas. Since the full structural equation model requires a large sample, the metropolitan areas data was first used to run the proposed model. Unfortunately, the model did not converge by using appropriate software (AMOS and LISREL), probably, as a result of the using of proxies as well as estimates for several indicators in the metropolitan area level data which provide inadequate information in confirming the proposed model. As a logical alternative, then, the OLS model is employed to test hypothesis using the state level data. The dependent variable, performing technology entrepreneurship, in the OLS model, is measured by an index data, which is based on the indicator variables and their corresponding factor score given by the confirmatory analysis (CFA) model conducted in Essay Two of this dissertation. Observable measures chosen in representing each component of the entrepreneur’s opportunity set are used as independent variables in the OLS model.

The results of the OLS estimates show that most of the independent variables employed in the model have the correct sign and several of them are statistically significant. While limitation of the study is acknowledged, the study contributes to entrepreneurship research as follows. First, the study introduces new ways of conducting empirical test in entrepreneurship research, and the proposed latent variable model of empirical test may be similarly used in future research when more accurate data become available. Second, the results of the study have some implications for regional policies in facilitating technology entrepreneurship and economic development.

The Region as the Entrepreneur's Opportunity Set

In economic literature, many studies of entrepreneurship or entrepreneurs have extensively focused on personal traits or unique human experiences of recognized entrepreneurs. For instance, Kihlstrom and Laffont's (1979) model has demonstrated that people with a preference for risk become entrepreneurs, a similar view as Knight's (1921) thoughts that entrepreneurs have a role to play in putting up economic actions in circumstances of risk and uncertainty. McClelland (1961 and 1987) contended that psychological needs for achievement propel people to pursue entrepreneurial action. In addition, Kirzner's (1979 and 1997) characterization of an individual's alertness to opportunity to profit, Casson's (1982) depiction of the entrepreneur's imagination and foresight, and Witt's (1999) interpretation of an individual entrepreneur's cognitive leadership, have also implied some sorts of individual attributes of entrepreneurs from unique perspectives. These arguments have all suggested that people may have different propensities to be an entrepreneur. Certainly, these studies have advanced our understanding of entrepreneurs and entrepreneurship when pertaining to individual human actors. However, one important phenomenon that has been overlooked by studies of entrepreneurship is that the emergence of entrepreneurship and enterprises are largely a regional and temporal phenomenon. For instance, Western Europe and the United States have persistently led the world in entrepreneurial innovation for centuries;

and in the United States, entrepreneurial activities have mainly clustered in its coastal areas such as the two famous technology industry clusters, “Silicon Valley” and “Route 128.” In Japan, the rising of entrepreneurship and modern enterprises occurred only after the Meiji-Restoration. Today, the massive emergence of entrepreneurial activities in China and India only happens after the disappearance of their ancient civilizations for hundreds of years but still concentrates in a handful of regions. These all suggest that there are geographic concentrations of entrepreneurial activities and uneven distributions of entrepreneurship across regions.

Literature in external economies (e.g., Marshall 1890 / 1920; and Arthur 1994), economics of geography (e.g., Krugman 1991a and 1991b; Feldman 1994; and Henderson 1994), as well as industry clusters (e.g., Porter 1990 and 1998; and Arthur 1990) documents the phenomenon and argued that regional competitiveness is provided by positive externalities derived from geographic proximity of co-location of firms or positive feedback process triggered by historical accident. Still, this argument alone may not be sufficient enough to explain why entrepreneurs start and grow their firms in certain locations. Therefore, there must be underlying incentive that the region can offer to entrepreneurs. Although studies have linked the concentration of entrepreneurial activities and the formation of firms and industry clusters (e.g., Feldman 2001; and Feldman and Francis 2001), “the region” as an incentive structure for “individual entrepreneurs” to actually perform their function has not been investigated in depth theoretically and empirically. What is in “the region” that drives the emergence of entrepreneurship? The major inquiry of this proposed study is to look for answers to this specific question.

Based on the view that the economic function of entrepreneurship is either the forming of ideas from "discovering opportunities to profit" (Kirzner 1979 and 1997) or the carrying out of "new combinations of means of production" (Schumpeter 1912/1934), I argue that entrepreneurial ideas may be conceived but may not be actually carried out. Correspondingly, this study advocates that entrepreneurship can be classified as "conceiving entrepreneurship" and "performing entrepreneurship." The former refers to the conceiving of new ideas of a business; and the latter is the actual execution of that idea. I further argue that the "performing entrepreneurship" is a function of what I refer to as "an entrepreneur's opportunity set" that a region presents, and the opportunity set constitutes the region's incentive structure for entrepreneurial activities. The entrepreneur's opportunity set is made of four important components, including availability of strategic resources, the ease of founding a firm, the ease of recombining resources, and the security of doing business (represents the risk of doing business with a reversed sign). Further explanation on each component of the opportunity set is provided below.

(1) The availability of strategic resources. According to Schumpeter (1912 /1934), entrepreneurs combine resources to make new products and services. Without key resources or inputs, entrepreneurs cannot organize profitable production. In the early age of industrialization, natural resources, such as land, water ways, and mines, were more important to economic production. However, human resources, especially intellectual capital, are key strategic assets in the age of technology. This is consistent with the resource-based theory of the firm (e.g., Wernerfelt

1984 and Barney 1991), in which the relationship between profitability and strategic resources has been illustrated.

(2) The ease of recombining resources. Again, according to Schumpeter (1912/1934), the function of an entrepreneur is to carry out “new combinations of means of production.” However, how efficient an entrepreneur can perform such a function depends not only on his ability but also on the ease of the flow of economic goods. In addition, the conceiving of new ideas of doing business or the finding of new means of production is based mostly on human interaction, particularly in the age of the knowledge-based economy. A region that facilitates the transactions of economic goods and the exchange of ideas, as suggested in Essay One of this dissertation, can provide a larger and better opportunity set for entrepreneurial performance.

(3) The ease of founding a firm. No matter what the economic function entrepreneurs perform, they need a firm to carry out their function (e.g., Witt 1999; Foss and Klein 2004). How easily a firm can be founded in a region is also an important factor of the entrepreneur’s location decision.

(4) The security of doing business. Entrepreneurs are generally conceived as risk-takers. This may or may not be true because an entrepreneur could have unique ways to reduce risks, but a region that can provide means to reduce the risks of doing business certainly offers favorable conditions for entrepreneurs. A region with low risk of doing business is equivalent to high security rate of doing business.

Based on these arguments made above, I hypothesize that performing entrepreneurship within a region (conceiving entrepreneurship is largely unobservable but would be partially conveyed by performing entrepreneurship) is a function of the entrepreneur's opportunity set that the region can provide. Accordingly, a conceptual model can be stated as:

$$PE = f\,(ASR, ERR, EFF, SEC) \tag{1}$$

Where,

PE: the performing entrepreneurship in a region;

$f\,(\bullet)$: a function represents the entrepreneur's opportunity set;

ASR: the availability of strategic resources;

ERR: ease of the recombining resources;

EFF: ease of founding a firm;

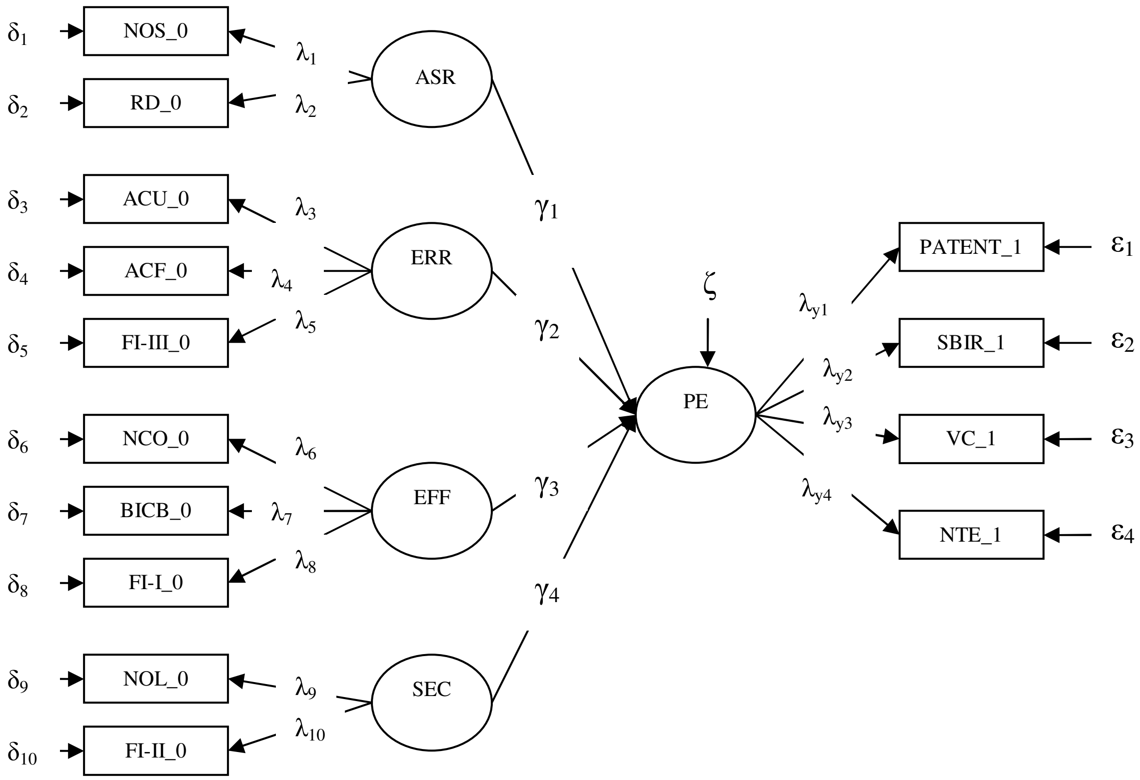
SEC: security of doing business.

Method and Empirical Model

The proposed structural equations with latent variables model

As one can see, all these variables in the conceptual model above cannot be directly observed or measured. A direct empirical test of the relationship between the dependent variable and independent variables is difficult. However, an empirical test of the hypothesis can be feasible under the framework of structural equations with latent variables. In such a framework, those unobservable and immeasurable variables can be treated as latent variables, and more than one observable or measurable indicator variables are usually chosen corresponding to each latent variable. As such, the relationship between the latent dependent variable and latent independent variables can be revealed indirectly. Diagram 3.1 below shows a proposed full structural equation model with latent variables in the case of technology entrepreneurship in the United States.

Diagram 3.1: The Proposed Full Latent Variable Model for Empirical Test



In the diagram, the variables inside rectangles are indicator variables, which are linked to their corresponding latent variable inside an oval. As for the case of high technology entrepreneurship, indicator variables with respect to each corresponding latent variable are specified as follows. For the latent dependent variable, performing technology entrepreneurship (PE), as demonstrated in Essay Two of this dissertation, four indicator variables are chosen to manifest it, including the number of technology patents granted (PATENT), the number of small business innovation rewards (SBIR), the amount of venture capital disbursement (VC), and the number of technology industry establishments (NTE) in time one.

For the latent independent variables, the number of scientists (NOS) and R&D investment (RD) in time zero are chosen as indicator variables to manifest availability of strategic resources (ASR); three indicators variables, including the number of anchor universities (ACU), the number of anchor firms (ACF), and "labor market freedom" represented by Freedom Index - Area 3 (FI_III) (less restriction on labor market freedom leads to higher score on FI_III), are selected to manifest the ease of the recombining resources (ERR); the number of technology consultants (NCO), the number of business incubators (BICB), and the "size of the government" measured by Freedom Index - Area 1 (FI_I) (the smaller the size of government the higher the score of FI_I), are used as indicator variables for the ease of founding a firm (EFF); and two indicators, including the number of intellectual property lawyers and "takings and discriminatory taxation" measured by Freedom Index - 2 (FI_II) (the smaller the takings and discriminatory taxation the higher of the score of FI_II), are employed to manifest the security of doing business (SEC). Further explanation on the underlying reasons for selecting these indicator variables will be provided in the following text of next section.

The advantages of such structural equation with latent variables modeling compare to conventional multivariate procedures, according to Byrne (1998), are as follows: (1) it takes a confirmatory, rather than an explanatory, approach to data analysis; (2) it offers explicit estimates of measurement errors while the conventional regression analysis is not capable of assessing them; and (3) its procedure incorporates both unobservable (latent) and observable variables rather than just uses observable measurement in the traditional regression modeling. However, a large sample of reliable data is required to produce acceptable outcomes for such a model with many variables. In an attempt to test the proposed full latent variable model (Diagram 3.1), I actually collected data on a sample of 265 metropolitan areas in the United States. Unfortunately, data for some of the indicator variables are either unavailable or incomplete. For instance, data on the three sets of freedom index, FI_I, FI_II, and FI_III, are only available at the U.S. state level. In actual testing, if a metropolitan area is within a single state, the state level data is used as a proxy measure for these three sets of Freedom Index of the metropolitan area; if a metropolitan area is across more than one states, then, the average of the freedom index scores of those involving states is used as a proxy measure for the metropolitan area. In addition to these three freedom-index indicator variables, there are no accurate data on the number of scientists (NOS) at the metropolitan area level; and the aggregated employment data on three occupational codes (15-0000: computer and mathematical occupations, 17-0000: architecture and engineering occupations, and 19-0000: life, physical, and social science occupations), are used as a proxy indicator for this variable. Even so, the data are still missing for many metropolitan areas. As a result, such a full structural equation model did not converge while using software based on the U.S. metropolitan area data set. While the U.S. state level data for all of these indicator variables are very reliable, a sample size of 50 is not near enough to run the model. However, I argue that the ordinary least square (OLS) model could be alternatively used based on the state level data, especially, with a successful selection of indicator measures of performing technology entrepreneurship in my previous essay. Detailed information on the alternative approach and data set is provided bellow.

The formation of the performing entrepreneurship index (PEI) and the OLS model

Since the confirmatory factor analysis (CFA) model in Essay Two of this dissertation has plausibly selected indicator measures for performing technology entrepreneurship, the forming of a single index of performing technology entrepreneurship for a region or a state becomes possible. Such an approach is similar to using G.P.A. and SAT scores to calculate an IQ score for an individual. Then, with a single measurable independent variable, OLS model can be reasonably employed. That is, an explanatory approach is still feasible with the forming of a single measure of the dependent variable. In the case of technology entrepreneurship, I use the data and results from Essay Two to calculate the performing technology entrepreneurship index as previously stated:

$$\text{PEI} = \text{sum}\,[(\text{data on each indicator variable} / \text{sample average}) * \text{factor score}] \qquad (2)$$

Where, PEI stands for performing technology entrepreneurship index for each region or state; “data on each indicator variable” represents actual data of each indicator variable for a region or state; “sample average” is actually the national average on each indicator variable; and “factor score” is the factor loading, obtained from the confirmatory factor analysis conducted in Essay Two, corresponding to each indictor variable.

To build the OLS model for empirical testing, I use the following argument on choosing independent variables and specific hypotheses with respect to the conceptual model previously proposed (equation 1), particularly, in the case of technology entrepreneurship. As previously mentioned, the availability of strategic resources has been argued an important component of the entrepreneur's opportunity set. While natural resources are important for traditional economic production, human or intellectual capital is critical to technological or innovative production. In addition, economic literature (e.g., Pakes and Griliches 1980) has long argued the importance of investment in research and development (R&D) in innovation. Therefore, in the case of technology entrepreneurship, I choose two independent variables of the OLS model as proxies of the availability of strategic resources and hypothesize respectively the follows.

Hypothesis 1a: a region's performing technology entrepreneurship (PEI) is positively related to the number of scientists (NOS) of the region.

Hypothesis 1b: a region's performing technology entrepreneurship (PEI) is positively related to the region's R&D investment (RD).

For the ease of recombining resources, the significance of the presence of certain institutions in the region has been argued in economic literature. While investigating the role of existing firms in the formation of biotech industry cluster, Feldman (2003) adopts "anchor hypothesis" and uses the term, "anchor organization" to explain those existing role-model firms' attracting of skilled labor pools and intermediate industries and guiding economic production in the region to certain specialized industries. In this essay, I argue that besides attracting resources the anchor organization also provide a platform for the interaction of individuals, and thus, the ease of recombining resources. I name two types of anchor organizations, “anchor universities” (ACU) and “anchor firms” (ACF). In addition to Feldman’s anchor hypothesis, Hyde (2003) argues that various institutions in Silicon Valley that lead to what he terms “a high velocity labor market” are important for the formation of the high technology industry cluster, suggesting free move of individuals may ease entrepreneur’s recombining of resources. While direct data on those institutions largely unavailable, “labor market freedom,” to certain extent, can be measured by freedom index area 3 (FI_III), an index calculated by The Fraser Institute and the National Center for Policy Analysis (2005). This freedom index area score is calculated based on the following three data: minimum wage legislation (high minimum wages restrict the ability of employees and employers to negotiate contracts, leading to lower labor market freedom), government employment as a percentage of total employment (as government employment increases, labor market freedom decreases), and union density (the percentage of unionized workers in a state; high percentage reduce the labor market freedom). Hence, I hypothesize the follows:

Hypothesis 2a: a region’s performing technology entrepreneurship (PEI) is positively related to the number of anchor universities (ACU) of the region.

Hypothesis 2b: a region’s performing technology entrepreneurship (PEI) is positively related to the number of anchor firms (ACF) of the region.

Hypothesis 2c: a region’s performing technology entrepreneurship (PEI) is positively related to the region’s labor market freedom (FI_III).

Given the importance of new businesses to the U.S. economy and the fragility (high failure rate) of new business ventures (Birch 1979 and 1987), Barrow (2001) argues the needs for business incubations. However, the evidence on the impact of business incubators is only anecdotal. While business consulting service may have a similar role to play as business incubation, over control or restriction from the government may discourage the founding of new business in a region. Consequently, for the ease of the founding of a firm, I incorporate the following independent variables into the OLS model, the number of technology consulting firm establishments (NCO), the number of business incubators (BICB), and the size of the government (measured by the freedom index area 1, FI_I; smaller size of government represents less control and higher score on FI_I). I hypothesize correspondingly the follows:

Hypothesis 3a: a region's performing technology entrepreneurship (PEI) is positively related to the region's number of technology consulting services (NCO).

Hypothesis 3b: a region's performing technology entrepreneurship (PEI) is positively related to the number of business incubators (BICB) in the region.

Hypothesis 3c: a region's performing technology entrepreneurship (PEI) is positively related to the region's size of government (FI_I).

It is obvious that the risk of doing business in the region is an ultimate concern for entrepreneurs' decision of business location. As the sign of variable is considered, I would like to use the security of doing business here in stead of risk of doing business. Of course, political and social stability would be important factors defining the security of doing business. While such factors may not be relevant in the case of entrepreneurial practice at the U.S state level, particularly in technology sectors, I argue that the practice of intellectual property laws could secure individuals innovative production and settle disputes among innovators. In addition, takings and discriminatory taxations can be a concern for all type of businesses. Arguing that the former can be measured using the number of intellectual property lawyers (NOL) and the latter may be measured by freedom index area 2 (FI_II) data, I have the following two hypotheses respectively:

Hypothesis 4a: a region's performing technology entrepreneurship (PEI) is positively related to the number of intellectual property lawyers (NOL) in the region.

Hypothesis 4b: a region's performing technology entrepreneurship (PEI) is positively related to the "takings and discriminatory taxation" (FI_II) by the region.

Based on these hypotheses made above, the base OLS model states as:

$$\begin{aligned} PEI\_1 = {} & \beta_0 + \beta_1(NOS\_0) + \beta_2(RD\_0) + \beta_3(ACU\_0) + \beta_4(ACF\_0) + \beta_5(FI\_III) + \\ & \beta_6(NCO\_0) + \beta_7(BICB\_0) + \beta_8(FI\_I) + \beta_9(NOL\_0) + \beta_{10}(FI\_II) + \varepsilon \end{aligned} \tag{3}$$

meaning that the performing technology entrepreneurship index in time period one (PEI_1) is a function of these selected independent variables in time period zero, plus a residual (ε).

Data and Analysis

As stated in Essay Two, four observable variables were employed and confirmed to be good measures of performing technology entrepreneurship at U.S. state level by the confirmatory factor analysis. Detailed data information on these four variables is as follows (see Table 3.1 below). Data on the number of technology patents (PATENT_1) are based on 32 technology patent classes which largely cover both the ICT and Biotech industries (Table 2.2, Essay Two) and collected from the U.S. Patent and Trademark Office; and the average number of patents from 2000 to 2004 on a per capita basis is used. Data on venture capital investment (VC_1), for both information technology and biotechnology, are collected from the SDC Database managed by Thomson Financial Inc.; the average amount of venture capital disbursement over the period of 2000 to 2004 is utilized as million of dollars in per capita basis. Data on the number of small business innovation rewards (SBIR_1) are extracted from the TECH-*NET* Database, managed by the Office of Technology, Small Business Administration (SBA); and the average number of small business innovation rewards over the period of 2000 to 2004 is also calculated on a per capita basis. For the number of technology establishments (NTE_1), 10 NAICS (North American Industry Classification System) codes were used to define both the ICT industries and the Biotech industries (Table 2.1, Essay Two); and the number of establishments, based on these codes, is collected from the American Fact-Finder, United States Census Bureau, 2002 Census; and the data is scaled on per capita basis. Using the data on these four variables, the dependent variable in the OLS model (equation 3) is calculated according to the formula given in equation 2 above.

Data description and sources on these independent variables of the OLS model (equation 3) are also outlined in Table 3.1 below, along with those four indicator variables in measuring performing technology entrepreneurship. The number of scientists (NOS_0) is measured by the number of doctorate holders in science and engineering in per capita basis in the year of 1997, provided by the National Science Foundation (NSF). Data on R&D investment (RD_0) are also collected from the NSF, calculated as the average amount in thousand-dollars per capita over the year of 1995 to 1999. The anchor university (ACU_0) is defined as a university that received federal R&D investment during 1995 to 1999 (according to NSF), and the number of which is scaled by population in millions. Anchor firms (ACF_0) are the firms (defined by NAICS codes, Table 1 in Essay Two) with more than 1000 employees during 1995 to 1999; the number of which are also scaled by per million population, and the data were extracted from the database, Compustat, S&P. The number of business incubators

Table 3.1: Data Description and Sources

Variable	*Description*	*Source*
PATENT_1	Number of utility patents per capita, 32 classes, 2000-2004 average	U.S. PTO
SBIR_1	Number of Small Business Rewards per capita, 2000-2004 average	TECH-*NET*, SBA
VC_1	Amount of venture capital, mil./per capita, 2000-2004 average	SDC Database
NTE_1	Number of high-tech establishments (10 NAICS), 2002	U.S. Census
NOS_0	Number of S&E doctorate holders per capita, 1997	NSF
RD_0	Federal R&D investment in millions per capita, 1995-1999 average	NSF
ACU_0	Number of universities (with federal R&D) per million population, during 1995-1999	NSF
ACF_0	Number of firms (> 1000 employees) per capita (based on 10 NAICS codes), during 1995-1999	COMPUSTAT, S&P
BICB_0	Number of business incubators per million population, before 2000	NBIA
NCO_0	Number of technology consultants (NAICS 5416) per capita, 1997	U.S. Census
NOL_0	Number of intellectual property lawyers per million population, 1998	Martindale-Hubbell
FI-I_0	A measure of the size of government (the smaller the size the higher the score on FI_I), 1995-1999 average	Fraser and NCPA
FI-II_0	Taking and discriminatory Taxation (less takings and discriminatory taxation means higher the score on F-II), 1995-1999 average	Fraser and NCPA
FI-III_0	Labor market freedom (less restriction on labor market indicates higher score on F-III), 1995-1999 average	Fraser and NCPA

Sample: 50 U.S. states

(BICB_0) is based on the list of incubators, from the website of the National Business Incubation Association (NBIA), and with a follow-up of short telephone interview of each incubator; but only those have operations before the year of 2000 are counted, and the number of which is scaled by per million population. The number of technology consultants (NCO_0) is extracted from American Fact-Finder, 1997 U.S. Census data, based on the NAICS code 5416 (Management, Scientific, and Technical Consulting Services); and the number of employees under which are scaled in per capita basis. The number of intellectual property lawyers is extracted from Martindale-Hubbell Law Directory 1998 and scaled by population in millions. Data on the following three variables, FI-I_0 (size of the government; smaller the government size the higher the score on FI-I), FI-II_0 (takings and discriminatory taxation; the lower the takings and discriminatory taxation the higher the score on FI-II_0), and FI-III_0 (labor market freedom; less restriction on labor market means higher score on FI-III), are all provided by Fraser Institute in Canada and the National Center of Policy Analysis in the United States; all of which are the average of index scores over the year of 1995 to 1999. Descriptive statistics of the data is summarized in Table 3.2 below.

Table 3.2: Summary of Descriptive Statistics of the Data

Variable	N	Minimum	Maximum	Mean	Std. Deviation
PEI_1	50	.160219	6.060112	.985000	1.078350
NOS_0	50	.844182	4.684046	1.872732	.815084
RD_0	50	.030688	1.452203	.216551	.262798
ACU_0	50	1.901655	16.976771	5.161786	3.190569
ACF_0	50	.000000	6.102174	1.149973	1.122858
NCO_0	50	.395043	3.762573	1.449562	.842590
BICB_0	50	.000000	5.627322	1.470801	1.536669
NOL_0	50	.000000	54.862719	15.946332	12.844267
FI_I	50	5.440000	8.680000	7.317200	.715268
FI_II	50	4.620000	7.020000	5.748000	.527481
FI_III	50	5.840000	8.360000	6.878000	.680495

The results of the OLS models are shown in Table 3.3 below, including Model 1 (equation 2, the base model, untransformed with all variables), Model 2 (Log-transformed dependent variable, ln_PEI_1, with all variables), and Model 3 (Log-transformed dependent variable, ln_PEI_1, with reduced independent variables; those variables left out include anchor universities (ACU_0), the number of technology consultants (NCO_0), the number business incubators (NICB_0), "takings and discriminatory taxation" (RI-II_0), and labor market freedom (FI-III_0)). Results of all three models indicate that while most of independent variables are estimated with a positive sign, and several of them are statistically significant. In Model 1, the

Table 3.3: OLS Model Estimates in the Case of Technology Entrepreneurship in the U.S.

Variables	Model 1 Untransformed with all variables		Model 2 Log-transformed (ln_PEI_1) with all variables		Model-3 Log-transformed (ln_PEI_1) and reduced	
	Std. Coefficient	*t*-Statistic	Std. Coefficient	*t*-Statistic	Std. Coefficient	*t*-Statistic
Intercept	-2.254	-1.722	-3.479	-3.350	-4.248	-6.265
NOS_0	0.110	0.099	0.121	1.119	0.104	1.098
RD_0	0.243**	2.070	0.264**	2.282	0.274**	3.002
ACU_0	0.002	0.024	-0.037	-0.425		
ACF_0	0.680***	5.953	0.396***	3.522	0.419***	4.331
NCO_0	-0.111	-0.877	0.051	0.411		
BICB_0	-0.010	-0.121	0.006	0.067		
NOL_0	0.216*	1.959	0.181	1.664	0.232**	2.458
FI_I	0.154	1.353	0.362**	3.228	0.315***	4.018
FI_II	0.029	0.280	-0.118	-1.144		
FI_III	0.011	0.122	-0.005	-0.056		
Adj. R^2	0.735		0.743		0.759	

a Dependent Variable for Model 1: PEI_1; Dependent Variable for Model 2 and Model 3: ln_PEI_1

* $p < 0.1$; **$p < 0.05$; and *** $p < 0.01$

untransformed base model, the results show that three independent variables, including R&D investment (RD_0), anchor firms (ACF_0), and intellectual property lawyers (NOL_0), have a standard coefficient of 0.243, 0.680, and 0.216 at the significance level of 0.05, 0.01, and 0.10 respectively. The rest of the variables in the model are all above the significance level of 0.10. Adjusted R^2 for the model is 0.735.

While observing non-normality in the residual, the dependent variable in Model 2 is log-transformed. As a result, while R&D investment (RD_0) and anchor firms (ACF_0) remain at the same significant level as in Model 1 with standard coefficient of 0.264 and 0.396 correspondingly, the significant level of number of intellectual property lawyers (NOL_0) is a little above 0.10 with a coefficient of 0.181. However, the size of the government represented by FI-I_0 has become significant at the level of 0.05 with a standardized coefficient of 0.362. Also, a little improvement in R^2 is observed, adjusted R^2 changes from 0.735 in Model 1 to 0.743 in Model 2.

In Model 3, five independent variables, including the number of anchor universities (ACU_0), the number of technology consultants (NCO_0), the number of business incubators (NICB_0), "takings and discriminatory taxation" measured by FI-II_0, and labor market freedom represented by FI-III_0, are dropped from Model 2. Four independent variables, namely, R&D investment (RD_0), anchor firms (ACF_0), intellectual property lawyers (NOL_0), and the size of the government represented by FI-I_0, are all significant at the level of 0.05, 0.01, 0.05, and 0.01, and with a coefficient of 0.274, 0.419, 0.232, and 0.315 respectively. Still, there is a little improvement in R^2. Specifically, the adjusted R^2 changes from 0.743 in Model 2 to 0.759 in Model 3.

In addition, collinearity diagnostics shows that the tolerance values (defined by 1/VIF; VIF is the Variance Inflation Factors) for the parameter estimates are all less than 1, within the acceptable level.

Based on the analyses made above according to Table 3.3, one can conclude the follows corresponding to previously stated hypotheses (pp. 56-57). We do not reject *Hypothesis 1b* (a region's performing technology entrepreneurship, PEI, is positively relate to the region's R&D investment, RD), *Hypothesis 2a* (a region's performing technology entrepreneurship, PEI, is positively related to the number of anchor universities, ACU), *Hypothesis 3c* (a region's performing technology entrepreneurship, PEI, is positively related to the region's size of government, FI_I), and *Hypothesis 4a* (a region's performing technology entrepreneurship, PEI, is positively related to the number of intellectual property lawyers, NOL). These suggest that the components of the entrepreneur's opportunity set, at least, partially, exist. Specifically, evidence indicates that availability of strategic resources (ASR, represented by R&D investment), ease of recombining resources (ERR, represented by the presence of anchoring firms), ease of founding a firm (EFF, represented by the size of the government), and the security of doing business (SEC, represented by the intellectual low practice) do have an impact on the performing technology entrepreneurship in the region. Although the result shows that most other representative variables of the components of the entrepreneur's opportunity set have a correct sign, their importance are not statistically suggested.

Implications

While most of efforts in entrepreneurship research have been made in investigating unique individual characteristics of entrepreneurs and their business practices, this study has mainly focused on some regional factors that may comprise the entrepreneur's opportunity set. In general, the empirical results suggest that there are such regional factors representing the existence of opportunity set. Specifically, the following implications could be drawn in the case of technology entrepreneurial development: (1) R&D investment is a key strategic resource, which is consistent with many other studies in the area of innovative production; (2) the presence of anchor firms could be important to innovative entrepreneurs if such anchors are understood as a platform for both the interaction of individuals within and beyond the firm as well as the spin-off of new firms; (3) a smaller size of the government in terms of spending and restrictions on firms is suggestively another important factor for the emergence of entrepreneurship; and (4) the presence of the intellectual property lawyers may also have some effect in providing incentive for entrepreneurial activities in technology sectors. Although other factors have not been evidenced importance statistically, they may worth further investigation, especially when the quality measures of them become available. Also, the proposed structure equations with latent variables approach may be employed in future studies of entrepreneurship when adequate information can be obtained.

Ideally, the variables selected in this dissertation may be used in across country studies since the variation in certain institutional indicators could be much larger among countries than among states within a country. However, the difficulty in selecting uniformed measures across countries and the problem of data availability are unimaginable. Perhaps, this makes the limitation of the study inevitable.

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APPENDIX A.

Data Set for Empirical Test at the U.S. State Level

Variable State	PATENT_1	SBIR_1	VC_1	NTE_1	PEI_1	NOS_0	RD_0	ACU_0	ACF_0	NCO_0	BICB_0	NOL_0	FI_I	FI_II	FI_III
Alabama	0.085833	0.113033	0.074720	0.504225	0.399895	1.474381	0.464672	5.267816	0.687106	0.632793	2.061319	5.448724	6.500000	6.080000	8.260000
Alaska	0.029625	0.028066	0.000000	0.652412	0.223535	1.810861	0.166837	8.141572	1.628314	0.877697	0	0.000000	6.020000	6.000000	6.380000
Arizona	0.327911	0.094607	0.238102	0.663644	0.804138	1.294071	0.188116	1.901655	1.056475	1.675748	0.84518	19.249113	7.420000	5.780000	7.940000
Arkansas	0.040582	0.022504	0.007925	0.377964	0.160219	0.865022	0.041966	4.620095	0.770016	0.625507	0.770016	5.330716	7.060000	5.640000	6.420000
California	0.876778	0.159196	2.232914	0.949809	4.140776	2.105214	0.410674	2.858226	2.88896	1.907714	0.706873	47.532904	7.660000	5.520000	6.380000
Colorado	0.636990	0.301979	1.272527	1.339808	2.852286	2.575721	0.320377	4.227263	2.735288	2.408734	1.491975	31.093326	7.980000	6.260000	8.000000
Connecticut	0.603599	0.130727	0.552006	0.890012	1.513132	2.528850	0.232712	4.176130	2.38636	2.820549	0.894885	15.154433	7.940000	5.500000	7.240000
Delaware	0.475775	0.140007	0.204546	0.987879	0.972733	4.684046	0.071559	5.318409	1.329602	1.065887	3.988807	11.790367	8.680000	7.020000	7.520000
Florida	0.128151	0.038883	0.192436	0.737145	0.591927	0.844182	0.180886	1.978278	0.791311	1.858978	1.121024	10.783545	6.740000	5.360000	7.620000
Georgia	0.118902	0.033805	0.529042	0.842487	1.097037	1.254376	0.465614	3.773675	1.431394	2.111359	1.821774	16.404834	8.060000	6.360000	7.320000
Hawaii	0.070403	0.074449	0.166483	0.546014	0.500046	1.997293	0.132648	4.140593	0	0.808821	1.656237	18.926412	6.940000	5.300000	6.120000
Idaho	2.213117	0.050535	0.304292	0.602691	1.939990	1.619835	0.175120	3.258959	1.62948	0.716309	4.073699	3.992558	7.280000	5.520000	6.700000
Illinois	0.237652	0.032667	0.302324	0.854702	0.841242	1.724971	0.095493	3.364681	1.148916	3.486870	1.06685	35.202525	8.280000	6.000000	6.560000
Indiana	0.173729	0.026140	0.055216	0.519600	0.348530	1.252673	0.069501	2.688480	0.33606	0.914653	2.35242	6.334516	7.900000	6.320000	7.200000
Iowa	0.303642	0.023488	0.016425	0.559581	0.376824	1.393924	0.079784	5.532887	0.345805	0.600460	1.383222	1.033459	7.660000	5.700000	6.180000
Kansas	0.129756	0.035388	0.139528	0.699367	0.502854	1.411608	0.070835	3.790811	0	1.520135	2.653568	3.758554	7.500000	5.520000	7.220000
Kentucky	0.050579	0.016615	0.051390	0.433654	0.238891	1.006895	0.030688	2.782957	0.252996	0.629689	1.26498	7.025661	7.020000	6.100000	6.360000
Louisiana	0.038827	0.016959	0.028384	0.412737	0.193355	1.178447	0.047629	3.619929	0.452491	0.911544	2.941192	10.134350	7.160000	6.500000	7.960000
Maine	0.067089	0.076342	0.089074	0.624529	0.409863	1.705486	0.069310	7.970352	1.59407	0.728418	5.579246	15.089820	6.320000	4.620000	6.020000
Maryland	0.489760	0.254896	0.712761	1.086679	1.845815	4.005950	1.452203	5.620521	0.969055	2.639157	2.713355	11.720707	6.760000	5.680000	6.100000
Massachusetts	0.947539	0.586684	3.206873	1.258039	6.060112	3.687727	0.520631	7.386843	6.102174	3.762573	0.802918	51.978383	7.780000	6.000000	6.800000
Michigan	0.204960	0.050817	0.056983	0.586391	0.410104	1.503713	0.075974	2.857786	0.714447	1.652453	1.326829	18.582563	7.560000	5.520000	6.760000
Minnesota	0.473105	0.075298	0.472757	1.061406	1.320167	2.027967	0.149026	4.617330	3.14818	2.215439	0.839515	39.265286	8.020000	5.160000	6.440000
Mississippi	0.033788	0.019855	0.025672	0.339456	0.168808	1.069498	0.099568	5.403073	0	0.474252	2.881639	2.139164	5.960000	5.580000	8.000000
Missouri	0.139393	0.023408	0.170591	0.603762	0.515951	1.696711	0.214304	4.018308	1.461203	1.521749	2.374455	19.196760	7.160000	6.220000	7.100000
Montana	0.105152	0.164300	0.012815	0.727157	0.429985	1.775550	0.086121	15.756503	1.125465	0.814730	5.627323	13.446418	6.100000	4.960000	5.880000
Nebraska	0.105267	0.028919	0.058868	0.606340	0.340526	1.737410	0.051712	5.345859	1.187969	0.742402	1.187969	14.152479	7.940000	5.660000	6.820000
Nevada	0.053890	0.042835	0.066469	0.725598	0.367257	0.918313	0.169422	2.840938	0	1.674504	1.704563	5.935708	8.460000	6.160000	6.800000
New Hampshire	0.441787	0.260198	0.912739	1.239540	2.153740	1.841226	0.222130	6.723074	2.521153	1.505770	2.521153	19.072259	8.260000	6.320000	6.600000

(Continued)

Variable State	PATENT_1	SBIR_1	VC_1	NTE_1	PEI_1	NOS_0	RD_0	ACU_0	ACF_0	NCO_0	BICB_0	NOL_0	FI_I	FI_II	FI_III
New Jersey	0.619633	0.091504	0.953349	1.413815	2.211533	2.429793	0.194894	2.554828	2.554828	2.941789	1.338243	13.273133	8.020000	5.320000	6.360000
New Mexico	0.153899	0.235692	0.027551	0.619273	0.514310	4.011631	1.108403	6.215304	0	1.074464	4.520221	10.036332	6.020000	5.640000	6.740000
New York	0.328726	0.055449	0.471525	0.768390	1.135159	2.081307	0.137155	5.299347	1.71292	2.155383	1.177633	54.862719	7.200000	5.300000	6.020000
North Carolina	0.333315	0.044402	0.363111	0.630357	0.933069	1.759215	0.117186	4.181842	0.52273	1.273766	0.914778	14.982480	7.860000	6.340000	7.100000
North Dakota	0.053454	0.058170	0.037056	0.544532	0.288218	2.047048	0.079822	16.976771	0	0.661828	4.630028	0.000000	6.600000	5.180000	6.340000
Ohio	0.132199	0.092224	0.088270	0.592478	0.452077	1.613853	0.259401	3.370592	0.709598	1.632741	2.306194	18.388307	7.640000	5.460000	6.340000
Oklahoma	0.069111	0.033265	0.025540	0.532251	0.254766	1.313403	0.047404	3.557960	0.592993	0.887955	0	5.286042	6.800000	5.580000	6.680000
Oregon	0.610889	0.092714	0.333753	0.808837	1.145430	1.809758	0.101194	6.067159	1.213432	1.085249	0	14.616181	7.660000	6.080000	6.020000
Pennsylvania	0.302354	0.080028	0.349405	0.672243	0.939119	1.889954	0.163560	4.987233	1.5534	2.071997	0	14.127440	7.080000	5.620000	7.020000
Rhode Island	0.173439	0.099376	0.211670	0.669131	0.681925	2.340657	0.443853	3.894987	1.947494	1.083529	0	15.516581	6.660000	4.720000	6.080000
South Carolina	0.049195	0.027277	0.126761	0.394143	0.345572	1.196985	0.048248	5.181778	0.777267	0.840740	0	8.164859	6.980000	5.820000	8.360000
South Dakota	0.073502	0.035439	0.034126	0.526061	0.269966	1.343683	0.050661	14.781644	0	0.395043	0	8.042270	7.560000	6.280000	7.800000
Tennessee	0.077653	0.033132	0.114095	0.425711	0.357901	1.518394	0.109764	4.189197	0.182139	1.354189	0	12.926287	7.440000	6.360000	7.860000
Texas	0.464974	0.052774	0.505553	0.707657	1.244306	1.417910	0.194100	3.493488	0.961975	1.779252	0	14.535510	8.080000	6.520000	6.840000
Utah	0.311564	0.105855	0.501746	0.872608	1.243303	2.203055	0.164482	3.310826	0.472975	1.434580	0	34.626678	7.820000	6.140000	6.620000
Vermont	1.089512	0.120155	0.023722	0.811327	1.001967	2.930150	0.090250	10.050113	1.675019	1.096713	0	14.989607	7.100000	4.960000	7.240000
Virginia	0.128269	0.213599	0.702586	1.142044	1.598742	2.175956	0.680487	3.952934	2.488884	3.631474	0	23.909862	6.800000	6.220000	6.840000
Washington	0.655435	0.105417	0.900024	0.830487	2.006243	2.266180	0.214005	3.175986	1.058662	1.404820	0	31.718179	7.420000	4.960000	5.840000
West Virginia	0.020473	0.043159	0.013844	0.396225	0.180815	1.060957	0.132596	5.498718	0	0.658563	0	6.058573	5.440000	4.960000	6.480000
Wisconsin	0.168056	0.050380	0.074700	0.551558	0.404148	1.579883	0.065101	5.320893	0.380064	1.028823	0	19.442502	7.760000	5.260000	6.720000
Wyoming	0.046092	0.104207	0.000000	0.723382	0.321693	1.654915	0.069520	2.044701	0	0.680354	0	2.037544	7.800000	6.320000	7.900000

VITA

Jianhong Xue was born October 2, 1962, in Wugong, Shaanxi, China. After attending Shaanxi Health School, he finished a three-year program in Health Administration from Xi'an Medical University. He entered business school in the United States while he was in an exchange visitor program and received B.S. (1999) in Business Administration, and M.S. (2004) and Ph.D. (2007) in Agricultural Economics, from the University of Missouri-Columbia. He worked as a radio-therapeutic technician in university hospital from 1981 to 1987 and a secretary in university administrative office from 1990 to 1995, in Xi'an Medical University. In 1987, he married a nurse, Xiaoqin Jia of Xi'an, Shaanxi, China.