INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

Bell & Howell Information and Learning
300 North Zeib Road, Ann Arbor, MI 48106-1346 USA

UMI®
800-521-0800
THEORIES OF THE FIRM: THE RELATIONSHIP BETWEEN UNIVERSITY TECHNOLOGY TRANSFER AND NEW VENTURE CREATION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Masahiro Okada, M.B.A.

*****

The Ohio State University
1999

Dissertation Committee:
Professor Jay B. Barney, Advisor
Professor David B. Greenberger
Professor Michael J. Leiblein
Dr. David N. Allen

Approved by
Advisor
Business Administration Graduate Program
ABSTRACT

This study examined theories of the firm in the context of new venture creation as a way of commercializing university technologies. When technologies created through basic and applied research by university researchers are transferred to the private sector, it occurs mainly through licensing to existing firms or new venture creation. To explain the probability of new venture creation over licensing to existing firms, three models have been constructed based on the three theories in organizational economics: transaction cost economics (TCE), resource-based theory of the firm (RBT) and real options theory (ROP). The moderating effects of external variables surrounding technology transfer, such as the scope and continuity of technology, personal traits of entrepreneurs, and institutional pressures based on extant entrepreneurship literature have also been taken into consideration in these models.
A questionnaire survey has been delivered on-line to the inventors in US research universities. Based on the logistic regression analysis of the data obtained through this survey, it was found out that the resource-based theory of the firm has the largest explanatory power among three theoretical models. As a single variable, the technology inimitability has the largest and positive effect on the probability of new venture creation. This variable was initially included in the transaction cost economics model, the direction of the effect was opposite to the one predicted in transaction cost economics. This result suggests that inventors perceived technology inimitability not as an anti-opportunism attribute of their technology, but rather as a source of sustainable competitive advantage in the context of resource based view of the firm.
Dedicated to my family
ACKNOWLEDGEMENTS

I wish to thank my advisor, Professor Jay Barney, for intellectual support, which made this dissertation possible. Especially, his intellectual enthusiasm to explore the new frontiers of strategy theories has always been, and will continue to be, inspiring my research.

I also thank Professor David Greenberger for his support and understanding during my entire program not only physically but also mentally. His words have cheered me up and given me confidence and the feeling of being cared for.

I wish to thank Professor Michael Leiblein for his useful comments, suggestions and insights as well as mindset necessary as a young scholar.

I am deeply grateful to Dr. David Allen for giving me this indispensable opportunity to study the inside of university technology transfer. His practical and academic knowledge greatly helped me enrich this dissertation.

Finally, I deeply thank Kathy Hutton for her accurate handling of documents and deep care for me and my wife during my entire academic development at Ohio State.
VITA

March 18, 1962 Born - Sapporo, Japan

1985 B.A. Political Science, Waseda University, Tokyo, Japan


1993 M.B.A. Keio University, Yokohama, Japan

1994 Arthur D. Little (Japan) Inc.

1994-1999 Graduate Teaching and Research Associate, The Ohio State University

PUBLICATIONS

N/A

FIELDS OF STUDY

Major Field: Business
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedication</td>
<td>iv</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>v</td>
</tr>
<tr>
<td>Vita</td>
<td>vi</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xiii</td>
</tr>
<tr>
<td>Chapters:</td>
<td></td>
</tr>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Research interest</td>
<td>1</td>
</tr>
<tr>
<td>1.2 The definition of key terms</td>
<td>6</td>
</tr>
<tr>
<td>1.3 Why study new venture creation instead of existing firms?</td>
<td>9</td>
</tr>
<tr>
<td>1.4 Detailed description of research question: the possible modes of technology commercialization</td>
<td>12</td>
</tr>
<tr>
<td>2. University technology transfer</td>
<td>16</td>
</tr>
<tr>
<td>2.1 &quot;University&quot; technology transfer</td>
<td>16</td>
</tr>
<tr>
<td>2.2 Theoretical advantages: simplicity due to the unique feature of university technology transfer</td>
<td>17</td>
</tr>
<tr>
<td>2.3 Fundamental similarity between technology transfer by universities and by purely commercial firms</td>
<td>21</td>
</tr>
<tr>
<td>2.4 Practical advantages: commercial potential of university technology</td>
<td>24</td>
</tr>
<tr>
<td>2.5 University technology transfer mechanism</td>
<td>29</td>
</tr>
<tr>
<td>2.6 Economic incentives and conflicts of interest in university technology transfer</td>
<td>38</td>
</tr>
</tbody>
</table>

vii
3. Literature review ................................................................. 44
   3.1 Organizational Economics ............................................. 45
      3.1.1 Transaction cost economics ..................................... 45
      3.1.2 Resource based theory of the firm ............................. 49
      3.1.3 Real options theory ............................................. 55
   3.2 New Venture Creation Models in Entrepreneurship Literature ........................................... 60
      3.2.1 Individual level factors ......................................... 61
      3.2.2 Organization and group level factors ......................... 65
      3.2.3 Society, industry and market level Factors .................. 65
         3.2.3.1 Population ecology theory ................................. 65
         3.2.3.2 Institutional theory ....................................... 66
         3.2.3.3 Social network models .................................... 68
         3.2.3.4 Industry and market environment models ................. 69
      3.2.4 Interactive models ................................................ 70

4. Hypotheses ............................................................................ 74
   4.1 Level of analysis .......................................................... 75
   4.2 Uncertainty and the nature of technology ........................... 76
   4.3 Transaction cost economics ............................................ 80
   4.4 Resource-based theory of the firm ................................... 85
   4.5 Real Options Theory ...................................................... 92
      4.5.1 New venture creation as a real option vehicle ............... 93
      4.5.2 Licensing to existing firms as a real option vehicle ....... 94
      4.5.3 Capacity of capturing the real option Value .................. 96
      4.5.4 Rough simulation .................................................. 98
      4.5.5 The cost of each vehicle ......................................... 102
      4.5.6 Value of real option and the capacity to realize it ........ 103
      4.5.7 Uncertainty and the variance of real option value ........... 105
      4.5.8 Market signals ..................................................... 107
   4.6 Summary ........................................................................... 108

5. Control factors ..................................................................... 109
   5.1 Institutional factors ...................................................... 109
5.1.1 Supportiveness of university policies .... 110
5.1.2 Negative peer pressure on faculty
Entrepreneurship ......................................... 111
5.1.3 Academic orientation of the perception of
personal reward ........................................ 111

5.2 Personal experience ........................................ 112

6. Methodology .......................................................... 114
6.1 Population and the unit of analysis .............. 114
6.2 Preliminary interviews ............................................ 115
6.3 Data collection ..................................................... 115
   6.3.1 Creating database of potential
       Respondents ......................................... 116
   6.3.2 Privacy concern in collecting e-mail
       addresses .............................................. 118
   6.3.3 Sending solicitation e-mails ......................... 118
   6.3.4 Distributing the survey, collecting and
       recording answers .................................. 119
6.4 Validity .............................................................. 120
   6.4.1 Face validity ............................................ 120
   6.4.2 Content validity ..................................... 121
   6.4.3 Construct validity ................................... 121
6.5 Operationalization .................................................. 122
   6.5.1 Dependent variable .................................... 122
   6.5.2 Independent variables .................................. 122
      6.5.2.1 The degree of asset specificity ...... 125
      6.5.2.2 The degree of technology
          imitability as a source of
          the threat of opportunism ................. 126
      6.5.2.3 The degree of tacitness of the
          knowledge useful for the
          development and commercialization
          of the technology ............................ 127
      6.5.2.4 The stage of technology at the
          time of transfer ............................... 129
      6.5.2.5 Technology continuity ...................... 129
      6.5.2.6 The variance of future economic
          return on technology
          commercialization ............................ 130
      6.5.2.7 The degree of endogenous
          uncertainty ................................... 132
   6.5.3 Control variables .......................................... 132
      6.5.3.1 Institutional variables ..................... 132
APPENDIX A: Incentive schemes for individual inventors... 200
APPENDIX B: Variables and corresponding statements .......... 206
APPENDIX C: Solicitation e-mail to potential
  respondents ........................................................................... 210
APPENDIX D: Zero order correlation matrix ............................ 211
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 The economic impact of university technology transfer (FY1980-FY1996)</td>
<td>26</td>
</tr>
<tr>
<td>2.2 National R&amp;D expenditure by performers in FY 1997</td>
<td>27</td>
</tr>
<tr>
<td>2.3 Technology licensing process</td>
<td>37</td>
</tr>
<tr>
<td>2.4 The average share of net income for inventors</td>
<td>40</td>
</tr>
<tr>
<td>6.1 Cronbach's alpha after pretest #5 (n=23)</td>
<td>136</td>
</tr>
<tr>
<td>6.2 Cronbach's alpha after official run (n=140)</td>
<td>137</td>
</tr>
<tr>
<td>7.1 Classification table (Example. N=200)</td>
<td>150</td>
</tr>
<tr>
<td>7.2 The result of logistic regression (all models)</td>
<td>155</td>
</tr>
</tbody>
</table>
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Transaction cost economics perspective (H1)</td>
<td>84</td>
</tr>
<tr>
<td>4.2</td>
<td>The Relationship between knowledge tacitness and the productivity of new ventures and licensing to existing firms</td>
<td>86</td>
</tr>
<tr>
<td>4.3</td>
<td>The relationship between the degree of knowledge tacitness and the technology transfer mode (H2)</td>
<td>88</td>
</tr>
<tr>
<td>4.4</td>
<td>Real options theory perspective (H3)</td>
<td>107</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

1.1 Research interest

This study attempts to explain new venture creation from an organizational economics perspective. Traditionally, new venture creation has been studied by researchers in entrepreneurship and organization theory assuming that entrepreneurs have already determined that creating a new venture is the best way to exploit a rent opportunity. Based on this assumption, factors that facilitate or constrain the founding of new ventures have been studied.

However, entrepreneurial rent can be exploited not only through the direct creation of new ventures, but also through other means. For example, when a novel technology can be patented, it can be licensed to other existing firms, which in turn commercialize the technology and put it into the marketplace. The inventor of the technology can benefit from licensing royalties. If the inventor belongs
to an incumbent firm, the opportunity can also be exploited by intra-firm commercialization by the existing firm. Or, the exclusive rights to the technology can be assigned (sold off) to existing firms as a one-time economic exchange, in return benefiting the party in which original inventors are involved.

In the traditional venture creation or organization founding literature, new ventures or new organizations have already been assumed to be the best rent exploitation modes for inventors, and the choice decision among alternative modes of rent exploitation has been neglected (See Chapter 3 Literature Review). In other words, in entrepreneurship and organization theory literature on new venture creation, scant attention has been paid to the prior process to new venture creation and founding, in which the entrepreneurs make a decision on which governance mode they will use to commercialize their technologies. To fill this niche, this study tries to answer the following question: Why is, or is not, the new venture creation chosen as a means to exploit entrepreneurial rent opportunities over other means such as licensing to existing firms or assignment of rights to other firms?
The primary purposes of this dissertation are 1) to explain and predict the likelihood of new venture creation as a result of rent exploitation mode selection under high uncertainty, and ultimately 2) to add theoretical insights to the theory of the firm.

Regarding the first purpose, this dissertation involves two research questions. One is to examine the explanatory power of three theories of the firm as applied to selecting new venture creation as a mode of rent exploitation. Those three theories are transactions cost economics (TCE), resource-based theory (RBT) of the firm and real options theory (ROP).

The other question is how significant the moderating effect of entrepreneurship-related factors is on the relationship between the organizational economic factors and the likelihood of new venture creation. These moderating variables are mainly introduced from the current entrepreneurship and organization theory studies. The level of those moderating variables ranges individual, organization, industry, and society (community).

The second purpose of the dissertation is to contribute to the further development of the theory of the firm. The study of firm existence is important firstly because every
study of firm performance is based on the fundamental assumption of firm existence. Since Coase (1937), theory of the firm has been developed in two aspects of the firm: 1) the reason of firm existence and 2) the determinants of its scale and scope (its boundary). Of these two issues, this paper is intended to contribute especially to the issue of firm existence.

In addressing the two purposes of the dissertation, this research has several possible contributions: 1) emphasizing significant potential of the cross-fertilization between Entrepreneurship and Strategy research, 2) the development of a comprehensive model of new venture creation with multiple levels of analysis, and 3) demonstrating the great potential of real options theory in analyzing entrepreneurial activities under conditions of extremely high uncertainty.

The potential of cross-fertilization between Entrepreneurship and Strategy research has long been recognized. Sandberg (1992) proposed potential contributions of strategic management to a theory of entrepreneurship especially in the areas of new business creation, innovation, opportunity seeking, risk assumption, top management teams, and group processes in strategic decisions. This
dissertation addresses three of these potential areas of overlap: new business creation, opportunity seeking, and risk assumptions by applying strategic management theories such as TCE, RBT, and ROP. At the same time, this dissertation points out that the study of new ventures not only gives researchers a convenient sample of firms relatively free from the confounding effects of size, age, and diversification characteristic of large established firms.

Second, this study proposes a comprehensive model of new venture creation with multiple levels of analysis, including individual, organization, and society levels. This responds to the call for the multi-level model of new venture creation (Gartner 1985, 1988, Rumelt 1987, Dean, Meyer & DeCastro 1993). The model also enables researchers to test the applicability of the three important strategy theories in explaining the new venture creation phenomenon, which has never been tried in both entrepreneurship and strategy literature.

Last, this dissertation shows the great potential of real options theory in studying a variety of entrepreneurial phenomena under conditions of extremely high uncertainty. The applicability of this theory seems not limited to new
venture creation. Because of the theory's inter-temporal nature, it can also be applied to the sequential investment decisions by entrepreneurial ventures, which implies its applicability to the early growth process of the newly created ventures. Much more subsequent research is expected in both strategy and entrepreneurship applying this theory to various entrepreneurial phenomena.

1.2 The definition of key terms

Throughout this dissertation, key terms are defined as follows. First, "entrepreneurship" is defined as "combining resources in new ways" after the definition by Schumpeter (1934, 1950). He defines entrepreneurship as innovation, or a new way of combining resources. Based on the definition of the "entrepreneurship", "entrepreneurs" are broadly defined as individuals who are the holders of the potential entrepreneurial idea, or a new combination of resources, and have an interest in and intention of exploiting that opportunity and realizing economic rent. More specifically, entrepreneurs are the holders of an idea of a new way to combine resources to commercialize technologies. Thus, being an inventor of a new technology per se does not necessarily constitute being an entrepreneur.
Only when the inventor intends to generate economic rent through the commercialization of the technology, he/she is entitled to be called as an entrepreneur, or being entrepreneurial.

The term "technology" used throughout this study is defined as seed technology as a result of basic and/or applied research, which has a potential to be commercialized through further applied research and/or product development. In other words, in order to utilize the technology to create new and useful products that expand the market and economy, the technology should be transferred from the basic/applied stage to the development stage. Entrepreneurship, defined above as the new way of combining resources, is at the very heart of this transfer and commercialization process.

The term "venture" assumes the existence of high degree of risk and uncertainty in the business activities. J.S. Mill (1848) asserts that the assumption of risk is a key ingredient of entrepreneurial activity. Thus, by using the term "entrepreneurial new venture creation", I intentionally assume the involvement of new ways of combining resources (new technology) and a high degree of risk and uncertainty in a new business venture.
Uncertainty and risk should also be clearly distinguished. Based on Knight (1933), risk is defined as measurable probabilities, and uncertainty as the degree to which probabilities are unmeasurable. The practical difference between risk and uncertainty is that "in the former the distribution of the outcome in a group of instances is known (either through calculation a priori or from statistics of past experience), while in the case of uncertainty this is not true, the reason being in general that it is impossible to form a group of instances, because the situation dealt with is in a high degree unique" (Knight 1933: 233). Thus, entrepreneurial activities are not like gambling with an already-known probability distribution (risk), but are pursued under uncertainty in which the probability of success or failure of the business is imperfectly predictable.

Lastly, the "new"ness of the venture is an important delimitation of the dependent variable of this study. This study tries to explain "new" venture creation instead of corporate entrepreneurship or other forms of opportunity exploitation by existing firms such as vertical integration, diversification or merger and acquisition. The focus of this study is the formation of brand-new independent
entrepreneurial ventures being built from scratch, even though other forms of investment will play an important role as its alternatives.

Another basic assumption of this dissertation is the role of entrepreneurs as destabilizers or disequilibrators of economic systems through innovation (Schumpeter 1934). Entrepreneurs take advantage of uncertainty or market information asymmetry (Kirtzner 1978, 1982) in order to exploit economic rent. This entrepreneurial behavior can lead to the more efficient allocation of resources at the macro level.

1.3 Why study new venture creation instead of existing firms?

There are several reasons for choosing new venture creation as a specific field of study to contribute to the theory of firm existence. The first important reason is that this particular phenomenon represents the opportunity to study brand-new firm organizations coming into existence from a zero base. Compared to the new business unit generated by merger and acquisition, vertical integration, or spinning off from existing firms, the study of entrepreneurial new venture creation enables researchers to
directly examine firm “creation and existence” rather than the scope and scale, or boundary of the firm. Entrepreneurial new venture creation may offer one of the purest and simplest forms of how and why firms emerge in the first place, which may help crystallize the theory of firm existence.

The second reason to study new venture creation in this theoretical context is that its creation process shows a dynamic picture of firm initiation. While the question of firm existence itself seems static in its original sense of market versus firm, the dynamic process of venture creation, which begins with the stage of firm non-existence to its existence, may enable researchers to capture new insights that would not be available through comparing the transactions by already-established firms and the ones using the market in a static manner. In addition, the study of established firms especially large firms that are frequently taken for granted as a representation of firms in business literature may be confounded by the degree of their diversification (Rumelt 1974). The history of large firms may make the nature of sample firms relatively more complex than newly created ventures. Thus, as suggested earlier, new ventures may represent a purer and simpler form of firm
organization, and are more effective as a subject of the study than established large firms. Schendel and Hofer (1979, p.309) referred to small businesses that include new ventures as "the simplest, cleanest, and easiest environment in which to see the basic strategic management tasks" and "a ready laboratory for study of strategic management variables without the confounding of a large number of other variables as would be characteristic of larger, more complex firms."

Last, the new venture creation process has interesting and important characteristics that should not be dismissed by today's strategy research: high degree of uncertainty in terms of technology and product market demand. Especially in advanced technology sectors such as biotechnology, information technology, and high-tech engineering, the degree of uncertainty is quite high compared to other industries. A relatively newer strategy theory such as real options theory (or strategic option theory) seems quite applicable to the cases of new venture creation that involve high degree of uncertainty.

Overall, the study of new venture creation seems quite relevant to, and useful for answering the question of firm existence. At the fundamental level, new venture creation and the theory of firm existence share the same construct:
the birth of new firm organization. Given this important linkage between the two, it is expected that the theory of new venture creation, if successfully constructed through this study, will undoubtedly contribute to the further development of the original theory of firm existence.

1.4 Detailed description of research question: the possible modes of technology commercialization

Primary interest of this study is not the explanation of how new technologies are generated, but, after those technologies are made, how they can be exploited, or commercialized and become a source of economic rent.

Suppose that a new technology invented by a researcher through a basic and/or applied research exists and is owned by an organization to which the researcher belongs. For this technology to be exploited as a source of rent opportunity, not only the technology itself, but the complementary resources or assets (Teece 1986, Amit & Schoemaker, 1993) are indispensable. Should these assets or resources surrounding the technology not exist, the commercialization would not be successful at all.

The nature of complementary resources may vary significantly depending on the state of the technology at
hand. When the technology has already reached and finished its product development stage, capabilities in management, manufacturing and marketing such as specific production facilities and distribution channels become important complementary resources. However, when the technology is still at the initial stage of applied research or at the basic research level, supplemental know-how for applied research and product development as well as physical resources for these activities become necessary. Therefore, having the technology itself does not guarantee the successful commercialization. As Teece (1986) suggests, these complementary resources are often specialized for the technology.

In terms of the modes of technology commercialization, there are at least four possible ways: corporate venture, new venture, joint venture or alliance, and licensing to existing firms.

Corporate venture: The rent opportunity is pursued within the organization where the seed technology was created. Thus the technology transfer occurs inside the firm (internal transfer). So called spinoffs led by the corporate decision, not by individual inventors, are also included here. This type of corporate spinoffs often work as
subsidiaries of the parent corporation, and thus are examples of internal corporate ventures.

New venture: A current (or former) member of the organization who created the seed technology also holds an idea of new resource combination. In this new venture creation mode, this individual chooses to commit him/herself in creating a new independent venture of the parent organization. In this venture, he/she plays an important development and/or managerial role. The right to the seed technology is to be licensed from the parent organization either on exclusive or non-exclusive basis.

Joint venture and alliance: In joint ventures, the organization that owns the technology partners with other firms and create an independent entity. Joint venture negotiation process may be initiated by either the organization that owns the seed technology or the other firm(s), depending on which party has the idea of new resource combination in the beginning. When the firms do not form a new entity but simply cooperate (with or without equity position) in commercializing the technology, that is an alliance (no new venture creation).

Licensing to outside existing firms: The seed technology is licensed to existing firms. Licensing may be
exclusive or non-exclusive. Licensing, as defined in this dissertation, may or may not include cooperative arrangements between licensor and licensees. As is originally meant by the term, licensing is a selling of the right to use the technology. This is simply a market-based transaction. Who initiates the licensing negotiation depends on whether the owner of the idea of new resource combination is the potential licensor or the potential licensee.

As discussed above, new venture creation can be interpreted as one of the modes of technology commercialization. Under certain conditions, licensing to existing firms may be chosen over new ventures, and vice versa. This study tries to explain these conditions based on the three contending theories of the firm by specifically examining the technology transfer from universities to the private sector.
CHAPTER 2

University technology transfer

This section surveys the content and the surrounding issues of university technology transfer, which is the field of this study. The theoretical argument will be made in Chapter 3 Literature Review and in Chapter 4 Hypotheses.

2.1 "University" technology transfer

Why does this study specifically focus on "university" technology transfer? Why not the transfer of technologies in purely commercial setting? There are three reasons for the choice of this research context: theoretical advantages, practical advantages, and methodological advantages. In the following sections, the nature and characteristics of the university technology transfer will be discussed along with these advantages of this research context.
2.2 Theoretical advantages: simplicity due to the unique feature of university technology transfer

The mission\(^1\) and the role of universities, whether they are public or private, is generally regarded as research, education and a contribution to the public through those activities. Due to this public nature of their interest, "corporate venture" and "joint venture" in which universities hold an equity position with intentions to obtain a direct control and managerial authority in the venture is not allowed. In other words, universities are not supposed to be run as for-profit corporations. Most private universities and some public universities such as OSU currently allow themselves to receive a minority ownership interest in licensee firms. According to a senior officer of a technology transfer office, however, given their public nature, the universities' equity position is restricted to be minor and generally perceived as a substitute for license royalties, not the source of controlling and managerial role in the venture. The situation is quite similar in private schools. Harvard

\(^1\)For example, the mission statement of the Ohio State University reads "(T)o encourage and support research by its faculty, students, and staff that will serve to expand the body of general knowledge and enrich the educational program of the University." That of Cornell University reads "to serve society by educating the leaders of tomorrow and extending the frontiers of knowledge."
University, for example, does not allow itself to own majority share of equities in private firms (generally less than 15%), nor allow itself to hold a Board position.

The treatment of individual researchers is a little different between public schools and private schools. Researchers in public schools such as OSU are allowed to own equity in private firms, but their share should not exceed 5%; nor are they allowed to be fully employed by private firms due to their state employee status. For example, university regulations at OSU limit the researcher's commitment to the extent that the venture activities will not negatively affect their responsibility for research and education as a university faculty member.

In private universities, researchers face less restriction in owning equities in private firms. In the case of Harvard University for example, there is no limitation for individual researchers in terms of the equity positions at private companies.

In summary, it is important to note that despite the public nature of the institution, individual university inventors can commit themselves to the new ventures in which they may play an important technological and/or managerial
role even in public universities, and in private universities under certain restrictions.

Nevertheless, the researchers as university resources can be directly involved in the commercialization process only through creating new ventures. (Consulting for existing firms that licensed their technology is interpreted as indirect involvement and less commitment in commercialization process in this regard.)

After all, when the university and the researchers attempt to commercialize their technology, they have to transfer it to outside the realm of university. Therefore, the decision to make by the university inventors and the technology transfer office is now reduced to whether they choose 1) licensing to existing firms that are third party outsiders, or 2) creating new ventures and license the technology to them with original inventors actively involved in the ventures. The first choice is characterized as an arm's length market transaction, while the latter seems to have more direct governance over the commercialization by having direct involvement of inventors and equity position by inventors and in some cases by universities as well. (See theoretical reasoning of each transfer mode in Chapter 3. Literature review and mainly in Chapter 4. Hypotheses.) Then
the research question is under what conditions one mode of transfer mechanism is chosen over the other.

This choice restriction among the governance modes of university technology commercialization has an implication not dismissible in interpreting the result of this study. The case in point is how inventors would choose the transfer mode when they wanted to commercialize internally using university resources. Of course, internal commercialization is not a viable choice because of the public mission of universities, and the researchers have to choose either creating new ventures, licensing to existing firms, or give up commercialization. How this internal commercialization incentive, when it exists, would affect the transfer mode choice decision? Some would choose to let others commercialize (licensing to existing firms), while others would choose to create new ventures and be actively involved in them. At this point I assume this internal commercialization incentive works equally in inducing these inventors toward either new venture creation or licensing to existing firms. Details of this issue will be discussed in Chapter 7 Results, data analysis, and discussion.

In creating new ventures, most researchers intend to stay in the university, while some small numbers of others may decide to take a leave or even abandon their position as university employees. This issue is related to and will be discussed in 6. Economic Incentives and Conflicts of Interest in University Technology Transfer of this chapter.
2.3 Fundamental similarity between technology transfer by universities and by purely commercial firms

One concern when applying the theories of the firm to new venture creation in the context of university technology transfer is, of course, seemingly quite different objectives or missions of the university and those of the private firm. The university has been traditionally perceived, and thought it ought, to be “non-profit” or a creator of public good, whereas business firms are all “for-profit” by definition. How would the non-profit nature of the university affect the decision making by university inventors and technology transfer offices in choosing the appropriate mode of commercialization? This question should be answered before proceeding this study any further.

In general, the firm in the private sector tries to generate or acquire proprietary technologies given that the firm has an exclusive right (such as patent) to them, so that other firms cannot duplicate the similar technology at low cost. This exclusivity, or property right, is at the heart of the source of sustainable competitive advantage. On the other hand, the public sector such as government laboratories, universities or other non-profit organizations in principle try to generate technologies in the “public
domain” where the technologies are assumed to be available openly to the public in order to improve the welfare of society and economy at large.

This public nature of university technology is the most fundamental difference from the technology generated in the private sector. Unless the university technology is legally protected, its commercial potential should be very limited, because private firms would have very little economic incentive in taking risks to develop and commercialize those “public” technologies that are readily available to all other potential competitors.

However, the situation shifted drastically in 1980 because of legislation. The 1980 Bayh-Dole Act enabled small businesses and non-profit organizations such as universities to retain statutory rights to innovations made under federally-funded research programs as long as institutions are interested in patenting and commercializing those inventions. The 1980 Stevenson-Wydler Act enabled federally funded innovations to be licensed on exclusive basis to the private sector. This exclusivity was a crucial factor to motivate the private sector to seek for entrepreneurial rent opportunities by commercializing university technologies.

22
that have more uncertainty than those developed in private sectors.

The underlying rationale by the Federal Government behind this legislation was to enhance national economic competitiveness through increasing the return on federal investment in research and development. There is also a firm belief by the Federal Government that it is the private sector, driven by market principles, that commercializes seed technologies in the best possible way. According to Parker & Zilberman (1993, p.88) "Tight government budgets, a slow economy, and increased global economic competition in the early 1990s have led U.S. government agencies to increase pressures on universities to accelerate the transfer of technologies out of their labs into the private sector. Local, state, and national level governments are paying increased attention to promoting university research as an economic development tool."

Because of this legislation, the fundamental difference between universities and the private sector no longer exist in terms of the capability to establish the exclusive status of technologies. And still, the non-profit nature of the university can be and is maintained and ensured by returning
earnings allocated to the university back to the institution to support research and education.

Having said this, however, there still exists a continuous debate on conflicts of interest in the process of university technology transfer: between economic incentives and the university's academic mission. These conflicts will be analyzed later in II-6: Economic Incentives and conflicts of interest in University Technology Transfer.

2.4 Practical advantages: commercial potential of university technology

The study of university technology transfer and commercialization is also important because of its business implication: The university technology, through its transfer to the private sector, has a significant commercial potential. To fully exploit the potential, with a legislative support by the federal government since 1980, U.S. universities have been dramatically increasing their role in commercializing seed technologies by enhancing their systematic efforts to transfer their technologies to the private sector.

According to The Licensing Survey FY 1991-1995 and The Licensing Survey FY 1996 both by Association of University
Technology Managers (AUTM), Inc., before both Acts in 1980, only 250 patents on average was assigned annually to U.S. universities as a whole, and the inventions and discoveries were often kept on laboratory shelves untouched and never brought into market. However, during 1991 and 1996, the average number of patents granted annually to universities had increased for 1,600 to 2,095. During the same period, the number of licenses and options executed between universities and the private sector increased by 63 percent. Between FY1980 and FY1996, technology transfer by universities had helped to create 1,881 new venture corporations. As a consequence of all these efforts, the contribution of universities' licensing activities to the economy amounted $24.8 billion and 212,500 jobs maintained in FY1996. These statistics are summarized in Table 2.1.

Gross royalties in Table 2.2 represents the economic performance of licensing by universities as licensors. In a study of thirty Offices of Technology Licensing (Parker & Zilberman 1993), 60 percent of all invention disclosures lead to licensing agreements, and 25 percent of those ever return money to the university. Twenty nine out of thirty universities are earning return more than they expend. Economic contribution measures the economic impact of
technology transfer on the private sector. This economic contribution is calculated as a combination of gross sales revenue from licensed technologies and pre-market investment by licensees. University technology transfer and commercialization has a significant economic impact.

One significant characteristic of university research is its pivotal role in basic research. Roughly 60% of R&D activities in basic research nationwide and 15% of applied research are conducted by universities and colleges (Table 2.2). Private industries account only for 23% of basic research. Because of the two Acts that enabled the allocation of property rights to university technologies, there is enough incentive for the private sector to further
conduct applied research and development based on the technology generated by the universities' basic research.

<table>
<thead>
<tr>
<th>Performer</th>
<th>[SM]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>205,742</td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td></td>
</tr>
<tr>
<td>31,212</td>
<td></td>
</tr>
<tr>
<td>Fed. Gov.</td>
<td>8.61%</td>
</tr>
<tr>
<td>Industry</td>
<td>22.99%</td>
</tr>
<tr>
<td>Univ&amp;Col</td>
<td>60.50%</td>
</tr>
<tr>
<td>Other</td>
<td>7.91%</td>
</tr>
<tr>
<td>non-profit</td>
<td></td>
</tr>
<tr>
<td>Applied</td>
<td></td>
</tr>
<tr>
<td>46,208</td>
<td></td>
</tr>
<tr>
<td>Fed. Gov.</td>
<td>11.00%</td>
</tr>
<tr>
<td>Industry</td>
<td>69.68%</td>
</tr>
<tr>
<td>Univ&amp;Col</td>
<td>15.05%</td>
</tr>
<tr>
<td>Other</td>
<td>4.27%</td>
</tr>
<tr>
<td>non-profit</td>
<td></td>
</tr>
<tr>
<td>Development</td>
<td></td>
</tr>
<tr>
<td>128,323</td>
<td></td>
</tr>
<tr>
<td>Fed. Gov.</td>
<td>6.76%</td>
</tr>
<tr>
<td>Industry</td>
<td>89.09%</td>
</tr>
<tr>
<td>Univ&amp;Col</td>
<td>2.81%</td>
</tr>
<tr>
<td>Other</td>
<td>1.34%</td>
</tr>
<tr>
<td>non-profit</td>
<td></td>
</tr>
</tbody>
</table>


The recent significant growth of technology transfer from universities to private industries reflects the fact that industries have realized economic opportunities in university-owned seed technologies and are willing to tap into university technology resources (Foster, 1998), given the secured assignment of property rights to academic technologies under the legislation since 1980.

Since this legislation in 1980, the federal government’s technology transfer policy prioritizes smaller...
firms as receivers of university technologies over larger firms. The underlying rationale of this technology policy is that R&D cost is especially burdensome for smaller firms of which financial capability is relatively limited under the assumption of inefficient capital market, and that the new technologies as a result of R&D tends to be owned exclusively by larger firms and those firms earn monopoly rent by charging higher than normal price (Galbraith 1952). The legal arrangement in 1980 enables universities to allocate technological resources to wider range of firms and as a result to reduce the deadweight loss caused by the monopolistic or oligopolistic ownership of new technologies by larger firms. However, the recent massive capitalization by smaller high-tech ventures at the NASDAQ market, for example, may suggests that the efficiency of capital market has increased. The federal technology policy prioritizing smaller firms might see some changes in specific sectors such as internet related sectors.

The number of patents granted to university technologies and the commercialization efforts by technology transfer offices are continuously increasing. This fact implies that there is a significant economic potential in commercializing the university-generated technologies by the
hands of the private sector. The successful examples of new venture creation based on university technology licensing at Silicon Valley in California (from Stanford and UC Berkley) and Highway 128 area in Massachusetts (from MIT, Harvard, Boston and etc.) also demonstrates that scientific inventions and technological resources of universities possess incredible commercial potential (Parker & Zilberman 1993). This is one reason why the study of this type of technology commercialization is meaningful in a practical sense.

2.5 University technology transfer mechanism

Various ways exist in which technologies are transferred from university to the private sector. Some of the vehicles of technology transfer include: (1) Employment of graduated students by the private sector, (2) Consulting practices by professors, (3) Publication of papers and presentations at the conferences, (4) License of intellectual property to outside firms or new ventures, and (5) Formation of research consortia among universities and private firms. This study specifically focuses on the transfer through licensing activities that are economic transactions, not educational nor not-for-profit.
While research consortia, or joint research cooperation, is also an activity based on economic motives, they are less critical to this study. In the research consortia on one hand, private firms are usually involved in basic research, of which commercial potential is still highly uncertain (that is the primary reason to join such consortia), whereas in licensing, the stage of technology development is much closer to the product development and commercialization. Since the purpose of this study is to seek for the economic implication of technology commercialization, not the new technology creation process, the study of licensing activities is more important.

Beginning in the late 1970s and throughout 1980s, universities established formal offices of technology Transfer to increase university-industry interaction and to promote commercialization of university inventions (Parker & Zilberman 1993). As of 1998, about 800 officers in Technology Transfer Offices of 186 universities are registered as members of Association of University Technology Managers (AUTM).

University technology transfer studied in this dissertation can be characterized as for-profit in that earnings allocated to individual researchers are personally disposable income, and the new venture creation based on university technology eventually leads to personal profits of entrepreneurs. Of course, the earnings allocated to the university itself are spent for non-profit purposes to comply with the university mission.
Currently, most major research universities in the U.S. have a “Technology Transfer Office”, sometimes called the “Office for Technology Licensing.” These offices are fully responsible and given authority to capture and manage all inventions generated within the university facilities and to transfer those technologies into marketplace. They work as a liaison or coordinator between individual university inventors and the private sector. The practical functions of the office include to protect those technologies by patents and copyrights, and to market those technologies to potential licensees in the private sector.

The process of technology transfer through the Technology Transfer Office consists of three phases: (1) Invention disclosure and screening, (2) the Invention Marketing and Patent Application, and (3) Licensing and the Prosecution of the Patent Application and Patent Issuance.

In the Ohio State University, for example, the technology transfer process is strictly divided into the above three phases and the duration of each phase is predetermined to guarantee and accelerate its progress. The director of the Office explained: “On a continuum of typicality (strict to lax), our approach is much more on the strict side in that the progress of each stage is guaranteed
by the fixed schedule and articulated procedures. This is because we needed some confidence building mechanism when we began invention disclosure activities so that researchers feel they can rely on the system. That's why the stage approach was created.” Even though few other AUTM office have such a strict step-wise approach, the element of the system is eventually similar to one another, and these steps are helpful to understand the technology transfer process in general.

Phase I: Invention disclosure and screening: The inventors in universities are required to send the Invention Disclosure Report to the Office as long as the invention is made “with more than incidental use of” university resources, or “if the inventor’s research was sponsored by the U.S. Government or other outside entity, or if the invention was developed as part of the inventor’s obligations to” the university. Only when “an inventor develops an idea, completely unrelated to” his/her “responsibilities to the university, the inventor will own the invention.” The main task of the Office at this point is to capture all the inventions by university researchers, whether they are faculty, staff or students.
The Office then make the first screening to dismiss obviously "unpatentable, non-novel and/or commercially non-viable inventions" (the first screening). Next, the more detailed screening is conducted for those inventions that passed the first screening, concerning "patentability, novelty, and commercial and license potential" (the second screening). When a disclosed invention passes both screenings, the following four actions are made by the Office at the end of phase I. (1) Filing "a patent application if patent filing costs can be covered" by potential licensees, (2) initiating the first eight months period of marketing (extendable) to the private sector by the Office to "identify an optionee or licensee that at minimum is willing to cover patent costs", (3) sending a memo to the inventors that the invention is now in the process of further analysis and marketing. Whenever the disclosed inventions did not pass the screenings, the "inventions" becomes the inventors' intellectual property, and they are eligible to pursue patent filing or any other actions for themselves. This phase usually takes eight to ten weeks from the date of the submission of the Disclosure Report.
Phase II: Invention marketing and patent application: The Office markets “non-confidential and confidential versions of Invention Disclosure Report to potential optionees and licensees.” The Office works “with the inventor(s) and other interested parties to identify and solicit commercial interest.” The Office can add another eight months period of marketing to the initial eight months with “either indications of commercial interest or mutual agreement between the inventor(s) and” the Office. “If the inventor(s) believe” the Office “is not diligently pursuing commercial interest in their invention, the inventor(s) may request assignment rights to the invention.” An ideal outcome of this phase is that the Office identifies the licensee of the technology who is willing to cover patent filing costs.

Phase III: Licensing and the prosecution of the patent application and patent issuance: Acquiring a patent is a long and time consuming process. After the first application is sent to the United States Patent and Trademark Office (USPTO), “far more frequently, however, the First Office Action”, which is the USPTO’s initial conclusion about the patentability, “will be a rejection based on the novelty, utility, or non-obviousness requirements. The applicant has
the right to require the Patent Office to reconsider its conclusion by distinguishing the invention from prior art, demonstrating that it was not obvious, or by modifying the application's claims to avoid the objections.” When an argument was made by the applicant, USPTO then responds “to the applicant’s arguments by either accepting, rejecting, or responding to the arguments with some mixture of acceptance and rejection” (a Second Office Action). “When the decision is a full rejection, the Second Office Action is often a final rejection.”

“However, frequently the door is still open for further argument because other approaches, within the USPTO and the courts may be used to overcome” the USPTO’s rejection. Ultimately, the USPTO “either accepts or rejects the arguments of the applicant. If accepted, the Patent Office issues a Notice of Allowance. After the payment of required fees, the patent issues in due time. If rejected, a notice of Final Rejection is issued.”

During the course of patent application actions described above, the inventor, the Technology Transfer Office, and the licensee review the decision by USPTO. But, it is basically the licensee to decide whether it continues the prosecution or not. If the licensee returns the
invention to the university, the Office will have another new eight months period to find a new licensee for the invention.

The whole process described above is charted in Table 2.3 Technology licensing process in the next page.
Submission of Invention Disclosure Report (IDR) by inventors to the Technology Licensing Office (the Office)

The first screening by the Office to dismiss "unpatentable, non-novel, and/or commercially non-viable inventions"

Pass

The second screening of "patentability, novelty, and commercial and licensing potential" by the Office

Pass

Phase I: 8 to 10 weeks

Not pass Inventors own intellectual property rights (IPRs)

Licensee identified

Initiating the first 8 months of marketing to find optionees or licensees

Joint effort by the Office and inventors to identify and solicit commercial interest

Licensee identified

Identification of licensees who are at least willing to cover patenting costs

Prosecuting patent application

Patent evaluation by the USPTO

Accepted

Licensing patented technologies

To existing firms

Table 2.3: Technology licensing process
2.6 Economic incentives and conflicts of interest in university technology transfer

This study assumes that the university inventors with a support of technology transfer offices, choose the best possible mode of technology commercialization. But, "best possible" in what sense? On one hand, the examination of the incentive structure of university technology transfer clearly shows that both individual inventors and the university, colleges and departments are allowed to earn economic returns from successful commercialization, thus are motivated to maximize them. However, there have been and still are continuing concerns on conflicts of interest between economic motives and academic missions. In this section, how similar (or different) university inventors and their surrounding environments are to purely commercially-motivated industry inventors.

First, the incentive schemes associated with university technology commercialization vary widely among AUTM registered universities. Each university adopts unique formula to calculate the proportion for individual inventors. However, when roughly averaged, the incentive structures have common features: 1) deducting costs for patenting, licensing, and marketing from the gross royalty income to
get the amount of net income, 2) allocating a certain percentage of the first some amount (it varies among universities) to individual inventors, 3) allocating the decreasing portion of the accumulated amount which exceeds the first amount to individual inventors.

Since a rough estimate of the proportion of net income allocated to individual inventors is sufficient information for the sake of the discussion in this section, 10 private universities and 10 public universities (total 20) were randomly selected to see the range of percentage given to individual inventors as accumulated amount of income increases in each incentive scheme (Table 2.4). The result was that, on average, 36.6% of the net royalty income goes to individual inventors as personal income, and the rest are divided among the university at large, the college and the department to which inventors belong.
<table>
<thead>
<tr>
<th>University (PR=private, PUB=public)</th>
<th>Range of % for inventors</th>
<th>Ave.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>AUBURN UNIVERSITY (PR)</td>
<td>30.0%</td>
<td>15.0%</td>
</tr>
<tr>
<td>BROWN UNIVERSITY (PR)</td>
<td>50.0%</td>
<td>20.0%</td>
</tr>
<tr>
<td>COLUMBIA UNIVERSITY (PR)</td>
<td>50.0%</td>
<td>25.0%</td>
</tr>
<tr>
<td>HARVARD UNIVERSITY (PR)</td>
<td>29.8%</td>
<td>21.3%</td>
</tr>
<tr>
<td>MIT (PR)</td>
<td>33.3%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Northwestern University (PR)</td>
<td>30.0%</td>
<td>30.0%</td>
</tr>
<tr>
<td>Old Dominion University (PR)</td>
<td>50.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Princeton University (PR)</td>
<td>50.0%</td>
<td>30.0%</td>
</tr>
<tr>
<td>Purdue University (PR)</td>
<td>33.3%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Stanford (PR)</td>
<td>33.3%</td>
<td>33.3%</td>
</tr>
<tr>
<td><strong>Private Average</strong></td>
<td>39.0%</td>
<td>29.1%</td>
</tr>
<tr>
<td>North Carolina State University (PUB)</td>
<td>21.3%</td>
<td>21.3%</td>
</tr>
<tr>
<td>SUNY-Stony Brook (PUB)</td>
<td>34.0%</td>
<td>34.0%</td>
</tr>
<tr>
<td>Texas A&amp;M University (PUB)</td>
<td>42.5%</td>
<td>42.5%</td>
</tr>
<tr>
<td>The Ohio State University (PUB)</td>
<td>42.5%</td>
<td>28.3%</td>
</tr>
<tr>
<td>Montana State University (PUB)</td>
<td>56.6%</td>
<td>28.3%</td>
</tr>
<tr>
<td>Penn State University (PUB)</td>
<td>40.0%</td>
<td>40.0%</td>
</tr>
<tr>
<td>Wayne State University (PUB)</td>
<td>75.0%</td>
<td>35.0%</td>
</tr>
<tr>
<td>INDIANA UNIVERSITY (PUB)</td>
<td>50.0%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Louisiana State University (PUB)</td>
<td>40.0%</td>
<td>40.0%</td>
</tr>
<tr>
<td>Virginia Tech (PUB)</td>
<td>42.5%</td>
<td>42.5%</td>
</tr>
<tr>
<td><strong>Public Average</strong></td>
<td>44.4%</td>
<td>33.7%</td>
</tr>
<tr>
<td><strong>Total Average</strong></td>
<td>43.6%</td>
<td>32.9%</td>
</tr>
</tbody>
</table>

1: These school calculate the proportion based on gross, not net. Therefore, net proportion was calculated given 15% is deducted from gross income as necessary costs.
2: Montana State only allows to support inventor's research, not as personal income.
3: Penn State gives instant $1000 bonus to inventors at the time of patent application.

Table 2.4: The average share of net income for inventors

Based on the above incentive scheme, individual inventor(s), the college and department of the inventor(s), and the entire university are all have economic incentives to commercialize university technology, and to maximize the economic return on research investment. Overall, a possible measure of the performance of technology transfer is the
return on investment: the total amount of income earned by the inventors, the Department and Colleges and the university, divided by the amount of research expense. In the university technology transfer, the sources of income consist of up-front licensing fee, quarterly royalty, milestone payments, and the liquidated equity.

The question is: Do these economic incentives contradict the academic mission of universities? In The Ohio State University, for example, the Office for Technology Licensing has a “Conflict of Interest Guidelines”, which defines the conflicts of interest as “situations” “in which there is a real or perceived conflict between an individual’s obligations to the University and his/her obligations to an external constituency or to his/her personal interests.” (Italic and bold as in the original.) More practically, an officer in the Office explained that from the university administrators point of view, conflicts of interest exist when granted research funds, assets, capabilities, or facilities available to university researchers are used for the interest of private economic reward.

For example, there may be a case where a university inventor is engaged in a new venture business based on the
technology generated by his/her research, and use his/her graduate assistants and/or university facilities to commercialize the technology. In this case, the university administrators could judge that the inventor's activities are violating the interest of the students and, thereby the university. Another case of conflict of interest is that an inventor, also a faculty member, spends much more time and energy on commercialization, and neglects the duties as a faculty member such as teaching classes and university service.

However, one of the interviewees, a manager of a university technology transfer office told me "there is a very fine line between problematic behaviors and those that are not." In reality, "potential material conflicts of interest are not always easy to recognize or deal with appropriately because of the complexity and diversity of University obligations", and the "perception of what constitutes a significant conflict of interest may vary among individuals."

From the perspective of the research interest in this study, these potential conflicts of interest should not be easily dismissed. When conflicts are serious, the commercialization process may be hindered and discouraged by
the university authorities, or the perception of the potential conflicts may significantly affect decision making by university inventors. These environmental factors must be included as important independent variables from the viewpoint of institution theory. (See Chapter 3.2.3.2 Institution theory, and 5.6 Institution theory for further discussion.
In this section, I report the result of literature review on new venture creation and technology licensing. The first group of literature is organizational economics theories: transaction cost economics (Williamson 1975, 1985), resource-based theory of the firm (Conner and Prahalad 1996) and real options theory (Myers 1977, Trigeorgis 1995, 1996). These theories directly approach how brand new ventures or new investments are made.

I also review literature on technology licensing. This is necessary because this research focuses on decisions by inventors in choosing either new venture creation or licensing to existing firms. Since these two options are mutually exclusive in the context of this study, licensing to third parties negatively affects the chance of new venture creation, and vice versa. The outcome of the review of this literature will be mentioned as related to each of the three theories of the firm discussed.
New venture creation has also been studied in entrepreneurship and organization theory literature either as new venture creation or organizational birth and founding. Therefore, the last part of this section summarizes the extant literature in these two disciplines, which will become an important source of control variables (See Chapter 5. Control factors).

3.1 Organizational economics
3.1.1 Transaction cost economics (TCE)

The reason for firm existence has traditionally been answered by the concept of transaction cost (Coase 1937, Williamson 1975). When the potential exchange partner may behave opportunistically under asset specificity, the market for the exchange transaction fails and the market transaction cost becomes prohibitive. As a result, the “firm" is selected (and created) as an alternative, which is a hierarchical governance mechanism to control the transaction partner's opportunism, given that the cost of forming and maintaining firm organization is less than the market transaction cost. In this sense this literature is a fundamental basis of new venture creation.
The number of empirical studies using transaction cost economics to explain new venture creation is quite limited. In strategic management, the vast majority of literature based on transaction cost economics focuses on governance mode choice issues, especially vertical integration (make or buy decision). Among a few exception, Johnsson and Hagg (1987) explains the mechanism of spinoffs, a sort of new venture, out of existing diversified firms based on a combination of transaction cost economics (Williamson 1979) and clan theory by Ouchi (1980). Ito (1995) also used transaction cost logic to explain the initial separation of the spinoffs from parent companies. Yet neither of them directly explains brand new venture creation from zero-base.

Russo (1995) is one of the exceptions which applied transaction cost theory to new organization founding, even though the theory is not directly applied to the new firm creation as explained below. Russo studied the rates of founding small scale power producing companies that use alternative ways of power generation such as wind turbines, solar energy collectors, and small hydroelectric facilities. The focus of his study is on how a key institutional force, the government, changes organizational environments, by
opening up new market niches (through regulation changes) that support the foundation of new ventures.

Russo's study is primarily based on population ecology and institution theory: How the environmental factors affect the rate of organization founding. However, he also applied transaction cost economics to explain the justification of institutional change by the government as a governance mechanism with an intention of controlling opportunistic behavior in contractual relationship between major electric energy buyers and major suppliers (Major electricity buyers put a pressure on large size suppliers for volume discount). When the volume discount is prohibited as an illegal conduct by regulations, newly established small size electricity manufacturers can have price competitiveness at the market.

Even though the literature on new venture creation based on transaction cost economics is quite limited, a fairly large volume of literature exists in technology licensing mainly in economics based on the assumptions of opportunism and principal-agent relationship.

Gallini and Wright (1990) explains the problem of licensing due to opportunism between licensor and licensee as follows. First, under asymmetric information where the licensor has a superior knowledge on the economic value of
the technology, the licensee will be reluctant to undertake specific investment in the technology without some precontractual assurance of its profitability. At the same time, due to the threat of imitation, the licensor will be reluctant to transfer the technology without either a initial payment or commitment by the licensee not to imitate. Contractor (1985) quoted in Gallini and Wright (1990) also describes these problems: "The licensee as the less-informed party has to be educated as to the value of the innovation without (the licensor), paradoxically, revealing too much." Teece (1986) in a similar vein describes the situation that the innovator (licensor) has incentives to overstate the value of the innovation (technology), while the licensee has incentives to "run with the technology" when the technology turns out to be a success.

According to Teece (1986), the success of licensing depends on the nature of "complementary resources or assets" that are necessary to commercialize the technology. When the complementary assets are "generic" ones that are general purpose assets which do not need to be tailored to the technology, contractual relationship such as license suffices to integrate the technology and the assets, however, when the complementary assets are specialized (unilateral
dependence) or cospecialized (bilateral dependence) to the technology, the "contractual relationships are exposed to hazards" because "one or both parties will have to commit capital to certain irreversible investments which will be valueless if the relationship between innovator and licensee breaks down." (P. 290)

To sum up, under the assumption of opportunism and information asymmetry, especially when the technology licensing requires technology specific irreversible investments by one or both parties, and/or there is a threat of imitation, the incentive not to use licensing to existing firms seems to increase. In the context of university technology transfer, when the incentive to avoid licensing to existing firms increases, the likelihood of new venture creation should increase.

3.1.2 Resource based theory of the firm

Another line of theories applicable to the explanation of new firm creation, are Kogut and Zander (1992, 1993) and Conner and Prahalad (1996). These studies endeavor to construct the resource based theory (RBT) of firm existence, which explains that firm organization is chosen over market regardless of the opportunism when the resource combination
under firm organization is expected to generate higher productivity than the same combination through market contracting.

Kogut and Zander (1992, p. 391) introduced the concept of "combinative capabilities" which are required in integrating necessary resources and explained, "combinative capabilities (enable the firm) to generate new applications from existing knowledge. By combinative capabilities, we mean the intersection of the capability of the firm to exploit its knowledge and the unexplored potential of the technology, or what Schumpeter (1965) originally called the degree of 'technological opportunity' ."

In the context of international technology transfer from home country to host country, Kogut and Zander (1993) explained that the extension of own firm boundary across national borders is chosen as a technology transfer vehicle over using other firms based on market contract, not because of the transaction cost or opportunism, but simply because the intra-firm transfer is more efficient and effective, especially when the technology is tacit and its codifiability is low. Since this line of thought explains the extension of firm boundary, this study does not directly explains new firm creation. However, the essence of
combinative capabilities can be well applied to new venture creation in the context of university technology transfer. (See the discussion in Chapter 4 Hypotheses for detail.)

According to Conner and Prahalad (1996), firm organization is interpreted as an employer-employee relationship where the employer has the right to manage or control the detail of employee’s production activities, whereas in the market contract, each party is autonomous. They explained that there are two possible effects of firm organization: the knowledge substitution effect and the flexibility effect. First, regarding the knowledge substitution effect, the firm and the market are characterized as follows:

“A primary effect of firm organization -of the authority relationship- is to cause an individual to use the knowledge of another before the former fully understands or agrees with it. Conversely, a main effect of market contracting -of autonomous relationship- is to oblige knowledge to be internalized before the individual agrees to modify its actions on the basis of that knowledge.” (Conner and Prahalad 1996, p. 485)

For this “knowledge-substitution” effect to make the firm organization more beneficial than market contracting, one of the transaction partners must possess more valuable knowledge than that of the other. Here, Conner and Prahalad raise an example of a nature of knowledge that explains
knowledge-substitution effect: its tacitness. When the knowledge held by one exchange partner is superior and more tacit in its nature, that knowledge cannot be easily absorbed under market contracting where the other partner should fully understand and internalize the knowledge to reflect the knowledge into its activities. Firm organization enables the tacit knowledge to be applied to the activities of the other exchange partner inside the firm more easily and forcefully based on employment relationship. As a result, the activities taken under the same objective (i.e., to manufacture a certain product, for example) may be executed more effectively and efficiently under firm organization than by market contracting. Thereby a new firm is created by those exchange partners.

As applied to the case of university technology transfer, the inventor of a technology may have a superior and tacit knowledge on how to develop the technology, how to organize the development team and so on. If this is the case, the integration of his/her knowledge into the commercialization process will be best realized by creating a new firm where the inventor will be directly involved in the process. On the other hand, in conventional licensing to existing firms, that integration is less likely to happen.
Another effect of firm organization reasoned by Conner and Prahalad is the flexibility effect. The flexibility effect accounts for "the relative cost, under two organizational modes, of altering the parties’ duties and responsibilities on an ongoing basis, in order to incorporate learning or unexpected opportunities arising during the course of the work. The flexibility effect concerns the dynamics of future knowledge acquisition and application." (Conner and Prahalad 1996, p. 486) Learning and flexibility under the unknown future are at the core of this effect and they are also indispensable elements of real options logic for new venture creation. In this sense, Conner and Prahalad’s theory of the firm combines the resource based logic and real options logic. Indeed, the firm seems to work as a storage of knowledge as well as a locus of learning leading to the strategic flexibility in the future.

One comparison exists between resource based logic and transaction cost logic. In resource based logic, increased productivity within firm organization over market is a reason of superiority of firm efficiency to the market. And in transaction cost logic, the firm’s superior productivity is also mentioned as the "team production" perspective of
the firm by Alchian & Demsetz (1972). The higher productivity achieved within an organization makes exchange partners choose firm structure rather than market contracting. However, the two theories are fundamentally different in terms of the source of productivity. In the RBT, the source of productivity is derived from stocks of knowledge in the organization, or organizing principle, which consists of tacit, social, and path-dependent organizational knowledge (Kogut & Zander 1992, Conner & Prahalad 1996), while in the “team production” logic based on TCE, the source of productivity is the hierarchical governance (or rewarding) mechanism that suppresses the organization member’s opportunistic behaviors such as shirking and dishonest in the team production effort.

To sum, comparing the literature on licensing based on transaction costs and the resource based theory of the firm, the underlying reasoning for choosing new venture creation over licensing to existing firms, for example, is that licensing to existing firms is costlier when opportunism is expected to arise in transaction cost logic, while new venture is more productive and valuable when the knowledge required is tacit in resource based logic. An empirical result in the context of international technology transfer
by Kogut and Zander (1993) shows that internal knowledge transfer is preferred to market-based contractual arrangement because internal transfer is more efficient than market contracting such as licensing to existing firms especially when the knowledge is less codifiable and harder to teach. In the university technology transfer case, new venture creation in which the inventor is directly involved in the commercialization seems equivalent to the internal transfer in their framework.

3.1.3 Real options theory

The third theory that may be applicable to firm existence and new venture creation is real options theory (or strategic options theory). The theory explains the nature of initial investment based on the "real option" concept (Myers 1977) which originates in the idea of a financial call option. In financial options, "the more volatile the price of the underlying asset, the more valuable the option becomes, as potential positive returns are greater, although potential losses are limited to the price of the option" (McGrath 1997). As applied to real business investments, real options theory explains that the initial investment under uncertainty in terms of the
viability of future economic opportunities can be characterized as a purchase of the real option for much smaller amount of investment. When this small initial investment supplies a strong claim on future investment, the real option once purchased enables the firm to retain the flexibility to take advantage of a unique access to better economic opportunities afterwards by adding further investment when uncertainty is resolved and the economic opportunity becomes viable (Lee 1997).

In the business management literature, real options theory has been applied mainly to joint ventures (Kogut 1991), international strategic alliances (Chi & McGuire 1996, Hurry, Miller & Bowman 1992) and foreign direct investment decisions (Chang 1995, Casson 1994). The theory has been little applied to the new venture creation and entrepreneurship. One important early exception is Rumelt (1987), which perceived the nature of entrepreneurship in the similar vein:

“Given limited liability and the right to cease operations and break contracts through declarations of bankruptcy, it is very possible that entrepreneurial activity will increase with increases in uncertainty. That is if the chances of very positive outcomes are limited, then more uncertainty can lead to a larger expected value of innovation” (Rumelt 1987, p.148).
Even though Rumelt (1987) never mentioned new venture creation as a real option, it seems clear that he applied in his mind the financial options concept to the new venture creation.

Trigeorgis (1996) recognized at least seven different types of real options: option to defer, time-to-build option (staged investment, so called a compound option in combination), option to alter operational scale, option to abandon, option to switch, growth options, and multiple interacting options. The real option concept Rumelt (1987) pointed out as a nature of entrepreneurial activities is a combination of growth option and option to abandon according to the typology by Trigeorgis.

McGrath (1997) studied a technology real option, which is highly applicable to the technology oriented new ventures. She defines the "technology real option" as:

"The 'price' of a technology option is the cost of development (which may occur in sequential stages). Completing the development of the technology creates an asset, consisting of the underlying right to commercialize the technology. 'Exercise' of such an option involves the further investments needed to commercialize the technology (which may also occur sequentially)" (McGrath 1997, p.975).

She even characterized the technology option in an almost similar way to Rumelt (1987):
"(S)o, the value of a real technology option increases as the variance of the expected value of net revenues minus commercialization cost increases. The greater the expected variance in net operating revenues less commercialization costs, the higher the possible value of underlying asset, although possible losses are limited" to the amount of investment up to the point of abandoning the option as "the sunk costs associated with the discontinued project" (McGrath 1997, p.976).

Based on Trigeorgis typology, McGrath’s technology real option is a combination of a growth option, a compound option, and an option to abandon.

Given the fact that the nature of university technology is mostly from basic and applied research that are before the development and commercialization stage, the interpretation of new venture initiation as a technology real option seems highly applicable to the current study. The objective of purchasing a technology real option as multiple interacting options that consist of growth option, compound option and option to abandon, is to secure the right under uncertainty to decide whether to proceed further commercialization, in other words to maintain the flexibility in deciding whether to make additional investment as uncertainty resolves.

Another important understanding about real options is that the higher the variance of the value of underlying
asset (the full potential value of technology opportunity) is, the higher the value of a technology option becomes, given that the loss is limited to the past investment as a sunk cost.

Based on these theoretical implications of real options to technology commercialization, the governance mode choice in commercializing technologies can be explained as a choice of option execution mechanisms. Two criteria are important in choosing the option execution mechanism: 1) flexibility of investment decisions and 2) the capacity to capture the upward potential of the real option. As for the first criterion, those who desire to maximize the economic outcome of commercializing their technologies are supposed to choose an option execution mechanism (governance mode) to ensure and optimize their control on investment decisions. Creating new ventures seems the best possible mode in this regard. In terms of the capacity to capture the upward potential, the mechanism of which the capacity is larger should be preferred especially when the upward economic potential is huge. On the contrary, when the upward potential is expected to be smaller, the capacity of commercialization modes may not matter so much. (See Chapter 4: HYPOTHESES for detailed
discussion on university technology transfer modes as vehicles to execute real options.

However, there may be an important limitation for the real options theory to be called as a "theory of the firm". For a theory to be called a theory of the firm, appropriability and reversibility should be included in the theory as key ingredients. Real options logic has a problem especially in the appropriability assumption.

Appropriability is the degree to which the firm can earn and retain profit by using its own firm resources. Ownership and exclusivity in using firm resources are the underlying assumptions of this concept. In this sense, a theory of the firm should be able to delineate the firm border within which any resources owned by the firm can be used exclusively. Both transaction cost theory and resource based theory assume this exclusiveness in using firm resources inside the realm of the firm. However, the real option logic does not and cannot theorize the "inside" of a real option, but only explains the value of an entire option and its execution.

3.2 New venture creation models in entrepreneurship literature
In the entrepreneurship literature, new venture creation has been studied based on various disciplines such as psychology (individual level), organization theory (organization and group level), and sociology (a group of people or society level). The literature of new venture creation in these disciplines is considered in this study because the literature is expected to be an important source of control variables in examining the likelihood of new venture creation. Therefore in this section, previous studies at each level of analysis are surveyed, and then integrated to construct a group of control variables to be included in the equation. (See Chapter 5. Control factors.)

3.2.1 Individual level factors (personal “traits” school and “behavior” school)

The traits school’s basic perspective is that the new venture creation is achieved by entrepreneurs who have special personal characteristics that are different from those of non-entrepreneurs. McClelland (1961) stated the importance of “from the act to the actor.” His research found out that “a high need for achievement” consisting of preference for challenge, acceptance of personal responsibility for outcomes and innovativeness,
characterizes successful initiators of new businesses. Following this line of thought, the “traits” approach flourished by seeking for the differentiating factors between entrepreneurs and ordinary managers.


However, Brockhaus and Horwitz (1986,p. 42-43) stated “(t)he literature appears to support the argument that there is no generic definition of the entrepreneur, or if there is we do not have the psychological instruments to discover it at this time. Most of the attempts to distinguish between entrepreneurs and small business owners or managers have discovered no significant differentiating features.” Gartner (1988) also advocates that the behavior of creating a new venture, not the personality of the founder, should be
fundamental to the definition of entrepreneurship, and that entrepreneurship is something one does and not who one is. He also states that the entrepreneur is part of the complex process of new venture creation, and that this process oriented approach should be taken to the study of entrepreneurship (Gartner 1988).

Another criticism is from the person-situation interaction perspective in psychology. Psychologists with this perspective argue that psychology’s emphasis on the person as the unit of analysis encompasses the behavior as the consequence of person-situation interactions that are well beyond the identification of specific personality variables presumed to lead to the foundation of new organizations (Mischel 1968, Sexton and Greenberger 1988, Shaver & Scott 1991). In the same vein, Herron and Sapienza (1992) proposed an integrated model, in which the new venture launch activities are determined by an interaction between industry context and the type and level of individual dissatisfaction (motivation) (See 3.2.4 Interactive models).

Among more behavior-oriented studies, Kruger (1993) empirically verified that the entrepreneurial intentions (Shapiro 1975, 1982) to create a new business is derived
from "perceived new venture feasibility (entrepreneur’s capability) and desirability (attractiveness of the venture)" and "a propensity to act on opportunities (desirability of control and achievement)." And, those perceived feasibility and desirability are derived from the quantity and quality of "prior entrepreneurship-related experience".

Busenitz and Barney (1997) has conducted another behavior and process oriented research. Even though this study does not directly approach the creation of new ventures, it empirically verifies that entrepreneurs are different from managers in large corporations in terms of the nature of decision-making processes, not the personal traits nor demographic characteristics. This study identifies entrepreneurs as founders of firms that had made their first sale in the past two years. The study shows that the entrepreneurs tend to use more decision-making biases and heuristics than managers in large organizations.

In sum, the "traits" approach began with a demographic differentiation between entrepreneurs and managers (non-entrepreneurs) with mixed empirical findings, then shifted toward more behavior oriented study of the facilitating
factors of new venture initiation, of which empirical findings are more robust.

3.2.2 Organization and group level factors

At this level of analysis, the amount of literature is quite limited, because organization emerges only after the new venture is created. Within that limited literature, the characteristics of potential venture founding team has been the primary object of study. Kamm and Nurick (1993) state that the "founding team's cohesiveness and longevity" affects the chance of new venture creation. When the founding team disbands, the chance of creation is reduced. However, this line of studies dismisses the case of one-person firm that is often the case in new venture creation.

3.2.3 Society, industry and market factors

3.2.3.1 Population ecology theory

Population ecology (Hannan and Freeman 1977, Aldrich 1979), as applied to the new venture creation, explains that the rate of new venture creation in an industry or society is affected by the past birth and death rate of organizations and the degree of density in the population (Delacroix and Carroll 1983, Hannan and Freeman 1987,
Aldrich 1990, and Tucker, Singh, and Meinhard 1990). According to this theory, the rate of new venture creation rapidly increases when the density of a population is initially low, then the venture creation rate goes down as the density increases and the supply of required resources becomes tight.

3.2.3.2 Institutional theory

In institutional theory, "legitimacy" is the primary concern. According to the theory, the environment is conceptualized in terms of understandings and expectations of appropriate organizational form and behavior that are shared by members of society [Zucker 1977, 1983]. Such normative understanding constitutes the institutional environment of organizations. Organizations experience pressures to conform to these common understandings, since the violation of these common norms may call into question the legitimacy of the organization, and thus, affect its ability to obtain resources and social support [Meyer and Rowan 1977; DiMaggio and Powell 1983].

Institutional theory has been applied to new venture creation in mainly two ways. First, the theory has been applied to reinforce the population ecology theory (Tucker,
Singh and Meinhard 1990). In this context, institutional theory explains that when the density of population is low, the increasing number of new types of organization helps to reinforce the legitimacy of the new type, while as the density exceeds a threshold, the increasing number of new ventures deteriorates their legitimacy. In this sense, institutional theory and the population ecology theory are complementary.

Another way of application of institutional theory is in its original sense: institutionalized rules and beliefs regulates the behavior of organization in the organizational population. Various institutionalized values may affect the likelihood of new venture creation. Government policies and procedures, public attitude toward entrepreneurship, organizational peer's attitude toward entrepreneurship and so forth. Especially in the university technology transfer context, the existence of a university mission that emphasizes knowledge creation, instruction and public service may significantly affect the behavior of university inventors. There is a potential conflict of interest between the university mission and economic incentives in commercializing the university technology. (Empirical implication of this logic will be discussed in Chapter 5.)
Control factors.) Integration of the institutional variables into the equation is quite important in this study.

3.2.3.3 Social network models

A "Social network" model of new venture creation (Aldrich and Zimmer 1986, Larson and Starr 1993) suggests that the new firm emerges out of the social interaction between entrepreneurs and potential constituencies of new ventures. Larson and Starr (1993) explain that the new firm emerges as the relationship between the entrepreneur and the potential suppliers evolves from simple and personal one to a dense, multidimensional and multilayered "network." The new venture is initiated when those "ties" reach a critical mass. This perception of the firm appears to be influenced by the perception of the firm as a nexus of contracts by Jensen and Meckling (1976).

Given this network nature of new venture creation process, the "socialization" school (Starr and Fondas 1992) explains that the new entrepreneurs experience socialization to learn the new work environment among network members ("socializing agents"), such as other entrepreneurs, customers, banks, incubating institutions, government agencies such as the Small Business Administration and so
forth. The successful socialization increases the likelihood of new venture initiation and the future performance of the venture as well.

3.2.3.4 Industry and market environment models

Dean, Meyer and DeCastro (1993) proposed a multilevel model, which involves the industry/market level environmental factors as well as organization level factors. One industry level factor is barriers to entry in the industry, which are expected to constrain new venture creation in an industry. This factor consists of the degree of product differentiation, capital requirements, excess capacity, and industry concentration in an industry. The other industry level factors are disequilibrating forces that facilitate new venture creation, such as demand growth, changes in demand characteristics, technological development, new sources of supply and political/regulatory change. Organizational level attributes such as age and size of existing firms are also included in the model as measures of organizational inertia, which may facilitate new venture creation. When organizational inertia reduces the chance of new business creation as spin-offs by existing established firms, new ventures are apt to be created from scratch.
Gnyawali and Fogel (1994), based on the past literature on entrepreneurship environment, constructed an integrated model of environmental factors along with five dimensions: government policies and procedures, socioeconomic conditions, entrepreneurial and business skills, financial assistance, and non-financial assistance.

3.2.4 Interactive models

The interactive model of new venture creation suggests that the interaction between factors at two different levels: individual factors and situational (environmental) factors lead to the likelihood of new venture initiation or entrepreneur’s decision to initiate the new venture. This model suggests that an entrepreneur’s disposition, demographic characteristics and environments jointly determine how entrepreneurs perceive and react the surrounding environment, and affect entrepreneur’s propensity to initiate new ventures. An interactive model of new venture initiation by Greenberger and Sexton (1988) is one of the earliest multiple level interactive models. In their study, individual factors include entrepreneurial vision, personality and desire for control. Environmental factors include salient precipitating events, family support,
and social support. This study mentions five basic reasons for individuals to consider venture initiation:

"(1) They identify an opportunity in the marketplace,
(2) They believe that they can manage a firm as effectively (or more effectively than) as other owners or managers,
(3) They possess an expertise or craft which can be developed into a business, (4) They have developed a product or process for which a niche in the marketplace can be found, and (5) They believe that other acceptable opportunities are limited and initiating a venture is the only acceptable alternative." (Greenberger and Sexton 1988, p.6)

The reasons above have an important implication to the model construction in Chapter 4. Hypotheses. Especially, the perception of new venture initiation as one of the alternatives to realize the market opportunity (related to the reasons (2) and (5)) seems quite relevant to this study. In fact, a director of a technology licensing office admitted that the following two factors are fundamental: the inventors’ perception of necessity and competency of their knowledge in commercializing their technology, and their perception of new venture creation as one of the most viable alternatives to commercialize their technology.
Herron and Sapienza (1992) constructed another interactive model that emphasizes the individual level psychological attributes and entrepreneur's behavior. According to the model, the entrepreneur's "search" behavior for the new opportunity is caused by the type and level of dissatisfaction which is moderated by the type and level of skills. The type and level of dissatisfaction is determined by the type and level of aspirations predetermined by the interaction among personal values, personality traits and context. Finally, the search behavior leads to a "discovery" of opportunities at the market, and when the opportunity is judged to be good enough to induce supports (i.e. potential participants in the new organization, customers, and other elements of the environment) necessary to form and sustain an organization (firm), the new venture launch activities are initiated.

An interactive model by Learned (1992) shows that the intention to found is led by the individual propensity to found which is an outcome of interaction between personal traits and background. External environment and the intention then interact and cause the final decision to continue the founding process or abandon.
Overall, it seems clear that when trying to analyze the mechanism of new venture creation, it is not enough to consider the entrepreneur's inherited personal traits nor environmental contexts. It is essential to take into account how entrepreneurs perceive their environmental context and their own resources to fit both together in order to capture the better economic opportunities. Thus, the basic process of new venture creation can be summarized based on the previous literature in entrepreneurship as, 1) the interaction between various business environments and entrepreneurs, which generates the perceived business opportunity, and, as a result of interaction, 2) the initiation of entrepreneurial new venture organization.
CHAPTER 4

HYPOTHESES

Based on the theories reviewed, the following hypotheses are introduced answering the original research question: On what basis is the decision between new venture (start-up) creation and conventional licensing to existing firms for university technology transfer made?

According to FY1997 AUTM Licensing Survey, 2,095 U.S. Patents were issued in FY1996 to 173 universities, and 333 start-up companies were formed in FY1997 based on university technologies. If it is assumed that the new ventures were created based on patents granted in the prior year to venture initiation, a rough estimate would be that one sixth of patented university technologies were commercialized through new venture creation while the rest were done by licensing to existing firms.

There are at least three organizational economics perspectives from which the question can be answered: transaction cost economics, resource based-theory of the
firm, and real options theory. In addition to these three perspectives, I also add institutional theory to construct one of the primary hypotheses, for the theory seems to explain an influential role of the university community in technology transfer process.

4.1 Levels of analysis

Before constructing testable hypotheses based on each theoretical perspective, I clarify the levels of analysis of this study. One level of analysis is of course the technology to be transferred from the university to the private sector. However, as shown in the literature review, other levels of environments, both endogenous and exogenous, seem to affect the likelihood of different transfer modes. Thus, this study has multiple levels of analysis: technology level, individual researcher's level (endogenous environment), and institutional level (group and organization).

The unit of analysis in measuring the dependent variable is individual technology. The dependent variable throughout all hypotheses is the technology transfer mode, that is whether the technology is transferred by (1) creating a new venture and licensing to that venture (I call
this simply as new venture creation from now on) or (2) conventional licensing to existing firms. These alternatives are mutually exclusive. The population of this study is the technologies disclosed by university researchers to offices of technology transfer in the US research universities, and licensed through those offices to either start-ups (new ventures) or existing firms.

National level environmental factors such as government policies and support for new venture creation, the public's attitude toward entrepreneurship, and national culture are thought to be constant in this study since the current study analyzes the population in the US. However, future research will deal with these national and regional levels of analysis.

4.2 Uncertainty and the nature of technology

Since this study tries to explain the outcome of decision making in technological areas (research universities and high-tech industries relying on biomedical, computer, chemical, and physical sciences), uncertainty and the nature of technology play critical roles in each theoretical perspective.
For example, even within the transaction cost economics, Sutcliffe and Zaheer (1998) identified at least three different types of uncertainties that have different effects on strategic decision making: primary, competitive and supplier uncertainties. These types of uncertainty turned out to have different and opposite effects on vertical integration decision. Folta (1998) pointed out two different types (endogenous and exogenous) of uncertainty in real option context, and realized that these two different uncertainties had different effects on the governance mode choice between equity collaboration and acquisition.

In terms of the nature of technology, the degree of tacitness, the scope (breadth), the stage, and the continuity of the technology are the four primary characteristics to be studied in this research.

The tacitness of the technology can be an important attribute of technology both in transaction cost economics and resource based view. And the following three characteristics of technology have been repeatedly mentioned throughout the face to face preliminary interviews with university technology transfer officers and inventors: the breadth (scope), stage, and continuity of technology.
The scope of technology refers to whether the technology is a "platform" technology or not. This was mentioned by interviewees as an important factor to determine the transfer mode as well as the market potential of the technology. "Platform" technologies work in a broad scope of applications. An example of "platform" technology is the basic gene manipulation technology in molecular biology. This technology can be applied not only to biology, but also to medical science (human genes), veterinarian medicine (animal genes), and agricultural bio-engineering (plant genes). The opposite of platform technologies are so-called "narrow niche" or "one-off" technologies, of which application in the product market is limited to a narrow niche. The scope of technology is especially important in estimating the potential value of real options, because the wider range of technology opportunities in platform technology work as a combination of multiple options and contribute to the value of real option as a whole. (See 4.5.6 Value of real option and the capacity to realize it.)

The stage of technology seems to have an important role in resource-based theory perspective in its relation to knowledge tacitness. The stage of technology means whether the technology is in the stage of basic research, applied
research, or development stage when it is transferred from the university to the private sector. Although it is rare that the university technology is at its development stage when it is transferred, the stage of technology at the time of transfer seems to influence the degree of necessity of inventors’ tacit knowledge in commercialization. (See 4.4 Resource-based theory of the firm for related discussion.)

The continuity of technology refers to whether the technology is "continuous" or "discontinuous" (Tushman and Anderson 1986). When a new technology has the potential to replace and discontinue the current technological system or paradigm in a field, the technology is "discontinuous" and "competence destroying" (Tushman and Anderson 1986). For example, new findings in physics and medical sciences often completely redraw the landscape of the discipline by replacing its basic assumptions. It is a "creative destruction" (Schumpeter 1934) and "paradigm" shift (Kuhn 1962). On the other hand, continuous technology is often observed in engineering, where new technologies can be added to current technologies to improve production efficiency in an incremental manner. In this case, the new technology can be readily introduced and accommodated into the existing technology system.
When the technology is continuous, it is more likely to be transferred by conventional licensing to existing firms. This mode of transfer enables the firm to use extant system and facilities so that the existing firms have an advantage over new ventures of which internal firm resources are quite limited. On the other hand, when a technology is discontinuous, or destroying the competence of existing firms, it is more likely to be commercialized by new ventures where entrepreneurs can build up a brand new development scheme and facilities from scratch without dealing with existing assets.

The above observation is also consistent with Afuah (1998) in which the disadvantage of incumbent firms (difficulties in unlearning and the burden of the old technology) and the advantage of new entrants (freedom of developing necessary resources and exploiting them) in introducing and developing innovations.

4.3 Transaction cost economics

When the potential exchange partner may behave opportunistically under the condition of asset specificity, the "firm" is selected (and created) as a hierarchical governance mechanism instead of the "market" in order to
suppress the transaction partner's opportunism, given that the cost of forming and maintaining firm organization is less than the market transaction cost. In this line of thought, a technology transfer mode refers to the governance mode selected by the owner of the idea of new resource combination. The primary source of uncertainty here is assumed to be the possibility of exchange partners' opportunistic behavior. Examples include moral hazard (Barney & Ouchi 1986, Holstrom 1979) and holdup problems (Klein, Crawford and Alchian 1978).

Asset specificity: When the commercialization of the technology necessitates specific investments or assets that are only useful in commercializing that particular technology, "asset specificity" exists. As a result of the "fundamental transformation" (Williamson 1975), both sides of the transaction are locked in the relationship in which they are vulnerable to the threat of moral hazard and holdup by each other.

This mutual specificity may happen as follows in the context of university technology transfer. When the potential licensee (existing firms) has to make a technology specific investment (i.e., specially customized R&D facilities, equipment, and/or customized production
facilities, etc.) to commercialize a particular technology, the potential licensee will be reluctant to license (thus pay for) the technology and make such an investment without prior assurance of the profitability of the investment. In this case, potential licensees may be able to choose so-called "option" contract with the university for less cost than full licensing to see if there is any commercial potential in that technology. Potential licensees can end this contract after a certain period when they see no commercial potential in it. However, this preliminary examination period may be used as an opportunity for the potential licensee to learn the technology for less cost.

Another possible case of opportunism occurs when the potential licensee is equipped with ample technological resources (vast patents pool, advanced R&D facilities, an army of leading edge researchers, and so forth) of its own. If this is the case, a university technology may be commercialized successfully only when that particular firm licensed the technology. In other words, the university may be required to arrange their research framework (both physical and intellectual) to fit the commercialization system of that company. This type of situation is not unusual especially when a specific firm sponsored the
research project at the university. Under this circumstance, the university may be exploited by the licensee because of the firm's very strong bargaining position.

As a result of asset specificity as described in above cases, the market for technology may fail. The market failure results in difficulties in identifying the potential licensees, or in disincentive for the university to be involved in licensing to existing firms. Therefore it becomes more likely for the owner of the technology to choose to create his/her own firm to realize a commercial opportunity and/or avoid opportunistic behaviors by potential licensees. In the context of university technology transfer, it takes the form of new venture creation by inventors themselves.

Overall, the degree of uncertainty generated by the specific nature of the technology increases the threat of opportunism, thereby market transaction costs. This makes the new venture creation less costly, and thus a more preferable choice (Figure 4.1).

Ease of imitation: This construct is included in this category based on license literature (Gallini and Wright 1990, Contractor 1985 and others). When a technology is easy to imitate or easy to "invent around" once the potential
licensee looks at or hears about the detail of the technology during the negotiation, the potential licensee may take advantage of this opportunity, abandon the negotiation, and easily create the perfect substitute of the university technology without paying the university. This possibility may cause further transaction cost to monitor and suppress opportunistic behaviors.

Therefore, if the technology is highly imitable, the inventor and the university may prefer new venture creation to licensing to existing firms. Creating new ventures enables the inventors of the technology to become licensees by themselves thereby excluding the chance of opportunistic behaviors by other potential licensees.

Figure 4.1: Transaction cost economics perspective (H1)
Hypothesis 1a:
The degree of asset specificity is positively associated with the chance of new venture creation.

Hypothesis 1b:
The degree of technology imitability is positively associated with the chance of new venture creation.

4.4 Resource-based theory (RBT) of the firm

In the RBT logic, the primary motivation for creating a firm organization is to realize better productivity by utilizing superior "tacit knowledge" of one party (Conner & Prahalad 1996), more specifically "combinative capabilities" (Kogut and Zander 1992), which is not available in market contracting. Needless to say, knowledge tacitness is one of the most important features of firm resources for it to be a source of sustainable competitive advantage (Barney 1986, 1991). Thus, the investment mode should be chosen so that the productivity of a combination of resources (performance) is maximized. Based on this logic, RBT predicts that the new venture creation is preferred to market contracting as long as the nature of the opportunity allows the tacit knowledge of one party to maximize the productivity of a resource.
combination. Whether the productivity of a resource combination can increase in the firm organization instead of market contracting depends on the degree of tacitness of the knowledge required in combining the resources (Figure 4.2).

\[ (P_f - P_c)^* \]

(Superiority of firm organization to market contracting)

\[ *P_f = \text{Productivity in firm organization}, \ P_c = \text{Productivity in market contracting}. \]

Figure 4.2: The Relationship between Knowledge Tacitness and the Productivity of New Ventures and Licensing to Existing Firms

When the degree of tacitness of the knowledge held by the university inventor is high, he/she can realize the maximum productivity of the resource combination only by creating his/her own firm and directly bringing in the
knowledge by him/herself. Licensing to existing firms through market contracting, on the other hand, would be less successful, because the tacit knowledge indispensable to develop and commercialize the technology is left in the inventor’s mind. When the degree of tacitness of the knowledge is low, on the other hand, the knowledge can be easily transferred through market contracting as attached to the technology itself.

It is important to note that this tacit knowledge in the context of university technology transfer is not the physical technology itself. This knowledge is a knowledge attached to, or surrounding the technology, which is quite useful in proceeding the commercialization process successfully. Barney (1991, p. 110) made an important comment regarding this point: “Notice that complex physical technology is not included in this category of sources of imperfectly imitable. In general, physical technology is by itself typically imitable.”

Hypothesis 2:
The degree of tacitness of the knowledge, useful for the development and commercialization of a certain
technology, is positively associated with the likelihood of new venture creation.

Figure 4.3: The relationship between the degree of knowledge tacitness and the technology transfer mode

Because tacit knowledge is imperfectly imitable, tacitness and inimitability are very close concepts. A dictionary definition of "tacit" is, "expressed or understood without being put into words; not spoken or written" (Longman Group Limited 1978). Thus, when the knowledge necessary to develop and commercialize a technology is tacit, knowledge is hard to be integrated in the commercialization process through arm’s length licensing. When focusing on this hard-to-describe, thus hard-to-replicate and hard-to-imitate knowledge, imperfect imitability of the technology (Lippman and Rumelt 1982, Barney 1991) becomes a close proxy of this construct.
Imitation occurs in one of two ways: direct replication or substitution (Barney 1996). These two ways of imitation are made costly or physically impossible by one of, or a combination of, the following factors: 1) unique historical conditions including path dependence, 2) causal ambiguity, 3) social complexity, and 4) substitutability. Based on this decomposition of imitability, hypothesis 2 can be rewritten as follows.

Hypothesis 2a:
The degree of path dependence in acquiring the knowledge, useful for the development and commercialization of a certain technology, is positively associated with the likelihood of new venture creation.

Hypothesis 2b:
The degree of social complexity in acquiring the knowledge, useful for the development and commercialization of a certain technology, is positively associated with the likelihood of new venture creation.
Hypothesis 2c:

The degree of substitutability of the knowledge, useful for the development and commercialization of a certain technology, is negatively associated with the likelihood of new venture creation.

Two characteristics of technology also indicate the degree of tacitness of the knowledge: the stage and continuity of technologies. The stage of technology on the basic-development continuum at the time of transfer seems to work as an indicator of both the degree of knowledge tacitness and the knowledge necessity. When a technology is closer to basic research side, its commercialization may need more input from inventors’ insights in the technology since it is still far from the market. If this is the case, the knowledge embedded in the minds of inventors may have the higher degree of tacitness from the viewpoint of outsiders, and the knowledge is expected to be very useful for commercialization.

Hypothesis 2d:
The closer the stage of technology is toward the basic research at the time of transfer, the more the likelihood of new venture creation becomes.

Continuity of technology is thought to be another indicator of the degree of tacitness and the necessity of the knowledge. As mentioned in the beginning of this chapter, the continuity of technology is another dimension of technology extracted from the preliminary interview as a possible determinant of transfer mode. When the technology is continuous, it means that the predecessor of the new technology already exists in the industry and the surrounding technology system has already been established. Thus continuous new technology can be quite articulate and easily understood by the industry. Incumbent firms not only can take advantage of their existing facilities and human resources, but also can apply the accumulated know-how of commercialization of the current technology to the new one. Therefore, commercialization by the incumbent firms seems more efficient and effective than by newly created ventures.

On the other hand, when the technology is discontinuous, the technology is unknown to the industry, and the knowledge associated with the technology is also hard to articulate
and understand, thus tacit, for the industry. Existing technology system in the industry cannot accommodate the new technology, and the whole technology system should be replaced with a totally new one. The advantage of existing facilities and accumulated knowledge becomes nullified. Rather, the new venture creation may be more preferable where the tacit knowledge of inventors can be integrated fully into commercialization without interference as seen in existing firms such as the organizational inertia, an obstacle to replacing the incumbent technology system to which the incumbent firms have already committed their resources.

Hypothesis 2e:
The more the nature of technology is "discontinuous", the higher the likelihood of new venture creation becomes.

4.5 Real options theory

As reviewed in Chapter 3 with regard to the value of real options, McGrath (1997) and Rumelt (1987) pointed out that the larger variance of future
economic return, or the larger upward potential, makes the value of real option greater.

The basic idea here is that real options exist in technology commercialization. Engaging the commercialization of university technology per se is a technology real option as multiple interacting options consisting of growth option, compound option and option to abandon. Therefore, the choice of possible university technology transfer modes - new venture creation or licensing to existing firms - are simply different means to gain access to these real options.

4.5.1 New venture creation as a real option vehicle

New venture creation is a purchase of the combination of growth option, compound option and option to abandon. Purchasing a growth option in this context is equivalent to an initial investment in creating a new venture. The inventor (now entrepreneur) should make, either by him/herself or relying on other sources, an initial small investment to continue the development and commercialization activities. Its exercise is to make a much larger investment such as establishing large productive capacity or conducting a large marketing campaign, when uncertainty in economic opportunity resolves. Once the new venture is founded, the
purchase of compound option is a series of investments in applied research or development activities. In combination, those two real options are purchased to secure the right and flexibility to take advantage of the future economic opportunity by adding further investment afterwards as the uncertainty is being resolved.

Whenever the future commercial potential of the technology turns out to be hopeless, the inventor has an option to abandon. This option to abandon was acquired automatically when he/she started the new venture with a small initial investment. The inventor can immediately quit the further investment, and declare bankruptcy. By doing so, the downward loss is minimized compared to the case where inventors would have made full-scale investment from the beginning (Rumelt 1987).

4.5.2 Licensing to existing firms as a real option vehicle

Licensing to existing firms can also be interpreted as a purchase of a real option. When uncertainty in future economic returns exists in a technology, purchasing a real option by choosing less hierarchical governance with less commitment is the way to maximize the future economic potential (Kogut 1991, Barney and Lee 1998). In the context
of technology investment under uncertainty, the firm in need of a certain technology is not supposed to choose to buy out immediately the target company that owns the technology, but to create a joint venture first, which is less hierarchical, then later if the uncertainty is resolved, you can exercise the option by acquiring the target (Kogut 1991, Folta 1998).

In the case of vertical integration of manufacturing function by a biotech company (Barney & Lee 1998), for example, the firm initially outsources the productive capacity to avoid its own investment in manufacturing, then later when commercial potential becomes visible, the firm can make a large investment to own its proprietary productive capacity.

Based on this logic, licensing to existing firms allows the inventor to let others conduct the product development to minimize the initial commitment in the commercialization while securing the claim for the future return potential in the form of royalty. If the commercialization turns out successful, the inventor receives royalties calculated by a certain percentage of sales revenues in addition to predetermined initial license fees and milestone payments.
4.5.3 Capacity of capturing the real option value

An important question is, which vehicle is better means or mechanism in fully capturing the potential value of the real option (commercialization of the technology)? The foremost criterion should be the capacity of each mechanism in capturing the full value of commercialization. When the value of a real option is potentially large, inventors and universities will benefit by choosing a mechanism with larger capacity in capturing the full value of economic outcome. In contrast, when the potential value is not so large, the two mechanisms may become indifferent.

Then, which mechanism is more capable in capturing the full potential value of commercialization?

If the new venture turns out successful, the inventor who is also a partial owner of the venture has the opportunity to exercise stock options after initial public offering (IPO). This opportunity is a distinctive feature of new venture creation, which is not available in licensing to existing firms. “IPO is a big incentive to create my own ventures,” said a university professor and entrepreneur in biotechnology in a face to face interview by the author. IPO is indeed an important element for entrepreneurs to fully capture their technologies’ economic value in the market.
Therefore, new venture creation may enable inventors to earn far more economic return through equity asset appreciation than in conventional licensing to third parties, if the technology is successfully commercialized and welcomed by the market. However, it is very hard to predict when the firm will become eligible for IPO, and how the market will value the firm. And of course, when commercialization fails, nothing is left for inventors.

In licensing, the way to capture the potential value of the real option seems relatively more steady and visible in advance, thus predictable compared to new venture creation. As described in PART II-6 Economic Incentives and Conflicts of Interest in University Technology Transfer, the form of economic return on licensing consists of (1) predetermined and fixed stream of cash flow in the forms of up-front licensing fee and milestone payments regardless of the degree of success of the commercialization, (2) the quarterly royalty payment based on a certain percentage of sales revenues, and (3) equity liquidation when universities received a part of shares of the start-up company as a substitute for up-front licensing fees. This is especially the case in new ventures of which financial capability is
limited. However, the proportion of licensing income through equity liquidation is quite small.

According to the 1997 AUTM Licensing Survey answered by 175 research institutions, of the FY 1997 total license income, $85.9 million (12%) came from various fixed fees and other pre-commercialization payments, $478.5 million (69%) came from royalties on product sales, only $22.4 million (3%) came from equity liquidation, and the remainder of $111.7 million (16%) was not classified in the survey.

4.5.4 Rough simulation
A rough estimate of the potential upside value that can be captured by new venture creation and licensing to existing firms can be conducted in the following fashion. Since the major portion of technology transfer has been occurring in biology, medicine and agriculture other than engineering', let's take biotech industry as an example. According to IPO Monitor (1999), there were 21 IPOs in the biotech industry during 1998, and the market value of those firms at the end of 1998 totaled $3,816.5M. Therefore, the average market

---

'According to the AUTM Licensing Survey FY 1997, 87% of gross license income was from inventions relating to life science while 13% was received from inventions relating to physical science, compared to 86% and 14%, respectively, in FY 1996.
value of each 1998 IPO firm was $181.74M. If the ownership of the original inventor was, for example, 5% (This is the maximum for state employees. There is no limitation for private university researchers.) at the end of the year of IPO, the value of his/her personal equity in the firm is worth $9.09M. Assuming a 15% discount rate, and that the IPO was realized in 5 years after the initiation of the venture, the net present value of the IPO at the initiation amounts to $4.03M. If the IPO occurred 10 years after the firm’s initiation, the NPV at the initiation is worth $1.79M.

The numbers calculated above give some idea of the upside value of the real option for an individual inventor that can be captured by new venture creation. Of course only when the commercialization turns out successful enough for IPO.

In licensing to existing firms, average annual income per license in FY1997 was approximately $100,000; $698.5M of license income was generated by 6,974 active licenses and options. When 36.6% of 85% of $100,000 were assigned to an individual inventor (15% of necessary cost such as legal fees, and 36.6% is the average percentage of net royalty income allocated to inventors calculated in Table 2.4, page 40.), his/her portion amounts to $31,100. Given these
numbers, let's calculate the NPV of the cash flow for him/her. Since patents expire in 20 years, the inventor may receive his/her portion of the income for 20 years. According to Industry Canada (1998), the size of global biotech industry is estimated to grow from US$15 billion in 1995 to US$38 billion by 2005 with an average annual growth rate of 9.74%. Based on the 1997 AUTM survey, 69% of the license income proportionally changes to sales. Thus it is assumed that 69% of the previous year's license income grows constantly for 9.74% every year. Given these assumptions with the same discount rate (15%) as in new venture creation, an average NPV of license income for an individual inventor is worth 0.24M.

Apparently, the pay off, or the upside value of the real option captured by new venture creation ($4.03M in case of IPO in 5 years, and $1.79M in 10 years), is much higher than that of licensing to existing firms, which is $0.24M.

To sum up, given the same technology opportunity, new venture creation may be a better vehicle of technology transfer in terms of the capacity to capture the economic value of commercialization if the upside potential of economic success (sales growth) is large enough. The distinctive feature of the opportunity of IPO in new venture
creation may make it possible for inventors and universities to fully capture the upside value of the commercialization, while in licensing, the capacity to capture it may be less. Gunsalus (1989, p.16) discussed the comparison between licensing to start-ups (new venture creation in this study) and conventional licensing to existing firms and stated that when a mandate to generate income to support other university programs exists, "licensing to a start-up venture may represent an opportunity to maximize institutional income. Although some percentage of ventures will never succeed, those that do may produce a far higher return on investment for the institution than typical licensing arrangements."

In the actual decision making process by inventors, they cannot precisely estimate the future value of the commercialization because of market and internal uncertainty, but can only perceive its upward economic potential. In reality, this perception on the variance of upward potential affects the transfer mode choice. Therefore, in the questionnaire, inventors are asked about how they perceive the upward potential of the commercialization of their technologies.
4.5.5 The cost of each vehicle

If the cost of new venture creation is much higher and outweigh its superior capacity, licensing may become more reasonable choice. In terms of the cost (or price) of the mechanism to implement the real option, new venture creation and licensing to third parties may be not so different depending on the nature of funding in new venture creation.

First, when the initial investment in creating new ventures can be financed purely by venture capitals, the fund is not a financial burden to inventors, since it is not loan, but an investment with the risk of capital loss involved. Venture capitalists always expect a chance of failure of the ventures they invest in as a part of their portfolio. Backed by the fund, inventors can pursue the potential upside value of their ventures without worrying about the downside loss.

In licensing, universities do not incur any cost, given that the patenting cost can be fully compensated by licensees ex post. Therefore, the cost of purchasing a real option is quite low (minimal) for both new venture creation and licensing to existing firms.

However, when inventors financed their ventures by their own personal fund or bank loan, or when universities
purchased (not were granted) a part of the new venture's equity, they do incur the cost (price) of real option purchase (creating new ventures). In this case, the cost of licensing seems lower than that of new venture creation.

4.5.6 Value of real option and the capacity to realize it

So far, two things have become clear. One is that the value of real option increases as the variance of potential economic outcome is expected to be larger. The other is that in implementing (i.e., purchasing and exercising) the real option, new venture creation has larger capacity to capture the full economic value of the commercialization than licensing to existing firms. With these two combined, it is hypothesized that as the inventors perceive the economic potential of their technology commercialization to be larger, they are more likely to choose new venture creation that has larger capacity to capture and accommodate the full upside value of the commercialization.

Hypothesis 3a:
The size of variance of future economic return on technology commercialization is positively associated with the likelihood of new venture creation.
The scope of technology is an important proxy of the variance of potential value of commercialization. When the scope of a technology, or the breadth of applicability of technology, is wide, this so-called “platform” technology may generate multiple numbers of different products. Therefore, preserving the right to commercialize the whole technology opportunities is equivalent to purchase a compound option as a combination of multiple growth options. In this compound option, even though the firm may fail in the first application, still left are the multiple commercialization opportunities for the firm to pursue.

The scope of technology has two characteristics: (1) With the possibility that multiple numbers of technology opportunities might turn out successful, technologies with wider scope may have higher upside potential than a single narrow niche technology (higher upside potential), and (2) Even if some opportunities may fail, other opportunities may still exist, thus increasing the flexibility of the investment and lowering the risk of total failure of the commercialization (lowering the downside risk). Especially because of the first characteristic, the variance of value of commercialization seems potentially higher in platform technologies than in “niche” technologies where there is
only a single or limited chance of commercialization. Therefore,

Hypothesis 3b:

The scope of technology is positively associated with the likelihood of new venture creation.

4.5.7 Uncertainty and the variance of real option value

Folta (1998, p. 1010-1011) introduced the two different types of uncertainty: endogenous uncertainty and exogenous uncertainty. "Endogenous uncertainty can be decreased by actions by firms", and "(t)his kind of uncertainty can only be resolved by learning." "(E)xogenous uncertainty is largely unaffected by firm actions, and is predominantly resolved over time."

In the context of university technology transfer, endogenous uncertainty is uncertainty in finding know-how to commercialize specific technologies, how to manage the organization of commercialization process, what materials are required for commercialization, and so forth. Those things can be learned only by walking through the actual process. Exogenous uncertainty is mostly market uncertainty and governmental/university policy change (institutional
factors). (See the next section, 5.1 Institutional factors for further discussion.)

Clearly, when inventors perceive the endogenous uncertainty to be high, they may be induced to be directly involved in the venture to facilitate effective learning in order to maximize the upside potential of the real option. As Folta (1998, p.1010) suggests, "(p)rojects involving greater degrees of endogenous uncertainty have a wider range of potential outcomes, and hence, more growth options." Thus the perception of higher endogenous uncertainty makes the real option more attractive (increasing value), and increases the likelihood of new venture creation.

When the degree of endogenous uncertainty is perceived to be low, the know-how to commercialize the technology is highly visible and predictable, and the incentive for inventors to be directly involved in the process may not be high. Even though learning (Barney and Lee 1997) is an important element in increasing the value of real options, the effectiveness or necessity of learning in the course of commercialization seems to be lower when endogenous uncertainty is low in the technology opportunity.
Hypothesis 3c:
The degree of endogenous uncertainty is positively associated with the likelihood of new venture creation.

Figure 4.4: Real options theory perspective (H3)

4.5.8 Market signals

The university and inventor's perception of how the market, both capital and product markets, would react the commercialization of their technology is an important indicator of the variance of the potential value of the technology commercialization. Their perceptions directly affect the technology transfer mode choice. These market
signals positively effect the "perceptions of new venture feasibility and desirability" (Bird, Hayward and Allen 1993, Krueger 1993) as well. Perceived product market signals are quite similar to perceived variance of future return on commercialization. Therefore, it will be operationalized as a single variable, perceived variance of future economic return on commercialization. Financial market signal was included in the equations as a control variable.

4.6 Summary

By testing the above hypotheses with several important control variables, it is expected that the relative significance of influential factors on the mode of university technology transfer becomes visible. Three main factors to be examined in choosing university technology transfer mode are: (1) Threat of opportunism, (2) Organizational knowledge tacitness, and (3) The upward potential of economic value of technology commercialization.
CHAPTER 5

CONTROL FACTORS

5.1 Institutional Factors

One strong force that may affect the choice of university technology transfer mode is a set of institutional factors. So far, the discussion has been developed under the assumption that the interests between university inventors and the university are fully compatible. However, the interest among universities, inventors, and industries often conflict with one another (Allen & Norling 1991).

In university technology transfer, the potential conflict between commercial interests and academic missions has always been a serious concern (Davis & Simpson 1987, Fairweather 1990). From the literature on faculty entrepreneurship (Bird, Hayward & Allen 1993, Bird & Allen 1989), as well as preliminary face to face interviews with technology transfer officers and university inventors, it has turned out: (1) Some universities have policies to
facilitate new venture creation while others have policies
to limit new venture creation to a certain degree. (2) Peer
pressure and reputation among co-workers at the department
level has a strong impact on scientists' entrepreneurial
behavior. (3) At individual inventor level, economic
incentives and academic reputation do not necessarily
coincide. These three factors are expected to effect on
technology transfer mode choice. Hence they will be included
as control variables.

5.1.1 Supportiveness of university policies

Although it is true that university technology transfer
has been facilitated by a national agenda, and fully
legitimated by 1980 Bayh-Dole Act and 1980 Steven-Wydler Act,
there is variance among universities in terms of the
supportiveness in entrepreneurial activities. Some
universities may prefer conventional licensing to new
venture creation since conflicts of interest are mainly
created by direct involvement of faculty members in new
venture activities.
5.1.2 Negative peer pressure on faculty entrepreneurship

The sub-culture of the workplace at the department level, which also coincides with different technology areas, is another institutional factor involved in transfer mode choice by inventors. When an inventor’s peers have a negative perception toward entrepreneurial activities by faculty members, the inventor may be discouraged from creating his/her own ventures to preserve his/her own reputation as an academic researcher.

5.1.3 Academic orientation of the perception of personal reward

In academe, economic incentive does not seem to be the only reward for invention. Inventors of new technologies can also be rewarded by publishing their findings in journal articles and presenting them at conferences. Especially when faculty members are non-tenured, the pressure to publish is significant.

Overall, when a researcher perceives academic reward more important than economic reward, his or her patented technology is likely to be transferred through licensing to existing firms rather than to new ventures. The reasons are that economic reward is supposed to be much larger in new
venture creation than licensing to existing firms, and that being involved in new ventures may force him/herself to sacrifice academic activities as commercialization proceeds. A relevant variable to reward perception is the inventor's tenure status. When the inventor is tenured, researchers may be more likely to choose licensing to existing firms in which there is less "conflict of interests" problem compared to new venture creation. If untenured, researchers may feel free to leave the university and start up their own firms because non-tenure status suggests less opportunity cost for leaving. However, the opposite may also be true, that is, untenured inventors are more likely to choose licensing to existing firms, because academic publication is much more important than engaging in entrepreneurial activities to get tenured.

5.2 Personal experience

Some researchers in the personal traits school of entrepreneurship and some practitioners in the preliminary interviews suggested that an inventor's past experience in industry, involvement in patent and/or copyright related activities, research intensity (the degree of commitment in research activities), or "prior entrepreneurial exposure" will also affect the tendency to be actively involved in
entrepreneurial activities. Thus, prior entrepreneurial experience was included as a control variable in this research.
CHAPTER 6

METHODOLOGY

6.1 Population and the unit of analysis

The population of this study is the technologies that have been created by university researchers and transferred to the private sector through licensing to existing firms or new ventures. The key incident delineating the timeframe of this study is the 1980 Baye-Dole Act that enabled universities to own intellectual property rights of the technologies created by university researchers. It is important to note that university technologies that were not, are not being, or are not likely to be transferred to the private sector are not included in the population of this study.

Therefore, as already explained in the section 4.1, the unit of analysis of this study is individual university technologies that have been, are being, or are likely to be transferred to the private sector, of which the licensees are identifiable.
6.2 Preliminary interviews

To understand the reality of university technology transfer and further develop the insight on control variables, the author conducted a series of preliminary interviews with a university inventor, a director of venture incubating facilities affiliated to the Ohio State University, and a director and officers at the Office for Technology Licensing (OTL) at The Ohio State University.

These interviews were quite fruitful in realizing the concepts of technology scope, technology continuity, university researchers’ perception of personal reward, their tenure status, and patent categories as important control variables and independent variables, thereby improved the content validity of this survey.

6.3 Data collection

As for the method of data collection, this study uses a questionnaire survey distributed via internet. Even though secondary information is available from Association of Technology Managers (AUTM) about university technology transfer (patent application and assignment, and licensing activities, etc.), all data are collected and compiled at the university level, not the individual technology level.
Thus, it was necessary to contact individual inventors to collect data on individual patented technologies.

Necessary data were collected in three stages: 1) Creating database of potential respondents who are university inventors, 2) Sending solicitation e-mails to those inventors, and 3) distributing and collecting data through the questionnaire survey made accessible on the author’s web site.

6.3.1 Creating database of potential respondents

Addressees of the solicitation e-mail are the primary inventors of patented university technologies. The primary inventor is an inventor who played a primary role in creating a patented technology. When a technology was created by more than one researchers, the USPTO database credits the primary inventor on the top of the list of inventors so that the primary inventor is identifiable. First, to capture the patented university technologies, the US Patent Bibliographic Database by the US Patent and Trademark Office (USPTO 1999) was used. First, 5,092 patents assigned to US universities between December 1, 1997 and August 31, 1999 were extracted from the database by using the manual search function on the database. The inventors'
e-mail addresses were obtained through the directory services on the assignee universities' home pages on the internet. As a result, 1,956 e-mail addresses were collected. In the database of 1,956 potential respondents, each case consisted of primary inventor’s name, patent name, US patent number, and primary inventor’s e-mail address.

One important point is that these patented technologies do not automatically constitute a sample of this study. Only when the technology was, is being, or is likely to be transferred to existing firms or new ventures, it is qualified to become a part of the sample. This condition ensures that the vehicle of commercialization, whether existing firms or new ventures, is clearly identifiable for each case.

There are patents of which patent assignee is not a single university. Co-assignees can be other universities, non-profit organizations other than universities (i.e. hospitals, research institutions, etc.), and other commercial companies. Especially, co-ownership by universities and commercial entities is often the result of research funded by the commercial entity, or CRADA (cooperative research activities among universities and commercial forms). This type of jointly owned patents were
excluded from the database because those technologies are inevitably commercialized by the patent holding firms, and there is no room for the choice of transfer modes between licensing existing firms and new ventures. Similarly, patents jointly owned by universities and other non-profit organizations were also excluded because there is no assurance that these technologies are transferred by the hands of universities.

6.3.2 Privacy concern in collecting e-mail addresses

Since the directory service on the web assumes public access, this methodology assures that there is no privacy concern in obtaining these addresses. When an e-mail address is not disclosed by a researcher’s will, the author did not search the address any further by searching inside of the institution’s home page. Researchers’ preference not to disclose their addresses was highly respected in this process.

6.3.3 Sending solicitation e-mails

Based on the list of e-mail addresses of primary inventors of patented university technologies, solicitation e-mails were sent to each inventor. To increase the
potential respondent's interest in the survey and response rate, customization was made in each solicitation mail by including primary inventor's name, patent name and the US patent number (Appendix A).

In the solicitation mail, it was asked if the inventor's patented technology was, is being or is likely to be transferred to existing firms or new ventures. If the answer is yes, they are invited to the survey site on the internet to answer the survey.

6.3.4 Distributing the survey, collecting and recording answers

Because of the screening in the solicitation mail, inventors were asked to answer the survey only when they can identify whether the technology transfer is through licensing to existing firms or to new ventures.

When the respondents complete the survey, they are asked to hit the submit button on the screen. This automatically transfers their answers to the database built in a server computer at The Ohio State University.

Using the internet in distributing the questionnaire is quite efficient because of its low cost for both researchers and respondents, mechanical accuracy (thus less measurement
errors), and the quicker response time than mail questionnaire surveys. This method requires virtually no variable costs such as postage, envelopes and the duplication of questionnaire (hard copies). It only requires a total of a few hours of occasional support by a computer technician from information systems department to set up a server database. This database receives all replies from respondents, accumulates and stores them automatically in an orderly manner without any human error. Once the data are collected and stored in the database, they can be easily and quickly converted to the text form suitable for a statistical analysis program (SPSS) run on personal computers.

6.4 Validity

6.4.1 Face validity

Face validity is often dismissed by researchers. However, due to the fact that the author is not a native speaker/writer of English, a professional English writer proofread all survey items for a small fee. Grammatical errors, wrong spelling, awkward English expressions were all corrected during the pretest period.
6.4.2 Content validity

As noted in 2. Preliminary interviews, content validity of the survey was much reinforced by initial interviews and a series of reviews of survey items by a technology transfer officer and dissertation committee members, who have both practical and theoretical knowledge of the research issue. Several independent variables were also found out to be included in the equations as a result of these reviews.

6.4.3 Construct validity

Since the statistical verification of construct validity (both convergent validity and divergent validity) requires the availability of already established other measurements of related constructs, it is very difficult to verify it under an exploratory setting of this study, where other previous measurements of related variables in the context of university technology transfer hardly exist.

However, the construct validity in its original sense represents how well we measure what we want to measure, and the basic idea of verifying it is through multiple operationalizations (Judd, Smith & Kidder 1991). In this sense, each of key constructs in this study was
operationalized in at least two ways in the multiple itemization process.

6.5 Operationalization

6.5.1 Dependent variable

The likelihood of new venture creation is the dependent variable. Licensing to new venture(s) is coded as "1", and licensing to existing firms is coded as "0."

6.5.2 Independent variables

Each hypothesis has the following constructs to be operationalized:

Hypothesis 1a:

The degree of asset specificity

Hypothesis 1b:

The degree of technology imitability

Hypothesis 2a

Path dependence

Hypothesis 2b

Social complexity

Hypothesis 2C

Technology stage

Hypothesis 2d
Technology continuity

Hypothesis 3a:

The variance of future economic return on technology commercialization

Hypothesis 3b:

The scope of technology

Hypothesis 3c:

The degree of endogenous uncertainty

The rest of this section is the description of operationalized variables in the form of statements used in the official survey after five pretests. In constructing the questionnaire, two items (statements) were prepared for each independent variable in the hypotheses to decrease measurement error. However, a single statement was assigned to each control variable, since these factors are more explicit and simple to measure (e.g. inventor’s tenure status).

The reason of choosing “two items” per variable was a very practical one: To shorten necessary time to complete the survey. When three or more items are used, the total number of items in the questionnaire increases by the multiple of ten, which is the number of key variables. After
the preliminary interviews with a university inventor, technology office staff members, and the first pretest, it was determined that this would severely degrade response rate. Therefore, it was highly desirable to design the survey in a way that respondents can complete it in ten minutes or less. After the author answered a preliminary version of the questionnaire as a simulation, it has been realized that approximately 30 questions seemed appropriate to complete in 5 to 10 minutes. Therefore, having 20 questions for 10 key variables plus roughly 10 questions for control variables was the initial plan. In the end, the questionnaire ended up with 35 questions by adding five more control variables.

Except for categorical variables, 5-point Likart scale was used in asking agreement questions with "-2" as "Strongly disagree", "+2" as "Strongly agree", and "0" as "Neither agree nor disagree" in the middle point. The use of negative and positive numbers reflects the bipolar nature of agreement (Spector 1992). As for the questions asking categorical and/or factual information such as the employment status of the inventor and the patent field of each technology, a simple multiple choice method was adopted.
6.5.2.1 The degree of asset specificity

Asset specificity was measured by asking about specialization on both parties: universities where the technologies were created and potential licensees where the technologies are further developed and commercialized.

Asset specificity (licensee) 1:
"It is likely that the licensee needs to make a specific investment, useful only in commercializing this technology."

Asset specificity (licensee) 2:
"The licensee of this technology has to make a new investment to commercialize this particular technology."

Asset specificity (university) 1:
"We needed to introduce specialized equipment to create this technology."

Asset specificity (university) 2:
"To create this technology, we had to expend our fund in customizing (or purchasing specialized) equipment in our lab."

After measuring asset specificity, a new categorical variable was created to measure the mutual asset specificity using the data collected on the above two variables (Asset specificity-licensee and asset specificity-university).

Mutual specificity is important because, in the transaction
cost logic, the fundamental transformation of the relationship between transaction partners occurs when both parties are locked in a specific transaction due to mutual asset specificity (Williamson 1975).

Based on this idea, a new variable, asset specificity pattern (ASPT), was created as a categorical variable that classifies the cases into four groups. These groups are classified in terms of the locus of specificity: 1) specificity in both the university and the licensee, 2) high specificity in the licensee but not in the university, 3) high specificity in the university and not in the licensee, and 4) neither of both.

6.5.2.2 The degree of technology imitability as a source of the threat of opportunism

Imitation occurs either by direct duplication or substitution (Barney 1996). Since the direct duplication of valid patents without paying royalties, licensing fees or any other form of payment is illegal, substitution is the only case in which the threat of opportunism may emerge. Illegal duplication does not constitute the threat of opportunism because one can expect that the law will protect intellectual property rights if the violation happens. In
the survey, how hard the technology is to imitate was asked. Therefore, the questions actually asked about "inimitability." The following statements were asked in the survey:

Technology imitability 1:
"Even other experts who have detailed knowledge about this technology may find it difficult to find a substitute for it."

Technology imitability 2:
"It is hard to make (or find) a substitute for this patented technology."

6.5.2.3 The degree of tacitness of the knowledge useful for the development and commercialization of the technology

As indicated in the hypotheses section (4.4), imperfect imitability of knowledge is used as a proxy of knowledge tacitness. Thus, knowledge can be "tacit" when one or more of the following natures exist in the knowledge: path dependence, social complexity, causal ambiguity and substitutability. Causal ambiguity was excluded because it becomes a source of tacitness only when parties involved are not aware of the causality. Thus, asking researchers about the degree of ambiguity of the causality between their
knowledge and the success of commercialization is awkward and does not provide an accurate measure of knowledge tacitness. Therefore, the questionnaire asked the following six statements to measure the other three constructs:

Path dependence 1:
"While creating this technology, I also accumulated specific experience and know-how, useful in commercializing this technology."

Path dependence 2:
"Knowledge acquired through the creation process of this technology is useful to commercialize this technology."

Social complexity 1 (Human network necessity):
"Interaction with colleagues, friends, or potential business partners is important to gain useful knowledge (either technical or non-technical) in commercializing this technology."

Social complexity 2 (Team necessity):
"Useful knowledge, which may be technical or non-technical, in commercializing this technology becomes available only when particular individuals get together as a team."

Substitutability 1:
"There is no substitute for my personal experience and knowledge to help commercialize this technology."
Substitutability 2:
"My direct involvement is indispensable to commercialize this technology successfully."

6.5.2.4 The stage of technology at the time of transfer

This construct was measured by asking the stage of the technology in research and development effort. The phrase used in the survey was: "The stage of your technology at the time of licensing contract:" with options: 1 as "basic research", 2 as "between basic and applied research", 3 as "applied research", 4 as "between applied research and development", and 5 as "development." At the end of this question, the definitions of the above three stages by National Science Foundation were attached for clarification.

6.5.2.5 Technology continuity

Whether the technology is "continuous" or "discontinuous" was operationalized and measured by asking the response to the following two statements:

(1) Technology continuity 1
"This technology may replace numerous existing products, services, or processes once it is commercialized."

(2) Technology continuity 2
"This technology may replace currently available technologies in the industry."

6.5.2.6 The variance of future economic return on technology commercialization

As discussed in literature review and hypotheses sections for real options theory, both new venture creation and licensing to existing firms can be interpreted as vehicles to access real options, and both of them have a limited down side risk because of the nature of each technology transfer mode. Therefore, it was asked in the survey how inventors perceive the upside economic potential of the commercialization. This upside potential reflects the outcome of commercialization as a whole, but it is also tightly connected to personal economic reward for inventors themselves.

Variance of option value 1:
"This technology has the potential to generate large economic returns."

Variance of option value 2:
"When commercialized successfully, this technology will generate total revenues more than $100,000 per year."
"$100,000 per year" in the above statement comes from the average royalty income per license based on 1997 AUTM data. Thus the statement is implicitly asking whether the technology would generate more than average economic revenue.

The scope of technology, as a proxy of the variance of the upside potential of the commercialization, represents whether the technology is "platform" technology or "narrow niche, one-off" technology. This construct was measured by asking the following two statements:

Technology scope 1:
"This technology works as a platform for a wide variety of commercial applications."

Technology scope 2:
"This technology has a narrowly specified commercial application." (Answers in the opposite direction to the first were expected in this statement.)

As another proxy of upside potential of the commercialization, market signals were also asked in the survey.

Product market signal:
"The product developed from this technology has (will have) considerable demand in the market."

Capital market signal:
"Financial capital is (will be) available to commercialize this technology."

6.5.2.7 The degree of endogenous uncertainty

The perception of the degree of endogenous uncertainty was measured by asking the degree of agreement to the following two statements:

"During the actual commercialization, there may be new findings (e.g. related technologies, know-how of product development, better skills, etc.) that further boost up the economic potential of this technology."

"What is being (or will be) learned during the actual commercialization process will further increase the upside potential of its economic success."

6.5.3 Control variables

Variables from institutional theory, entrepreneurship literature, and face to face preliminary interviews were included in the equation as control variables.

6.5.3.1 Institutional variables

The degree of agreement to the following statements was asked in the questionnaire.
Supportiveness of surrounding environments:

University policy level:
"In general, this university supports new venture creation by its faculty members."

Department level: This construct measures the level of supportiveness of peer researchers who are the inventor’s colleagues in his/her department (workplace).
"In my department, people openly discuss ideas of entrepreneurship in relation to commercializing technologies."

Community level: This construct represents the overall supportiveness of the community for the entrepreneurial activities. The following item measures how researchers perceive the community surrounding them is supportive in pursuing entrepreneurship.
"Necessary support systems for the creation of new ventures - such as incubating facilities, capital, and human resources - are available in this community (city level)."

Academic orientation of reward perception: Based on the survey by Bird, Hayward & Allen (1993) and Bird & Allen (1989), the following statements were presented in the questionnaire: "Academic rewards (i.e., publishing, reputation among scientists, etc) are more important to me
than the commercial success of my technology.” (Perception of reward)

"Are you tenured in the above potion?" (Tenure status)
This is a yes-no question, and coded as a dummy variable with "yes (tenured)" as a reference.

6.5.3.2 Prior exposure to entrepreneurial activities

Based on the survey by Bird, Hayward & Allen (1993) and Krueger (1993), the construct is measured by asking the degree of agreement to the following statement:

"The amount of my industry experience as consultant, engineer, manager, etc. is:" (1-5 points from "Very little" to "Very rich")

The list of variables and corresponding statements shown in the survey are organized in APPENDIX B: Variables and Corresponding Statements. The actual appearance of the survey on the World Wide Web is in APPENDIX C.

6.5.3.3 Patent field and statutory category

Following a technology transfer officer's advise, broad categories of patents in terms of basic academic disciplines and the types of patents specified by the patent law were asked in the survey.
In the question of patent field, the respondents were asked whether the patent belongs to which of the following fields: biotechnology, medical other than bio-, chemistry/physics other than bio-, engineering/instrumentation/manufacturing, or other. Statutory category was also asked: process, machine, composition of matter, manufacture, or other (a combination of two or more of the above). Both variables were coded as dummy variables with the first item as a reference respectively.

6.6 Pre-test survey

6.6.1 Internal consistency reliability (Cronbach's alpha)

After the initial structure and contents of the questionnaire were completed, a series of pretests were conducted to verify and improve the reliability of the measurement. After each pretest, correlation between two items for each variable was calculated. When the coefficient is lower than .7, the item was modified and tested again. In each test, a different sample was used since asking the same questions to the same respondents more than once was quite problematic. It was known through preliminary interviews and the first pretest that the potential respondents are
extremely busy conducting research and teaching. Approximately 135 to 150 mails were sent in each pretest, and the sample size ranged from 20 to 23 (average response rate = 15%).

After the fifth pretest (n=23), the Cronbach’s alpha for each of the key constructs became close enough to, or more than a satisfactory level except for one variable (Asset specificity for licensees). Generally, levels of .7 or more are perceived as representing “good” reliability (Nunnaly 1978, Litwin 1995). Cronbach’s alphas at the end of the fifth pretest were as follows.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cronbach’s alpha</th>
<th>Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset specificity (licensee)</td>
<td>0.4283</td>
<td>To be dropped</td>
</tr>
<tr>
<td>Asset specificity (university)</td>
<td>0.7950</td>
<td>Good</td>
</tr>
<tr>
<td>Technology imitability</td>
<td>0.8269</td>
<td>Good</td>
</tr>
<tr>
<td>Knowledge tacitness (social complexity)</td>
<td>0.6071</td>
<td>Moderate</td>
</tr>
<tr>
<td>Knowledge tacitness (path dependence)</td>
<td>0.5138</td>
<td>Marginally OK</td>
</tr>
<tr>
<td>Knowledge tacitness (substitutability)</td>
<td>0.5831</td>
<td>Marginally OK</td>
</tr>
<tr>
<td>Technology scope</td>
<td>0.6120</td>
<td>Moderate</td>
</tr>
<tr>
<td>Technology continuity</td>
<td>0.6473</td>
<td>Moderate</td>
</tr>
<tr>
<td>Variance of real option value</td>
<td>0.7664</td>
<td>Good</td>
</tr>
<tr>
<td>Endogenous uncertainty</td>
<td>0.7012</td>
<td>Good</td>
</tr>
</tbody>
</table>

Table 6.1: Cronbach’s alpha after pretest #5 (n=23)
Four variables reached .7 level, three reached .6, and two reached .5 level. Only asset specificity (licensee) failed to reach .5 level. This variable was the most difficult one in improving the correlation coefficient during five pretests, and it was thought that dropping off this variable was inevitable after the fifth pretest. As for the knowledge tacitness which has three variables as proxies, at least one exceeded .6 level showing a moderate and tolerable level of reliability. Based on this judgement of reliability after the fifth pretest, the official run was conducted by sending 931 solicitation mails in total with 142 responses (nominal response rate* = 15.25%).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cronbach's alpha</th>
<th>Reliability Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset specificity (licensee)</td>
<td>0.6172</td>
<td>Moderate</td>
</tr>
<tr>
<td>Asset specificity (university)</td>
<td>0.6680</td>
<td>Moderate</td>
</tr>
<tr>
<td>Technology imitability</td>
<td>0.7123</td>
<td>Good</td>
</tr>
<tr>
<td>Knowledge tacitness (social complexity)</td>
<td>0.4423</td>
<td>To be decomposed</td>
</tr>
<tr>
<td>Knowledge tacitness (path dependence)</td>
<td>0.7013</td>
<td>Good</td>
</tr>
<tr>
<td>Knowledge tacitness (substitutability)</td>
<td>0.7812</td>
<td>Good</td>
</tr>
<tr>
<td>Technology scope</td>
<td>0.7180</td>
<td>Good</td>
</tr>
<tr>
<td>Technology continuity</td>
<td>0.6242</td>
<td>Moderate</td>
</tr>
<tr>
<td>Variance of real option value</td>
<td>0.8597</td>
<td>Good</td>
</tr>
<tr>
<td>Endogenous uncertainty</td>
<td>0.6903</td>
<td>Good</td>
</tr>
</tbody>
</table>

Table 6.2: Cronbach’s alpha after official run (n=140)
Cronbach’s alpha was recalculated for each multi-item variable as the final test of internal consistency. With a larger sample size, the official run provided greater internal consistency. As Table 6.2 shows, all Cronbach’s alphas exceeded .6 except social complexity that is one of the three measures of knowledge tacitness. Thus, all, except one, multiple item measures were found reliable. Answers to multiple items were averaged to create one measurement.

As a result of low alpha value, which is less than .5, it was decided to decompose social complexity and treat two items as two separate variables. One item was named as “the necessity of human network in acquiring useful knowledge for commercialization”, and the other was named as “the necessity of specific team for commercialization.”

6.6.2 Other improvements during pretests

Some other improvements were also made possible during the five pretests mostly based on comments by survey respondents and academic advisors of the author.

First, in the job title section, “research scientist” was added followed by comments from respondents that the survey should have it as a job title since many technologies
are invented by research scientists in universities, not always by faculty members.

Second, a question about tenure status was added. Initially, a question asking academic titles was intended to identify the tenure status of respondents. However, it had turned out that academic titles are not the accurate measure of tenure status. Therefore, a question directly asking the tenure status of respondents was added at the third pretest.

Third, statutory category of patents was added at the third pretest to further clarify the nature of technology based on the suggestion by the director of technology transfer at OSU.
CHAPTER 7

RESULTS, DATA ANALYSIS AND DISCUSSION

7.1 Response rate

Among 931 potential respondents who received the solicitation mail, 142 inventors returned their answers online. Thus, nominal response rate was 15.25%. As noted above, the addressees of solicitation mails include inventors whose technologies have never been, are not being, or are not likely to be transferred to the private sector. These inventors are not in the population of this study. In fact, 30 inventors among 931 replied that they decline to answer the survey because their technologies have never been, and won’t be transferred in the foreseeable future. Also, 40 solicitation mails were returned due to delivery error caused by invalid addresses. When these inventors are subtracted out of 931, the response rate increases to 16.49%. 8 respondents out of 142 were excluded because they chose the technology transfer mode as “other.”
7.2 Response bias

The proportion of each transfer mode (licensing to existing firms vs. licensing to newly created ventures) was 67.9% and 32.1% respectively within the sample (n=134). According to the data from AUTM license survey from 1996 and 1997, the numbers of new licenses during the year were 2,741 and 3,328 respectively, and the numbers of new ventures created based on those licenses were 248 and 333. Even though new licenses and new venture establishment based on them may not necessarily coincide in the same year, the average proportion of the number of new venture creation to the number of newly licensed technologies is roughly 9.5% (9.04% for 1996 and 10.00% for 1997). If only one technology is always licensed by a new venture, the proportion of new ventures in the respondent group of this study seems three times as large as in the total population. However, the director of a technology transfer office commented that often a combination of technologies are licensed such as the core patent and the necessary technology to manufacture products based on the core patent.

Some factors seem to have contributed to this "bias". First, inventors who have transferred or are going to transfer their technologies to their new ventures might be
more willing to answer the survey than those who did not and will not transfer them to new ventures. They may have thought that answering this survey would enhance the exposure, and possibly publicity, of their technologies. Second, as a director suggested, new ventures might have licensed more than one patent.

Other than the proportion of new ventures to the number of licenses, an obstacle exists in examining response bias. That is the anonymity of this survey. In general, when dealing with sensitive questions in survey questionnaires, there is a trade-off between increasing response rate and the detection of who responded and who did not to check the response bias by comparing the both groups’ demographic characteristics. In this study, anonymity, which ensures stronger protection of privacy, was prioritized because some of the questions asked for sensitive information on investment decisions and personal beliefs.

For example, the necessity of specific investments in commercialization and the economic potential of technologies are sensitive questions for some inventors when the actual licensing negotiation is in progress, because the secrecy of the content of licensing agreement is critical in some cases. In addition, asking about colleague’s supportiveness, tenure
status, and the priority between academic achievement and economic success may also be sensitive to some respondents.

If many potential respondents chose not to answer the survey because they did not want to disclose their identity and sensitive information, survey results may suffer even more serious response bias. In fact, under the promise of strict anonymity, still some potential respondents declined to answer the survey because of this very reason. Therefore, it is believed that this anonymity did not increase the response bias, rather helped to reduce it.

E-mails from potential respondents who declined to participate in the survey revealed some of the reasons that they decided or chose not to answer the survey even if their technologies were, are being, or likely to be transferred. The most common reason was that they were busy and had "no time" to participate. Second, they could not answer the survey because they were away from home (i.e., vacation, sabbatical leave, etc.) and had very limited access to the web. Third, some potential respondents reported that they could not respond the survey because of confidential clause in the licensing contract or because of on-going licensing negotiation. Fourth, illness was the reason of not answering
the survey. Fifth, some expressed no interest in the survey on technology transfer.

Among the above reasons, the third reason: confidential clause might have applied more to the cases of licensing to existing firms rather than new venture creation where licensors and licensees are, in a sense, in the same boat. Thus this reason may have contributed to the lower proportion of licensing to existing firms than in the population.

As explained above, a difference does exist between respondents and non-respondents. It is necessary to take this into consideration when interpreting the results of data analysis.

7.3 Binary logistic regression analysis

Reflecting the nature of the dependent variable of this study, which is categorical and dichotomous, logistic regression analysis was conducted. In logistic regression analysis, the likelihood of the occurrence of one alternative over the other is estimated in the form of odds ratio, which means how much one unit increment of an independent variable increases the odds of an event to occur. Partial contribution of each independent variable among all
independent variables is also shown as a result of logistic analysis.

A logistic regression model can be written in terms of the log of the odds of an event occurring ("log of the odds" is called "logit").

\[
\log(P(\text{event})/P(\text{no event})) = B_0 + B_1X_1 + B_2X_2 + \ldots + B_pX_p
\]

, where \(P\) is probability, \(X_1 \ldots X_p\) are independent variables, \(B_1 \ldots B_p\) are corresponding coefficients, and \(B_0\) is a constant.

One thing to notice here is what the "odds" mean. In the logistic analysis, "odds" are not just probabilities such as "80% chance of rain", but the ratio of probabilities. For example, under the assumption that new venture creation and licensing to existing firms are mutually exclusive, let's suppose that the chance of new venture creation is 33.33\% in a case and that of licensing to existing firms is 66.66\%. The odds of new venture creation in this case is 33.33/66.66 = .5. This means that new venture creation is half as likely as licensing to existing firms. Since interpreting estimated coefficients by using the "log of odds" is intuitively difficult, the above equation can be rewritten in terms of odds:

\[
P(\text{event})/P(\text{no event}) = e^{B_0 + B_1X_1 + B_2X_2 + \ldots + B_pX_p}
\]
, where $e$ is the base of the natural logarithms, which is approximately 2.718. Based on this expression, we can say that when $B_i$ is positive, "the factor will be greater than 1, which means that the odds are increased; if $B_i$ is negative, the factor will be less than 1, which means that the odds are decreased." (SPSS Inc. 1997, p.43)

Odds ratio, expressed as $\text{Exp}(B)$ in SPSS output, represents a factor by which the odds increases when the value of the independent variable increases by one unit with all other variables constant.

The Wald statistic is used to test the null hypothesis that the coefficient is zero. The Wald statistic with dichotomous dependent variable ($df = 1$) is the square of the ratio of the coefficient to its standard error.

Partial correlation between the dependent variable and each of the independent variables is the $R$ statistic. $R$ ranges between $-1$ and $+1$. When $R$ is positive, it indicates that as the value of the independent variable increases, the likelihood of the event occurring also increases. The larger value of $R$ indicates that the variable has relatively larger contribution to the model.
7.4 The possibility of self selection bias

One concern before applying binary logistic regression to the models is the possibility of self selection bias (Heckman 1979). Shaver (1998) points out that it is problematic to apply regression analysis to the relationship between strategy choice and firm performance because of the self selecting nature of strategy choice, which is different from the assumption of random assignment in ordinary regression analysis. In fact, each firm self-selects a strategy depending on its own firm resources and industry conditions (Masten 1993).

Shaver (1998) empirically examined how self selection bias can affect the result of regression analysis of the relationship between entry mode choice in foreign direct investment and firm performance. According to the result, without correcting the bias, the effect of greenfield strategy over acquisition turned out to be inflated compared to the result with the correction in which the statistical significance of entry mode choice disappears.

However, it seems that the concern of self selection bias as Shaver (1998) raised does not apply to this particular study. In fact, the dependent variable of this study is not the firm performance, but the strategy choice
itself which is independent variable in Shaver (1998). Actually, this study examines the determinants of self-selected strategies. Therefore, this study in a sense responds to the Shaver (1998)'s concern by tracing back the determinants of self-selected strategies, given that the next step of this study is the performance implication of the strategy choice.

Another possibility of self selection is in the inventors' decisions to transfer their technologies. However, this study focuses only on the technologies that have already been, is being, and will highly likely be transferred to the private sector. Whether the university technologies are transferred or not does not constitute an independent variable in this study. Population of this study exclude the technologies that is not likely to be transferred. Therefore, there is no self selection concern in this study.

7.5 Zero-order Correlation

To check multicollinearity, the zero-order correlations among all independent variables were calculated (Appendix D). The result shows that none of the pairs of variables has a correlation as high as .7 or above which is believed to be a
problematically high correlation. The largest correlation was .445 between path dependence and knowledge substitutability. Thus, multicollinearity does not exist in a problematic manner.

7.6 Four models and hypotheses tests

The first model tested the explanatory power of transaction cost economics, the second model tested the resource based theory of the firm, and the third model tested the real options theory. The fourth model was the full model in which all independent variables were introduced in one equation and the relative contributions of the three theories were examined.

7.6.1 Criteria for the goodness of the fit of the model

In addition to the examination of the effect of each independent variable on the dependent variable, the assessment of the fit of the model as a whole to the observed data is crucial, especially when comparing the explanatory power of different models. The following criteria were used to assess the fit of each model in terms of model discrimination and model calibration.
Model discrimination evaluates how successfully the model can distinguish the cases into two groups based on estimated probabilities of the event to occur: the one with the event actually occurring and the other with no event. Needless to say, the event in this study is new venture creation (= licensing to newly created ventures) and the non-event is licensing to existing firms.

A preliminary criterion for model discrimination is classification table (Table 7.1). In this example, among 100 cases with the event actually not occurring ("No" under "Observed" in the above chart), 75 cases were correctly estimated to have more than 50% of probability of the event not occurring. However, among 100 cases with the event actually occurring, only 40% of them were estimated correctly to have less than 50% of probability of the event occurring. When the percentage correct is less than 50%, it

<table>
<thead>
<tr>
<th>Observed</th>
<th>Predicted</th>
<th>Percent correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>Yes</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in each column are the numbers of cases.

Table 7.1: Classification table (Example. N=200)
means the prediction is worse than flipping a coin. Given that this condition is met, the overall percent correct (57.5% in this example) can then be used as a criterion to evaluate the model discrimination as a whole model.

Model calibration evaluates how well the predicted probabilities and the observation match. Three criteria were used: the likelihood, the goodness of fit statistic, and the Nagelkerke $R^2$.

The likelihood is the probability of the observed results based on the parameter estimates. This works as an indicator of how well the model fits the observed data. It is usually expressed as -2 times the log of the likelihood (-2LL). When the model has a good fit to the data, the likelihood becomes high, thereby the smaller value of -2LL.

The goodness of the fit statistic compares the observed probabilities (100% or 0%) to the predicted probabilities:

$$Z^2 = \Sigma \left( \frac{\text{Residual}_i^2}{P_i(1-P_i)} \right)$$

where residual is the difference between the observed value and the predicted probability $P_i$. The smaller value for this statistic represents the better fit.

Nagelkerke $R^2$ is similar to the $R^2$ in the linear regression analysis. It explains how much proportion of the
variation in the dependent variable is explained by the model.

In the following section, the test result of the three theoretical models is first summarized, then reported in detail in addition to the result of the full model which combines all three theoretical models. In testing each model, "forced enter" was first conducted to see the effect of all independent variables and control variables. Then, forward and backward stepwise logistic regressions were conducted to identify the combination of variables that maximizes the fit of the model.

7.6.2 Summary of the test results of theoretical models
7.6.2.1 Transaction cost economics model

Hypothesis 1a (asset specificity) was partially supported. Among three variables to measure asset specificity, "asset specificity in the licensee" had a positive effect on the odds of new venture creation with moderate statistical significance (alpha level = .1). Asset specificity in the university and asset specificity pattern (mutual specificity) did not have statistically significant effects.
Hypothesis 1b (technology imitability) was not supported. On the contrary, technology imitability had an effect in the opposite direction (alpha level = .05) on the odds of new venture creation. That is, technology imitability had a negative effect on the odds of new venture creation.

7.6.2.2 Resource based theory model

Hypothesis 2a (path dependence) was not supported.

Hypothesis 2b (social complexity) was partially supported. Among the two proxies of social complexity: “human network necessity in acquiring the useful knowledge” and “team necessity in embodying the useful knowledge”, the former had a statistically significant positive effect on the odds of new venture creation (alpha level = .05), while the latter did not.

Hypothesis 2c (substitutability) was not supported.

Hypothesis 2d (technology stage, whether the technology is more toward basic research rather than development) was not supported.

Hypothesis 2e (technology continuity, whether the technology is discontinuous or not) was not supported.
7.6.2.3 Real options theory model

Hypothesis 3a (perceived variance of future economic return) was not supported.

Hypothesis 3b (technology scope, whether the technology is a platform technology) was not supported.

Hypothesis 3c (endogenous uncertainty) was supported. Endogenous uncertainty had a strong positive effect on the odds of new venture creation (alpha level = .05).

7.6.3 Results of logistic regression of the four models

In conducting the logistic regression, the model 0 containing only control variables was tested first, then relevant theoretical variables were added to the model 0 to test each theoretical model (model 1, 1', 2 and 3). Control variables included in model 0 were perception of personal reward (RWPC), patent's statutory category (PATF), patent's disciplinary category (PATS), department's support (DPSP), and market signal in financial market (MKSGF). These variables were kept throughout the following theoretical models.

The following table shows the combined test results of the three theoretical models and the full and best model all combined.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 0 Controls only</th>
<th>Model 1 TCE (ASPL&amp;ASPU)</th>
<th>Model 1 TCE (ASPT)</th>
<th>Model 2 RBT</th>
<th>Model 3 ROP</th>
<th>Model 4 Full and best</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWPC</td>
<td>.7294*</td>
<td>.7077*</td>
<td>.7285*</td>
<td>.7695</td>
<td>.8067</td>
<td>.7636</td>
</tr>
<tr>
<td>PATF(Machine)</td>
<td>.2582**</td>
<td>.1890**</td>
<td>.2416**</td>
<td>.3639</td>
<td>.2920*</td>
<td>.2718*</td>
</tr>
<tr>
<td>PATS(Chem/Phys exc bio)</td>
<td>.2591*</td>
<td>.2388*</td>
<td>.2541*</td>
<td>.2168**</td>
<td>.2332**</td>
<td>.2260*</td>
</tr>
<tr>
<td>DPSP</td>
<td>.8369</td>
<td>.8020</td>
<td>.7867</td>
<td>.7562</td>
<td>.7650</td>
<td>.7470</td>
</tr>
<tr>
<td>MKSGF</td>
<td>1.1304</td>
<td>1.0381</td>
<td>1.0811</td>
<td>.9838</td>
<td>.8582</td>
<td>.8867</td>
</tr>
<tr>
<td>ASPL</td>
<td>1.8221**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.4243</td>
</tr>
<tr>
<td>ASPU</td>
<td>.9927</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMTB</td>
<td>1.7311**</td>
<td>1.6798**</td>
<td></td>
<td></td>
<td></td>
<td>1.7290**</td>
</tr>
<tr>
<td>ASPT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.8965</td>
</tr>
<tr>
<td>HUNTW</td>
<td>2.0171**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.8497**</td>
</tr>
<tr>
<td>TEAM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.4552</td>
</tr>
<tr>
<td>TPOP</td>
<td>1.1820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STC</td>
<td>1.8893</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCCN</td>
<td>1.3259</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOPV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5265</td>
</tr>
<tr>
<td>ENUN</td>
<td>2.4392**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.6922**</td>
</tr>
<tr>
<td>TSCP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0529</td>
</tr>
<tr>
<td>Constant (estimated value)</td>
<td>1.0294</td>
<td>-2.7353</td>
<td>-.1686</td>
<td>-4.1761**</td>
<td>-3.7272*</td>
<td>-5.9885**</td>
</tr>
</tbody>
</table>

Negelkerke R²               | .232                  | .313                    | .275              | .337        | .318        | .382                 |

-2 Log Likelihood (-2LL)    | 137.953               | 128.757                 | 133.103           | 123.944     | 128.078     | 120.249              |

Change of -2LL to model 0   | n.a.                  | -9.196                  | -4.850            | -14.009     | -9.875      | -17.704              |

% correct for new ventures  | 41.46%                | 41.46%                  | 41.46%            | 55.00%      | 46.34%      | 58.54%               |

Overall % correct prediction| 74.42%                | 72.09%                  | 72.09%            | 77.34%      | 74.42%      | 78.29%               |

(Numbers on the right of each variable show odds ratio in each model except for constant value.)

(Alpha level: ***=.01, **=.05, *=.1)

Table 7.2: The result of logistic regression (all models)
7.6.4 Transaction cost model (model 1 and 1')

In this model, asset specificity and technology imitability are the main independent variables. In addition to the two variables: asset specificity in the university and that in the licensee, a third variable was created afterwards (asset specificity pattern denoted as ASPT) to measure the mutual specificity by categorizing cases based on the values of the initial two variables. Since this new variable was based on the initial two variables, it naturally had a high correlation with them (.64 with ASPL and .61 with ASPU). Therefore, the transaction cost model was tested in two versions to avoid the problem of multicollinearity: one (model 1) with asset specificity in the licensee (ASPL) and in the university (ASPU), and the other (model 1') with asset specificity pattern (ASPT).

Asset Specificity (Hypothesis 1a): Among three variables measuring asset specificity, only "asset specificity in the licensee" had a statistically significant effect. Its estimated odds ratio, 1.8221, means that the degree of asset specificity in the potential licensee had a positive impact on the odds of new venture creation. Also, it means that when the inventor judges the degree of
specificity by one point higher in the 5 point Likart scale, the odds of new venture creation increases by 82%.

When the potential licensee has to make the specific investment to commercialize particular technologies, and the investment's value for the second best use is much lower than that for the primary use, the potential licensee may not be willingly involved in the commercialization. The licensor (university and inventor) or other competitors may take advantage of this situation. If this is the case, the licensor finds it difficult to attract the potential licensees. Therefore, the inventor has to create a new venture to commercialize his/her own technologies, thereby the odds of new venture creation increases.

Technology imitability (Hypothesis 1b): This hypothesis was not supported. In fact, technology imitability had a statistically significant effect (alpha level = .05), but in the opposite direction to that predicted in the hypothesis. The estimated odds ratio, 1.7311, suggests that the technology inimitability (difficulty in imitating) had a positive impact on new venture creation. Also, the odds ratio means that when the inventor judges the inimitability of his/her technology by one point higher in the 5 point
Likart scale, the odds of new venture creation increases by 73%.

This is quite contrary to how the hypothesis 1b predicted. In the hypothesis, it is predicted that when the technology is easy to imitate, the potential licensees may behave opportunistically and the inventors would avoid licensing to existing firms and create new ventures to commercialize their technologies. In other words, this hypothesis predicts that when the technology is hard to imitate, inventors would feel safe in negotiating licensing contracts with existing firms because these potential licensees are not be able to exploit the technologies and free ride during the negotiation period. This issue will be discussed in detail in the following discussion section.

Control Variables: The result of logistic regression showed that three control variables have statistically significant effects on the dependent variable. Those are perception of personal reward, patent field (Machine), and statutory category of patent (Chemistry/Physics except bio).

Perception of personal reward had a negative effect (alpha level = .1). This shows that the odds of new venture creation to licensing to existing firms decreases when inventors prefer academic reward to economic reward. Its
odds ratio, .7077 means that when the inventor chooses one higher value in the 5-point Likart scale in answering the inclination toward academic reward, the odds of new venture creation decreases by 30%.

Patent's statutory field (Machine) had also a statistically significant negative effect (alpha level = .05). The reference item in this variable is patent field (Process). Therefore, the odds ratio .1890 means that when the technology to be transferred was "machine" instead of "process", the odds of new venture creation declined by 81%.

Patent's disciplinary category (Chemistry/Physics except bio) also had a statistically significant negative impact (alpha level = .1). Its odds ratio .2388 suggests that the odds of new venture creation decreased by 76% when the technology was in the field of chemistry or physics unrelated to biotechnology.

Among variables that have statistically significant effects in this model, the order of partial contribution was, with the largest contribution first, the statutory category of patent (machine), technology imitability, reward perception, and asset specificity (licensee).

As an entire model, this transaction cost model explained 31.3% of the variation of the dependent variable.
In terms of the goodness of the fit of the model, -2LL showed 128.757, which is a little improvement (-9.196) from the base model (model 0). However, there is a problem in model discrimination. Correct rate for new venture creation was less than 50% (41.46%), which means that this prediction is not as good as flipping a coin, even though the total correct rate is 72.09%.

7.6.5 Resource-based theory model (model 2)

The primary construct in this model is knowledge tacitness. This construct was further broken down into six variables: 1) human network necessity in acquiring the knowledge (denoted as HUNTW, a proxy of social complexity), 2) team necessity in embodying the knowledge (denoted as TEAM, another proxy of social complexity), 3) path dependence (denoted as TPDP), 4) knowledge substitutability (denoted as TSUB), 5) the stage of technology, and 6) technology continuity.

The variable that had statistically significant effect was human network necessity (hypothesis 2b: social complexity). None of the other variables: path dependence (hypothesis 2a), knowledge substitutability (hypothesis 2c), the stage of technology (hypothesis 2d), and technology
continuity (hypothesis 2e), showed statistically significant effect.

Human network necessity had a statistically significant (alpha level = .05) positive impact on the dependent variable with the odds ratio of 2.0171, which means that when the respondent judges the degree of necessity by one point higher on the 5 point Likart scale, the odds of new venture creation increases by almost 102%.

Among the control variables, patent field (Chemistry/physics except bio) had a statistically significant negative impact when compared to the case in biotechnology.

The effect of patent field (Chemistry/physics except bio) and human network necessity had roughly the same magnitude on the dependent variable, but in the opposite direction.

As an entire model, this resource based model explained 33.7% of the variation of the dependent variable. \(-2LL\) was 123.944 showing significant improvement \((-14.009)\) from the base model (model 0). In terms of the model discrimination, this model predicted both licensing to existing firms and new venture creation with more than 50% of correct rate. As a whole, this model explanatory power of this model is
superior to that of the transaction cost model (model 1 and 1').

7.6.6 Real Options Model (model 3)

Hypothesis 3a (the perceived variance of future economic return on technology commercialization) was not supported.

Hypothesis 3b (the scope of technology) was not supported.

Hypothesis 3c (the degree of endogenous uncertainty) was supported (alpha level = .05). There was a positive effect on the dependent variable. Also, when the respondent judges the degree of endogenous uncertainty by one point higher in 5 point Likart scale, the odds of new venture creation increases by 144%. This variable had the largest impact among all variables that had statistically significant effects in this model.

Among control variables, statutory category of patent (Machine) and patent field (Chemistry/Physics except bio) both showed negative effects with statistical significance of .1, and .05 respectively.

In terms of the fit of the model, the correct rate for new venture creation is slightly less than 50%, which is not
as good as flipping a coin. -2LL indicating the fit of the model was 128.0714, which is a moderate improvement from the base model, and the amount of improvement is roughly the same as the transaction cost model. Negelkerke R square of .318 shows that 31.8% of variance of the dependent variable is explained by this model. This R-square is slightly better than the transaction cost model (.313).

7.6.7 Full model

The last model examines the relative explanatory power of all independent variables across the three different theories in a single equation. As shown in the full and best model (Table 7.2), technology imitability and human network necessity were the only independent variables left in the equation (alpha level = .05) as a result of backward stepwise analysis. Variance of option value regained its statistical significance (alpha level = .1). All other theory-based independent variables were excluded out of the equation (cut-off alpha level = .1). Statistical significance of statutory category of patents (Machine) and patent field (Chemistry/physics except bio) were still intact (alpha level = .1).
The estimated coefficient of technology imitability (.5476) suggests that technology inimitability (difficulty in imitating) had a positive effect on the odds of new venture creation. Its odds ratio (1.7290) means that when technology inimitability is judged by one point higher in the 5 point Likart scale, the odds of new venture creation increases by 73%.

As an entire model, this model (model 4: the full and best model in Table 7.2) is much superior to the other three models in terms of the improvement of the goodness of fit (-2LL of 120.249) and Negelkerke R square (.382).

7.7 Discussion

Overall, each of the three models showed an explanatory power to a certain degree; Asset specificity in the licensee (transaction cost logic), human network necessity (measuring social complexity as a proxy of knowledge tacitness in the resource based theory), and endogenous uncertainty (real options theory) all did have statistically significant effects within each separate model. In addition, as already reported, the resource based theory model had a better fit than the other two models. Therefore, it can be concluded that the resource based theory of the firm explains the
conditions under which new ventures are created through university technology transfer better than the other two theories of the firm. In this regard, the mission of this study has been accomplished.

Also, the full model showed the statistically significant effects of technology imitability, human network necessity and variance of option value in one equation. This suggests the possibility of theory integration.

Among all these theoretical variables, an especially important finding was that technology inimitability, initially included in the transaction cost model, maintained statistically significant strong positive effect in the combined model, and the direction of the effect was the opposite to that predicted in the transaction cost model. In this regard, we can no longer rely on the transaction cost logic.

Originally in the context of the transaction cost logic, hypothesis 1b predicted that the higher imitability of the technology leads to the higher odds of new venture creation. The underlying logic was that the potential licensee may take advantage of the high imitability of the technology during its license negotiation or option contract under which the potential licensee can "taste" the new
technology’s commercial potential. Under this circumstance, the potential licensee may be able to easily learn (and steal) the content of the new technology without having the official licensing contract. Then the potential licensee would close the negotiation legitimately and run away with the information of the technology to commercialize independently. Based on this possibility of opportunism, the transaction cost logic predicts that the university inventors choose to commercialize their imitable technology by creating new ventures of their own (internalization).

The actual result was contradictory to this prediction. It has turned out that the inventors tend to choose new ventures as a technology transfer vehicle when the technology is hard to imitate, not when it is easy to imitate. This issue will be further discussed in the conclusion section that tries to reinterpret the entire result.
<table>
<thead>
<tr>
<th>Variables</th>
<th>B (estimated coefficient)</th>
<th>S.E. (standard error)</th>
<th>Wald</th>
<th>Sig.</th>
<th>R (partial contribution)</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOPV</td>
<td>.3825</td>
<td>.3235</td>
<td>1.3982</td>
<td>.2370</td>
<td>.0000</td>
<td>1.4660</td>
</tr>
<tr>
<td>ENUN</td>
<td>.9399</td>
<td>.4470</td>
<td>4.4216</td>
<td>.0355**</td>
<td>.1243</td>
<td>2.5598</td>
</tr>
<tr>
<td>TSCP</td>
<td>-.0293</td>
<td>.2246</td>
<td>.0170</td>
<td>.8962</td>
<td>.0000</td>
<td>.9711</td>
</tr>
<tr>
<td>PATF(Machine)</td>
<td>-1.2422</td>
<td>.6786</td>
<td>3.3514</td>
<td>.0671*</td>
<td>-.0929</td>
<td>.2887</td>
</tr>
<tr>
<td>PATF(Composition)</td>
<td>.2014</td>
<td>.9026</td>
<td>.0496</td>
<td>.8235</td>
<td>.0000</td>
<td>1.2231</td>
</tr>
<tr>
<td>PATF(Manufacture)</td>
<td>-.5828</td>
<td>.6071</td>
<td>.3771</td>
<td>.0000</td>
<td>.5584</td>
<td></td>
</tr>
<tr>
<td>PATF(Other)</td>
<td>-.07248</td>
<td>17.5499</td>
<td>.1602</td>
<td>.6890</td>
<td>.0000</td>
<td>.0009</td>
</tr>
<tr>
<td>PATS(Medical exc bio)</td>
<td>.3664</td>
<td>.9196</td>
<td>.1588</td>
<td>.6903</td>
<td>.0000</td>
<td>1.4426</td>
</tr>
<tr>
<td>PATS(Chem/Phys exc bio)</td>
<td>-1.3595</td>
<td>.7664</td>
<td>3.1467</td>
<td>.0761*</td>
<td>-.0856</td>
<td>.2568</td>
</tr>
<tr>
<td>PATS(Eng/Inst/Mfg)</td>
<td>-1.4105</td>
<td>.9748</td>
<td>2.0939</td>
<td>.1479</td>
<td>-.0245</td>
<td>.2440</td>
</tr>
<tr>
<td>PATS(Other)</td>
<td>-.1887</td>
<td>.5733</td>
<td>.1061</td>
<td>.7447</td>
<td>.0000</td>
<td>.8297</td>
</tr>
<tr>
<td>RWPC</td>
<td>-.2301</td>
<td>.1941</td>
<td>1.4055</td>
<td>.2358</td>
<td>.0000</td>
<td>.7944</td>
</tr>
<tr>
<td>DPSP</td>
<td>-.3013</td>
<td>.2001</td>
<td>.2377</td>
<td>.1321</td>
<td>-.0413</td>
<td>.7399</td>
</tr>
<tr>
<td>PREX</td>
<td>.0549</td>
<td>.1998</td>
<td>.0754</td>
<td>.7836</td>
<td>.0000</td>
<td>1.0564</td>
</tr>
<tr>
<td>TNST</td>
<td>-.3796</td>
<td>.5154</td>
<td>.5311</td>
<td>.4662</td>
<td>.0000</td>
<td>.6869</td>
</tr>
<tr>
<td>MKSGF</td>
<td>-.0999</td>
<td>.2355</td>
<td>.1800</td>
<td>.6713</td>
<td>.0000</td>
<td>.9049</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.5603</td>
<td>2.3560</td>
<td>2.2836</td>
<td>.1307</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Alpha level: ***.01., **.05., *.1

Classification table

<table>
<thead>
<tr>
<th>Observed</th>
<th>Predicted</th>
<th>Percent correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>81</td>
<td>7</td>
</tr>
<tr>
<td>Yes</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Overall</td>
<td>78</td>
<td>28</td>
</tr>
</tbody>
</table>

-2LL 124.304
Goodness of fit 134.786
Nagelkerke R-square .317
N 127

Table 7.6: Logistic Regression - model 3 (Real options: full and best model)
7.5.6 Model comparison

In this section, the three models based on transaction cost economics, resource based theory of the firm, and real options theory are compared in terms of the goodness of the fit of the model.

<table>
<thead>
<tr>
<th>Correct prediction</th>
<th>Transaction cost model</th>
<th>Resource based theory model</th>
<th>Real options theory model</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: (licensing to existing firms)</td>
<td>87.50%</td>
<td>89.77%</td>
<td>92.05%</td>
</tr>
<tr>
<td>1: new venture creation</td>
<td>46.15%</td>
<td>52.63%</td>
<td>48.72%</td>
</tr>
<tr>
<td>Total % correct</td>
<td>74.80%</td>
<td>78.57%</td>
<td>78.84%</td>
</tr>
<tr>
<td>-2LL</td>
<td>123.665</td>
<td>121.236</td>
<td>124.304</td>
</tr>
<tr>
<td>Goodness of fit stat</td>
<td>129.464</td>
<td>132.282</td>
<td>134.786</td>
</tr>
<tr>
<td>Nagelkerke R-square</td>
<td>.3230</td>
<td>.3270</td>
<td>.3170</td>
</tr>
</tbody>
</table>

Table 7.7: Comparison of the three models

As shown in the Table 7.7, the explanatory power of the three models seems almost the same. However, there are slight but important differences among them. In terms of the correct prediction rate, the resource based model is the only model that was able to predict the occurrence of new venture creation with more than 50% correct. Since the primary focus of this study is to predict the occurrence of new venture creation, this index is of the most importance.
Also, the resource based model's Nagelkerke R-square is the highest among the three.

When rank-ordered among the three in terms of indices of the fit of the model, the resource based model was not the worst in any respect. The model seems to have the best fit among the three (Table 7.8).

<table>
<thead>
<tr>
<th>Correct prediction</th>
<th>Transaction cost model</th>
<th>Resource based theory model</th>
<th>Real options theory model</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: (licensing to existing firms)</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>1: new venture creation</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total % correct</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>-2LL</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Goodness of fit stat</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nagelkerke R-square</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 7.8: Rank order of the three models (1: the highest rank among the three models, 3: the worst among three.)

7.5.7 Full model

The last model examines the relative explanatory power of all independent variables across the three different theories in a single equation. As shown in the best model (Table 11), technology imitability was the only independent variable left in the equation (alpha level = .05) as a result of backward stepwise analysis. All other theory-based independent variables were excluded out of the equation.
(cut-off alpha level = .1). Statistical significance of statutory category of patents (Machine), patent field (Chemistry/physics except bio), and department level support were all moderate (Alpha level = .1).
<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig.</th>
<th>R</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(estimated coefficient)</td>
<td>(standard error)</td>
<td></td>
<td></td>
<td>(partial contribution)</td>
<td>(odds ratio)</td>
</tr>
<tr>
<td>ASPL</td>
<td>.3073</td>
<td>.3698</td>
<td>.6906</td>
<td>.4060</td>
<td>.0000</td>
<td>1.3598</td>
</tr>
<tr>
<td>ASPU</td>
<td>.0296</td>
<td>.2111</td>
<td>.0197</td>
<td>.8884</td>
<td>.0000</td>
<td>1.0301</td>
</tr>
<tr>
<td>IMTB</td>
<td>.5368</td>
<td>.2954</td>
<td>3.3025</td>
<td>.0692*</td>
<td>.0919</td>
<td>1.7105</td>
</tr>
<tr>
<td>HUNTW</td>
<td>.4739</td>
<td>.3651</td>
<td>1.6845</td>
<td>.1943</td>
<td>.0000</td>
<td>1.6062</td>
</tr>
<tr>
<td>TEAM</td>
<td>.2746</td>
<td>.3142</td>
<td>.7638</td>
<td>.3822</td>
<td>.0000</td>
<td>1.3160</td>
</tr>
<tr>
<td>TPD</td>
<td>.1463</td>
<td>.3861</td>
<td>1.436</td>
<td>.7047</td>
<td>.0000</td>
<td>1.1576</td>
</tr>
<tr>
<td>TSUB</td>
<td>-.0976</td>
<td>.3126</td>
<td>.0976</td>
<td>.7548</td>
<td>.0000</td>
<td>.9070</td>
</tr>
<tr>
<td>STTC</td>
<td>-.0599</td>
<td>.2488</td>
<td>.0790</td>
<td>.7786</td>
<td>.0000</td>
<td>.9325</td>
</tr>
<tr>
<td>TCCN</td>
<td>.1218</td>
<td>.2768</td>
<td>1.937</td>
<td>.6598</td>
<td>.0000</td>
<td>1.1296</td>
</tr>
<tr>
<td>VOPV</td>
<td>.3531</td>
<td>.3758</td>
<td>.8829</td>
<td>.3474</td>
<td>.0000</td>
<td>1.4234</td>
</tr>
<tr>
<td>ENU</td>
<td>.3528</td>
<td>.5858</td>
<td>.3626</td>
<td>.5471</td>
<td>.0000</td>
<td>1.4230</td>
</tr>
<tr>
<td>TSCP</td>
<td>-.1219</td>
<td>.2613</td>
<td>.2177</td>
<td>.6408</td>
<td>.0000</td>
<td>.8852</td>
</tr>
<tr>
<td>PATF(Machine)</td>
<td>-1.2029</td>
<td>.7915</td>
<td>2.3099</td>
<td>1.286</td>
<td>-.0448</td>
<td>.3003</td>
</tr>
<tr>
<td>PATF(Composition)</td>
<td>.6794</td>
<td>1.0981</td>
<td>.3828</td>
<td>.5361</td>
<td>.0000</td>
<td>1.9728</td>
</tr>
<tr>
<td>PATF(Manufacture)</td>
<td>-.6269</td>
<td>.6881</td>
<td>.8301</td>
<td>.3622</td>
<td>.0000</td>
<td>0.5342</td>
</tr>
<tr>
<td>PATF(Other)</td>
<td>-7.0835</td>
<td>18.0022</td>
<td>.1548</td>
<td>.6940</td>
<td>.0000</td>
<td>.0000</td>
</tr>
<tr>
<td>PATS(Medical exc bio)</td>
<td>.6663</td>
<td>1.0188</td>
<td>4.278</td>
<td>.5131</td>
<td>.0000</td>
<td>1.9470</td>
</tr>
<tr>
<td>PATS(Chem Phys exc bio)</td>
<td>-1.4506</td>
<td>.8231</td>
<td>3.1060</td>
<td>.0780*</td>
<td>-.0847</td>
<td>.2344</td>
</tr>
<tr>
<td>PATS(Eng/Inst/Mfg)</td>
<td>-1.2571</td>
<td>1.1993</td>
<td>1.0987</td>
<td>.2946</td>
<td>.0000</td>
<td>.2645</td>
</tr>
<tr>
<td>PATS(Other)</td>
<td>-2.557</td>
<td>.6541</td>
<td>.1438</td>
<td>.8959</td>
<td>.0000</td>
<td>.7744</td>
</tr>
<tr>
<td>RWPC</td>
<td>-.2182</td>
<td>.2208</td>
<td>.9760</td>
<td>.3232</td>
<td>.0000</td>
<td>.8040</td>
</tr>
<tr>
<td>DPS</td>
<td>-.3718</td>
<td>.2297</td>
<td>2.6202</td>
<td>.1055</td>
<td>-.0634</td>
<td>.6895</td>
</tr>
<tr>
<td>UPOL</td>
<td>-.0468</td>
<td>.2477</td>
<td>.0357</td>
<td>.8501</td>
<td>.0000</td>
<td>.9543</td>
</tr>
<tr>
<td>CMSP</td>
<td>.1144</td>
<td>.2221</td>
<td>.2656</td>
<td>.6063</td>
<td>.0000</td>
<td>1.1212</td>
</tr>
<tr>
<td>PREX</td>
<td>.0637</td>
<td>.2229</td>
<td>.0817</td>
<td>.7750</td>
<td>.0000</td>
<td>1.0658</td>
</tr>
<tr>
<td>TNST</td>
<td>-.1908</td>
<td>.6199</td>
<td>.0947</td>
<td>.7582</td>
<td>.0000</td>
<td>.8263</td>
</tr>
<tr>
<td>MKSGF</td>
<td>-.1603</td>
<td>.2570</td>
<td>.3893</td>
<td>.5327</td>
<td>.0000</td>
<td>.8519</td>
</tr>
<tr>
<td>Constant</td>
<td>-7.3473</td>
<td>3.0282</td>
<td>5.8869</td>
<td>.0153**</td>
<td>.0000</td>
<td>1.0531</td>
</tr>
</tbody>
</table>

Alpha level: ***.01, **.05, *.1

Classification table

<table>
<thead>
<tr>
<th>Observed</th>
<th>Predicted</th>
<th>Percent correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>78</td>
<td>10</td>
</tr>
<tr>
<td>Yes</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>Overall</td>
<td>78</td>
<td>21</td>
</tr>
</tbody>
</table>

-2LL: 114.315
Goodness of fit: 121.554
Negelkerke R-square: .385
N: 126

Table 7.9: Logistic Regression - model 4 (Full model: all variables)
<table>
<thead>
<tr>
<th>Variables</th>
<th>B (estimated coefficient)</th>
<th>S.E. (standard error)</th>
<th>Wald</th>
<th>Sig.</th>
<th>R (partial contribution)</th>
<th>Exp (B) (odds ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASPL</td>
<td>.3316</td>
<td>.3474</td>
<td>.9111</td>
<td>.3398</td>
<td>.0000</td>
<td>1.3931</td>
</tr>
<tr>
<td>IMTB</td>
<td>.5691</td>
<td>.2832</td>
<td>4.0394</td>
<td>.0444**</td>
<td>.1150</td>
<td>1.7667</td>
</tr>
<tr>
<td>HUNTW</td>
<td>.4842</td>
<td>.3281</td>
<td>2.1776</td>
<td>.1400</td>
<td>.0339</td>
<td>1.6229</td>
</tr>
<tr>
<td>TEAM</td>
<td>.3711</td>
<td>.2725</td>
<td>1.8547</td>
<td>.1732</td>
<td>.0000</td>
<td>1.4494</td>
</tr>
<tr>
<td>VOPV</td>
<td>.4279</td>
<td>.3009</td>
<td>2.0219</td>
<td>.1550</td>
<td>.0119</td>
<td>1.5340</td>
</tr>
<tr>
<td>PATF(Machine)</td>
<td>-1.2867</td>
<td>.7511</td>
<td>2.9351</td>
<td>.0867**</td>
<td>-.0779</td>
<td>.2762</td>
</tr>
<tr>
<td>PATF(Composition)</td>
<td>.4992</td>
<td>.6794</td>
<td>3.2222</td>
<td>.5703</td>
<td>.0000</td>
<td>1.6474</td>
</tr>
<tr>
<td>PATF(Manufacture)</td>
<td>-.5105</td>
<td>.5880</td>
<td>.7536</td>
<td>.3853</td>
<td>.0000</td>
<td>.6002</td>
</tr>
<tr>
<td>PATF(Other)</td>
<td>-7.2426</td>
<td>17.8947</td>
<td>1.638</td>
<td>.6857</td>
<td>.0000</td>
<td>.0000</td>
</tr>
<tr>
<td>PATS(Medical exc bio)</td>
<td>.3164</td>
<td>.9233</td>
<td>1.175</td>
<td>.7318</td>
<td>.0000</td>
<td>1.3722</td>
</tr>
<tr>
<td>PATS(Chem/Phys exc bio)</td>
<td>-1.4225</td>
<td>.7596</td>
<td>3.5067</td>
<td>.0611**</td>
<td>-.0988</td>
<td>.2411</td>
</tr>
<tr>
<td>PATS(Eng/Inst/Mfg)</td>
<td>-1.2370</td>
<td>1.0058</td>
<td>1.5127</td>
<td>.2187</td>
<td>.0000</td>
<td>.2903</td>
</tr>
<tr>
<td>PATS(Other)</td>
<td>-.2885</td>
<td>.5976</td>
<td>.2332</td>
<td>.6292</td>
<td>.0000</td>
<td>.7494</td>
</tr>
<tr>
<td>RWPC</td>
<td>-.2667</td>
<td>.1991</td>
<td>1.7809</td>
<td>.1820</td>
<td>.0000</td>
<td>.6767</td>
</tr>
<tr>
<td>DPSM</td>
<td>-.3450</td>
<td>.1980</td>
<td>3.0382</td>
<td>.0813*</td>
<td>-.0820</td>
<td>.7082</td>
</tr>
<tr>
<td>MKSGF</td>
<td>-.1651</td>
<td>.2311</td>
<td>.5104</td>
<td>.4750</td>
<td>.0000</td>
<td>.8478</td>
</tr>
<tr>
<td>Constant</td>
<td>-.6.1439</td>
<td>.24489</td>
<td>6.2942</td>
<td>.0121**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Alpha level: ***.01, **.05, *.1

Classification table

<table>
<thead>
<tr>
<th>Observed</th>
<th>Predicted</th>
<th>Percent correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>77</td>
<td>11</td>
</tr>
<tr>
<td>Yes</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>Overall</td>
<td>93</td>
<td>33</td>
</tr>
</tbody>
</table>

-2LL: 115.734
Goodness of fit: 118.984
Negelkerke R-square: .373
N: 126

Table 7.10: Logistic Regression - model 4 (Full model: best model)
The estimated coefficient of technology imitability (.5691) suggests that technology inimitability (difficulty in imitating) had a positive effect on the odds of new venture creation. Its odds ratio (1.7667) means that when technology inimitability is judged by one point higher in the 5 point Likart scale, the odds of new venture creation increases by 77%.

Among control variables, the effect of department level supportiveness became statistically significant only in the full model. The survey questionnaire asked the degree of agreement with the following sentence: “In my department, people openly discuss ideas of entrepreneurship in relation to commercializing technologies.” Surprisingly, the logistic regression result showed that this variable has a negative effect on the odds of new venture creation. This is quite contrary to the intuition that when there is an atmosphere that supports entrepreneurial activities by faculty members in the department, that would facilitate new venture creation.

One possible cause is the content of the statement asked in the questionnaire. In the statement, creating new ventures was expressed in a quite abstract term “ideas of entrepreneurship.” Some (or most) university inventors may
have taken this term in a broad sense and thought that licensing their technologies to existing firms was also "entrepreneurial." If this is true, the variable would definitely have a negative impact on the odds of new venture creation.

As an entire model, this model (the best model in Table 7.10) is superior to the other three models in almost every important aspects (Table 7.11 & 7.12). However, the superiority of the full model also raises an important question.

<table>
<thead>
<tr>
<th>Correct prediction</th>
<th>Transaction cost model</th>
<th>Resource based theory model</th>
<th>Real options theory model</th>
<th>Full model</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: (licensing to existing firms)</td>
<td>87.50%</td>
<td>89.77%</td>
<td>92.05%</td>
<td>87.50%</td>
</tr>
<tr>
<td>1: new venture creation</td>
<td>46.15%</td>
<td>52.63%</td>
<td>48.72%</td>
<td>57.89%</td>
</tr>
<tr>
<td>Total % correct</td>
<td>74.80%</td>
<td>78.57%</td>
<td>78.84%</td>
<td>78.57%</td>
</tr>
<tr>
<td>-2LL</td>
<td>123.665</td>
<td>121.236</td>
<td>124.304</td>
<td>115.734</td>
</tr>
<tr>
<td>Goodness of fit stat</td>
<td>129.464</td>
<td>132.282</td>
<td>134.786</td>
<td>118.984</td>
</tr>
<tr>
<td>Nagelkerke R-sqaur</td>
<td>.3230</td>
<td>.3270</td>
<td>.3170</td>
<td>.3730</td>
</tr>
</tbody>
</table>

Table 7.11: Comparison of the full model with the other models
The full model was initially intended to examine not only the relative explanatory power of independent variables based on three different theories of the firm, but also the possibility of theory integration. However, the result shows that the only one variable, technology imitability, has a very strong effect that even suppresses the effects of all other variables. Why is this so? This issue is further discussed in the following section.
7.6 Discussion

Overall, each of the three models showed an explanatory power to a certain degree; Asset specificity in the licensee (transaction cost logic), human network necessity (measuring social complexity as a proxy of knowledge tacitness in the resource based theory), and endogenous uncertainty (real options theory) all did have statistically significant effects within each separate model. In addition, as already reported, the resource based theory model had a slightly better fit than the other two models. Therefore, it can be concluded that the resource based theory of the firm explains the conditions under which new ventures are created through university technology transfer better than the other two theories of the firm. In this regard, the mission of this study has been accomplished.

However, it has unexpectedly turned out that when independent variables based on the three theories were combined into a single model, technology imitability, one of the independent variables in the transaction cost model, has the strongest effect, and the effects of all other independent variables have vanished in the logistic regression, presumably suppressed by the effect of technology imitability.
Moreover, the direction of the actual effect of technology imitability was the opposite to the one predicted in the transaction cost hypothesis. Therefore, we can no longer rely on the transaction cost logic on this matter. A new explanation is needed.

Back in the context of the transaction cost logic, hypothesis 1b predicted that the higher imitability of the technology leads to the higher odds of new venture creation. The underlying transaction cost logic was that the potential licensee may take advantage of the high imitability of the technology during its license negotiation or option contract under which the potential licensee can “taste” the new technology’s commercial potential. Under this circumstance, the potential licensee may be able to easily learn (and steal) the content of the new technology without proceeding to the official licensing contract. Then the potential licensee is can close the negotiation legitimately and run away with the information of the technology to commercialize it later by itself. Based on this possibility of opportunism, the transaction cost logic predicts that the university inventors choose to commercialize their imitable technology by creating new ventures.
The actual result was contradictory to this prediction. It has turned out that the inventors tend to choose new ventures as a technology transfer vehicle when the technology is hard to imitate, not when it is easy to imitate. What is the explanation of this?

One candidate is the original version of the resource based view of the firm (Barney 1986, 1991, and 1996). According to this theory, the firm gains sustainable competitive advantage when it retains (or acquires through strategic factor market) the resources that are valuable, rare, and imperfectly imitable, coupled with an effective organizational arrangement. Based on this logic, an imperfectly imitable technology can be at least a source of temporary competitive advantage in its market.

Throughout the preliminary interviews, university inventors and technology officers repeatedly commented that the university inventors have a strong tendency to believe that their technologies are quite unique. In that sense, the inventors seem to believe that the technologies they created are at least “rare”.

Therefore, as long as the inventors strongly believe that their technologies are rare and imperfectly imitable, they may find the economic opportunity associated with their
own technologies irresistible, and may well choose new
venture creation as a mode of transfer to fully exploit the
opportunity by themselves.

As above, the original version of the resource based
view offers a viable explanation to this unexpected
direction of the effect of technology imitability. Neither
transaction cost logic or real options theory can explain
this new finding.

Another explanation comes from an intuition that the
inventors have affection toward their technologies. In the
face to face interviews with transfer officers and inventors,
the author observed the inventors' strong attachment to
their technologies, and it was often expressed by the term
"babies" they used in the conversation. They often mentioned
their technologies as their "babies." This strong attachment
was quite obvious, and may have affected their tendency to
choose new venture creation instead of licensing to existing
firms. Unfortunately, this construct was not included in the
control variables in this study.
CHAPTER 8

CONCLUSION

In light of the original purpose of this study, which is to examine the relative explanatory power of the three theories of the firm, this study made an achievement to some extent. It was empirically verified that the resource based model that includes human network necessity in acquiring the useful knowledge to commercialize the technology was the most powerful explanation of new venture creation.

However, the effect of one variable, namely the effect of technology imitability, could not be explained by any of the theories initially adopted for this study. Further theory building and its examination is necessary to explain the strong positive effect of technology inimitability on the odds of new venture creation. As explored in the discussion section, the resource based view seems to have a room to be developed in this direction.
8.1 Overall finding

In light of the original purpose of this study, which is to examine the relative explanatory power of the three theories of the firm, this study completed the initial mission. It was empirically verified that the resource based model that includes human network necessity in acquiring the useful knowledge to commercialize the technology was more powerful than the other two models in explaining the odds of new venture creation over licensing to existing firms.

However, the effect of one variable, namely the effect of technology imitability, could not be explained by any of the models designed for this study. Further theory building and its examination is necessary to explain the strong positive effect of technology inimitability on the odds of new venture creation.

8.2 Reinterpretation of the results

8.2.1 Resource based theory
In the initial theoretical model building, this study adopted a version of the resource based theory of the firm (Conner and Prahalad 1996) of which emphasis is on tacit knowledge in combining resources. In fact, human network necessity in acquiring useful knowledge for commercialization, one of the variables that represent knowledge tacitness, had a statistically significant positive effect both in the resource based model (model 2) and the fully combined model (model 4). However, it seems better to include the effect of technology inimitability in the resource based model as well.

Indeed, the original version of the resource based view of the firm (Barney 1986, 1991, and 1996) asserts that the firm gains sustainable competitive advantage when it retains (or acquires through strategic factor market) the resources that are valuable, rare, and imperfectly imitable, coupled with an effective organizational arrangement. Based on this logic, an imperfectly imitable technology can be at least a source of temporary competitive advantage in its market.

As for the rareness of the technology, throughout the preliminary interviews in this study, university inventors and technology officers repeatedly commented that the university inventors have a strong tendency to believe that
their technologies are quite unique. In that sense, the inventors at least believe that their technologies are "rare". Therefore, as long as the inventors strongly believe that their technologies are rare and imperfectly imitable, they may find the economic opportunity associated with their own technologies irresistible, and may well choose new venture creation as a mode of transfer to fully exploit the opportunity by themselves.

As such, the original version of the resource based view predicts that the higher degree of technology inimitability increases the likelihood of new venture creation.

8.2.2 Transaction cost logic versus resource based view

Given that both resource based model and transaction cost model could have included technology imitability as their key independent variable, this study actually have examined two contradictory hypotheses, one from resource based view, and the other from transaction cost logic.

Hypothesis A (Resource based theory)
The higher degree of technology inimitability increases the likelihood of new venture creation over licensing to existing firms.
Hypothesis B (Transaction costs logic)

The higher degree of technology inimitability increases the likelihood of licensing to existing firms over new venture creation, thereby decreases the likelihood of new venture creation.

These two hypotheses are perfectly contradictory because the predicted direction of the effect of technology inimitability is the opposite.

As the result of logistic regression indicates (Chapter 7), technology inimitability did have a statistically significant strong positive effect on the odds of new venture creation. This result clearly supports the hypothesis A (resource based theory) and rejects hypothesis B (transaction costs theory).

8.3 The value of technology commercialization

In the above reinterpretation of resource based theory, the conditions of “rareness” and “imperfect imitability” were met for the resource to be a source of sustainable competitive advantage. How about the “value” of the resource? However rare and inimitable a resource is, the
resource cannot be the source of competitive advantage if it is not valuable. The result that the variance of option value regained its statistically significance, even though moderate, in the fully combined model (model 4), may suggest some supporting role of the real options perspective in this regard.

The result can be interpreted as follows. When university inventors determine the technology transfer mode, they see whether the technology commercialization would achieve larger upside value (entrepreneurial rent) or not by looking at the future potential variance of the economic value of the commercialization. If they see this strategic value of the technology transfer is large enough, they choose new venture creation given that they at least perceive the technology as rare and imperfectly imitable.

8.4 Why not transaction costs?

Then, the next important question is why does not transaction cost model explain the new venture creation in the university technology transfer as well as the resource based view does? In order to answer this question, fundamental difference between the two theories should be reexamined.
First of all, at the heart of the transaction cost theory is to minimize transaction costs under the threat of opportunism caused by asset specificity. In other words, in the context of university technology transfer, transaction partners select the governance mechanism so that the cost of governance would be minimized, no matter what technology is being transferred. Regardless of the uniqueness or particular nature of the technology, transaction partners choose the governance mode depending on whether asset specificity exists or not.

However, the transaction cost variables were all nullified mostly by the technology inimitability, human network necessity, and the future variance of economic return of the commercialization in the full model. This empirical finding suggests that at least the entrepreneur’s motives of choosing new venture creation depends not on the cost of governance caused by the threat of opportunism. Rather, inventors’ decision relied on the value of the technology recognized by the nature of the technology which may lead to sustainable competitive advantage at the market, and the potential value of its commercialization.

From a broader theoretical point of view, in the strategic management, a fundamental assumption is that the
ultimate goal of each individual business is to maximize the economic rent. From this perspective, minimizing governance costs cannot be the necessary and sufficient conditions in choosing the best possible vehicle to maximize economic rent.

8.5 Limitation and future research agenda

One limitation in a theoretical sense is, as noted in Chapter 3 Literature Review, the qualification of real options theory as a theory of the firm. In this study, real options theory indeed supplemented the resource based model in explaining the value of strategic options. However, the theory cannot explain the reversibility and appropriability to be an independent theory of the firm. Therefore, I preliminarily conclude that the effectiveness of real options theory as an independent theory of the firm is limited, but it supplements the resource based theory of the firm in evaluating the value of resources.

Another important limitation of this study from the theoretical aspect is the fact that this study does not include the "performance" aspect of technology transfer. In this study, the primary focus was on the transfer mode choice itself, but the performance of each transfer mode once chosen by inventors and universities could not be
examined. This limitation seriously hinders this study to have performance implications. Even though the author initially made an effort to collect performance data, there were reasons that the performance data could not become available. First, the amount of licensing royalty in each licensing contract was highly classified information. Since the level of analysis of this study is each individual transfer, this was a serious barrier in accessing performance data. Second, it was physically difficult to collect data on the economic performance of newly created ventures due to the survey design. The amount of initial investment, revenues and cost structures, and the ownership structure were completely undetectable due to the anonymity of the survey.

Among other limitations of this study is its generalizability. Because there may be a response bias in the data collected in this study, the more sophisticated procedure in conducting survey questionnaires is necessary. Especially, it is important to identify who responded and who did not, so that the researcher can accurately detect the nature of non-respondents to see if there is any systematic difference between the respondents and non-respondents.

188
Also, the university technology transfer still seems to have an important difference from the fully commercial technology transfer. Some university inventors actually replied to the solicitation e-mail and said that they still believe that technology transfer with commercial interests is not, and should not be their job due to the public nature of the university activity. Even though the personal reward perception and the university policy toward entrepreneurial activities were measured and controlled in this study, they may not fully represent the particularity of university setting. The effect of public nature of university activities will be truly realized when compared to the fully commercial setting. Comparative study of university technology transfer (university to business) and fully commercial transfer (business to business) may reveal an important difference or similarity between the two.

In addition, the role of technology licensing office in each research university may have had an important effect. In this study, the effectiveness of technology licensing offices was assumed to be constant across universities, and the data was collected at the individual inventor/technology level. In addition to the university policy supportiveness which was measured and controlled in this study, the
effectiveness of technology licensing offices may have been a necessary control variable.

Another potentially necessary addition to this study is the viewpoint of governmental support/regulation in university technology transfer. Especially, if there is any particular policy support exists in a specific technology field compared to others might have affected the odds of new venture creation in certain technology areas. The study of "political" aspect of new venture creation is the necessary next step for this line of research to have further implications to policy makers and practitioners as well.

8.6 Practical contribution

To practitioners, such as university inventors and technology officers at universities, this study offers rich information on what factors affect the inventor’s decision making process in which they choose either transferring their technology through new venture creation or licensing to existing firms. Especially, this study offers information not only at the aggregated university level, but also at each individual inventor and technology level. In fact, during the course of survey distribution and collection, more than 100 potential respondents showed their interests
in the summary results of the survey, and some commented that this type of information is seriously in need among university inventors to know the situation of other inventors and universities. Association of University Technology Managers (AÜTM) does have a function to collect and offer very useful data in this category, but all of them are at the aggregated university level. It is hoped that this study may supplement the information collected by the AÜTM.
BIBLIOGRAPHY


386-405.


Teece, D.J. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing


APPENDIX A. Incentive schemes for individual inventors
(PR: private school, PUB: public school)

<table>
<thead>
<tr>
<th>University</th>
<th>Incentive scheme for individual inventors</th>
</tr>
</thead>
</table>
| Auburn University (PR)| 30% of Net Proceeds with Net Proceeds being Up to $100,000  
25% of Net Proceeds with Net Proceeds being the Next $100,000  
20% of Net Proceeds with Net Proceeds being the Next $100,000  
15% of Net Proceeds with Net Proceeds being everything over $300,000 |
| Brown University (PR) | i. the first $100,000 of net income shall be distributed equally between the inventor and the department of the inventor.  
50% to the Inventor(s)  
50% to the Department(s)  
ii. net income in excess of $100,000 but less than $1,000,000 shall be distributed as follows.  
25% to the Inventor(s)  
75% to the University  
iii. net income in excess of $1,000,000 shall be distributed as follows  
20% to the Inventor(s)  
80% to the University |
| Columbia University (PR) | When net income from the conception is $100,000 or less, the inventor's share will be 50% of that income.  
When net income from the conception exceeds $100,000, the inventor's share will be 50% of the first $100,000 and 25% of the excess. |
| Harvard University (PR) | Cumulative Amounts Received First $50,000 Above $50,000  
Creator(s)  
35%  
Creator(s)' Department  
30%  
(The creator(s) may direct the use of half of the department's share so long as he/she/they remain at Harvard.)  
School (Dean's Office or Vice President)  
20%  
President and Fellows of Harvard College  
15%  
Total  
100% |
| Indiana University (PUB) | Of the first $100,000 of net revenue:  
The Creator(s) shall receive one-half (50%)  
The Campus(es) responsible for the applicable intellectual property shall receive one-quarter (25%)  
The University shall receive one-quarter (25%)  
Of the next $300,000 of net revenue:  
The Creator(s) shall receive forty percent (40%)  
The Campus(es) shall receive one-quarter (25%)  
The University shall receive thirty-five percent (35%)  
Of the next $600,000 of net revenue: |
<table>
<thead>
<tr>
<th>Institution</th>
<th>Distribution Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Louisiana State University (PUB)</td>
<td>Forty percent (40%) of all Distributable Royalties shall be paid to the respective inventors within thirty days of receipt, unless a different schedule is otherwise agreed in writing by LSU and any inventor. Ten percent (10%) of all Distributable Royalties shall be allocated to the Office of the President. The remaining fifty percent (50%) of all Distributable Royalties shall be allocated within the appropriate campus as directed by the Chancellor of that campus.</td>
</tr>
</tbody>
</table>
| MIT (PR)                    | Royalty income received during the preceding M.I.T. fiscal year for a technology license shall be distributed once annually as follows:  

1. Deduct 15% from Gross Royalty Income. This deduction is directed toward covering the expenses of the Technology Licensing Office.  

2. Deduct out-of-pocket costs and, in some cases a reserve to arrive at Adjusted Royalty Income. Out-of-pocket costs are direct assignable expenses to a specific case such as patent filing, prosecution and maintenance fees and specific marketing costs. When out-of-pocket costs in the next M.I.T. fiscal year are forecast and future income unlikely, a reserve may be deducted. Any excess reserve will be promptly distributed after forecast costs are paid.  

3. Distribute one-third of the Adjusted Royalty Income to the inventors/authors.  

4. The remaining two-thirds of Adjusted Royalty Income becomes part of a Departmental (or Laboratory; Note 1) Pool which aggregates all of the remaining Adjusted Royalty Incomes for that Department for the year, then subtracts (i) all unreimbursed patenting costs for the year for all inventions from that Department; and (ii) a pro rata allocation for costs (if any) of running the TLO in excess of the 15% deductions. Subtract/Add the difference between 15% and the actual pro-rata cost of running the TLO. |
The Departmental Pool, if positive, is divided:

1/2 to M.I.T. General Fund
1/2 to Laboratory/Department

If the Departmental Pool is negative, the General Fund absorbs the costs.

**NOTE 1:** Distribution of the "Departmental Share" of the Departmental Pool shall be to the department if it is the organization which administered the research contract from which the invention arose, or to the Interdepartmental Laboratory if the latter administered the contract.

**NOTE 2:** Certain patenting costs are an element of M.I.T.'s indirect cost rate and are therefore borne by all research sponsors. In order to avoid complexity, this consideration is purposefully omitted from the above calculations.

<table>
<thead>
<tr>
<th>University</th>
<th>Distribution Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montana State University (PUB)</td>
<td>Two-thirds of the first $30,000 per year, one-half of the next $30,000 per year and one-third of the remainder will be designated through the university budget or financial office to support the work of the inventor while employed by the university and/or to promote discoveries at the university. The rest will be distributed to a designated fund and will be used to support and expand research at the university.</td>
</tr>
<tr>
<td>North Carolina State University (PUB)</td>
<td>The gross royalty revenues (net amount received by the University if there is a specific agreement in a grant or contract with a sponsor) generated by a patent or invention shall be the basis upon which the inventor's royalty is calculated. Unless otherwise agreed, the inventor's share of royalty revenues shall be 25% of the gross revenue. In the case of co-inventors, the 25% of gross revenue shall be subdivided equally among them, unless the inventors, with the concurrence of the Intellectual Property Committee, determine a different share to be appropriate. Applicable laws, regulations or provisions of grants or contracts may, however, require that a lesser share be paid to the inventor. In no event shall the share payable to the inventor or inventors in the aggregate by the University be less than 15% of gross royalties received by the University.</td>
</tr>
<tr>
<td>Northwestern University (PR)</td>
<td>A deduction of 20% to cover the legal expenses for patent filing and prosecution and for marketing of the new technologies will be taken</td>
</tr>
</tbody>
</table>
annually from the gross license revenue, followed by a deduction for any direct assignable expenses, like patent fees, for the specific case. Income then remaining is the net income, which is distributed as follows.

A. Thirty percent (30%) of the net income to the inventor.
B. Twenty percent (20%) of the net income to a University account for the inventor to support the inventor's research. Should the inventor leave the University, this amount remains with the Technology Transfer Program. In no instance will this amount be transferred to an account of the inventor's designee.
C. Ten percent (10%) of the net income to the department or departments in which the inventor serves.
D. Five percent (5%) of the net income to the school or center in which the inventor serves.
E. Thirty-five percent (35%) of the net income to the Vice President for Research to support the Technology Transfer Program operating expenses, to encourage and assist in the development of new patents, or for other appropriate and related purposes, including facilities integral to the invention or discovery.

<table>
<thead>
<tr>
<th>The Ohio State University (PUB)</th>
<th>the inventors' or creators' share of royalties received by the University (including the Research Foundation) for their inventions, etc., is as follows:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For gross royalties that are up to $75,000 the individual(s) receive one half of gross. Anything beyond $75,000 one third of (gross in excess of $75,000 minus any expenses in excess of $37,500). For example: for $200,000 cumulative gross royalties, with $42,500 cumulative expenses, the cumulative share for all individuals would be:</td>
</tr>
<tr>
<td></td>
<td>$1/2 \times 75,000 + 1/3 \times [(200,000 - 75,000) - (42,500 - 37,500)] = $77,500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Old Dominion University (PR)</th>
<th>The calculation of net royalty shares is</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inventor/Author - 50%</td>
</tr>
<tr>
<td></td>
<td>University - 50%</td>
</tr>
<tr>
<td>Institution</td>
<td>Details</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Penn State University (PUB) | The inventor(s) will receive a $1,000 incentive payment at the time a patent application is filed. After recovery of any direct patent or copyright prosecution, maintenance, or infringement litigation costs incurred by the University, royalty revenues are distributed as follows:  
  40% Inventor(s)/Creator(s)  
  20% Originating administrative unit  
  40% Pennsylvania Research Corporation |
| Princeton University (PR)   | Any income realized by the University from its rights in an invention will be distributed as follows: For an invention in which the University owns all rights in accordance with Section C, above, the inventor will be paid the following percentages of the Net Income realized by the University: fifty percent (50%) of the first $100,000; forty percent (40%) of the next $400,000; and thirty percent (30%) of the amount in excess of $500,000. "Net income" is defined as the total amount received by the University for a particular invention, less any expenditures made by the University for patenting, marketing, licensing, or in any other way managing the invention. This does not include general office expenses of the Office of Technology Transfer or ORPA. |
| Purdue University (PR)      | The committee shall, as a general principle but subject to all relevant provisions of this Memorandum (including, but not limited to, those relating to sponsored programs), award a two-thirds interest to the University and a one-third interest to University personnel in the net proceeds derived from Inventions and Materials belonging to the University.                                                                                              |
| Stanford (PR)               | Fifteen percent of cash gross royalties is deducted to support OTL's operating costs (the difference, if any, between the 15% deduction and OTL's budget is directed to the OTL Research Incentive Fund under the auspices of the Dean of Research.) Any direct expenses, such as patent costs, are then deducted. The remaining cash net royalties are divided three ways: one third to the inventor(s); one third to the inventor(s)'s department; and one third to the inventor(s)'s school. |
| SUNY--Stony Brook (PUB)     | 40% of the Gross Royalties are returned to the inventor(s) (Statutory)  
  60% of the Gross Royalties (adjusted gross royalties) are distributed on-campus as follows:                                                                                                                                                                           |
<table>
<thead>
<tr>
<th>Institution</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas A&amp;M University (PUB)</td>
<td>First, patent expenses are recovered. The net balance is distributed:</td>
</tr>
<tr>
<td></td>
<td>15 percent to the A&amp;M System for TLO operations,</td>
</tr>
<tr>
<td></td>
<td>42.5 percent to the university or agency from which the licensed</td>
</tr>
<tr>
<td></td>
<td>technology arose, and</td>
</tr>
<tr>
<td></td>
<td>42.5 percent to the inventor(s).</td>
</tr>
<tr>
<td>Wayne State University</td>
<td>Gross royalty income returning to the University will first be used to</td>
</tr>
<tr>
<td></td>
<td>repay all costs associated with patent development, patent application</td>
</tr>
<tr>
<td></td>
<td>and licensing. Following the deduction of such expenses, net royalty</td>
</tr>
<tr>
<td></td>
<td>income will be distributed among the inventor(s) and other University</td>
</tr>
<tr>
<td></td>
<td>units according to the following formula:</td>
</tr>
<tr>
<td></td>
<td>Net Income</td>
</tr>
<tr>
<td></td>
<td>Inventor</td>
</tr>
<tr>
<td></td>
<td>Department</td>
</tr>
<tr>
<td></td>
<td>University</td>
</tr>
<tr>
<td></td>
<td>Up to $10,000</td>
</tr>
<tr>
<td></td>
<td>75%</td>
</tr>
<tr>
<td></td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Next $90,000</td>
</tr>
<tr>
<td></td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>Next $900,000</td>
</tr>
<tr>
<td></td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>45%</td>
</tr>
<tr>
<td></td>
<td>Over $1 million</td>
</tr>
<tr>
<td></td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>Virginia Tech (PUB)</td>
<td>Revenues generated by the successful commercialization of IPs owned by</td>
</tr>
<tr>
<td></td>
<td>the university (whether or not protected by patent and/or copyright)</td>
</tr>
<tr>
<td></td>
<td>shall be shared equally between the university and the originator(s)</td>
</tr>
<tr>
<td></td>
<td>of the IP.</td>
</tr>
</tbody>
</table>
APPENDIX B: Variables and corresponding statements

Abbreviation in parentheses is the name of variables, and Q *-* indicates the position of each question in the actual on-the-web survey.

**Dependent variable:**  [Likelihood of New Venture Creation (LNVC): Q I-1]

The likelihood of new venture creation is the dependent variable. New venture creation is coded as “1”, and licensing to existing firms is coded as “0.”

**Independent variables:**

1. The degree of asset specificity
   (1) [Asset specificity licensee 1 (ASPL1): Q IV-15] “It is likely that the licensee needs to make a specific investment, useful only in commercializing this technology.”
   (2) [Asset specificity licensee 2 (ASPL2): Q IV-19] “The licensee of this technology has to make a new investment to commercialize this particular technology.”
   (3) [Asset specificity university 1 (ASPU1): Q III-12] “We needed to introduce specialized equipment to create this technology.”
   (4) [Asset specificity university 2 (ASPU2): Q III-14] “To create this technology, we had to expend our fund in customizing (or purchasing specialized) equipment in our lab.”

2. The degree of technology imitability
   (1) [Imitability 1 (IMTB1): Q II-10] “Even other experts who have detailed knowledge about this technology may find it difficult to find a substitute for it.”
   (2) [Imitability 2 (IMTB2): Q II-7] “It is hard to make (or find) a substitute for this patented technology.”

3. The degree of tacitness of the knowledge useful in developing and commercializing a technology.
   (1) [Path dependence 1 (TPDP 1): Q III-11] “While creating this technology, I also accumulated specific experience and know-how, useful in commercializing this technology.”
(2) [Path dependence 2 (TPDP 2): Q III-13] "Knowledge acquired through the creation process of this technology is useful to commercialize this technology."

(3) [Social complexity 1 (TSCX1): Q IV-16] "Interaction with colleagues, friends, or potential business partners is important to gain useful knowledge (either technical or non-technical) in commercializing this technology."

(4) [Social complexity 2 (TSCX2): Q IV-20] "Useful knowledge, which may be technical or non-technical, in commercializing this technology becomes available only when particular individuals get together as a team."

(5) [Substitutability 1 (TSUB1): Q IV-17] "There is no substitute for my personal experience and knowledge to help commercialize this technology."

(6) [Substitutability 2 (TSUB2): Q IV-21] "My direct involvement is indispensable to commercialize this technology successfully."

4. The stage of technology at the time of transfer
(1) [Stage of technology (STTC): Q I-2] The stage of technology at the time of transfer
   "The stage of your technology at the time of licensing contract was (is, or would be):" Basic as 1, applied as 3, and development as 5. 2 and 4 are in-betweens.

5. Technology continuity as a proxy of the degree of tacitness of the knowledge useful in developing and commercializing a technology.
(1) [Technology continuity 1 (TCCN1): Q II-6] "This technology may replace numerous existing products, services, or processes once it is commercialized."

(2) [Technology continuity 2 (TCCN2): Q II-9] "This technology may replace currently available technologies in the industry."

6. The variance of future economic return on technology commercialization
(1) [Variance of option value 1 (VOPV1): Q V-23] "This technology has the potential to generate very large economic returns."

(2) [Variance of option value 2 (VOPV2): Q V-25] "When commercialized successfully, this technology will generate total revenues more than $100,000 per year."

7. Market signal
(1) [Product market signal (MKSGP): Q V-24] "The product developed from this technology has (will have) considerable demand in the market." (product market)

(2) [Financial market signal (MKSGF): Q V-26] "Financial capital is (will be) available to commercialize this technology." (capital market)

8. Technology scope
   (1) [Technology scope 1 (TSCP1): Q II-5] "This technology works as a platform for a wide variety of commercial applications."
   (2) [Technology scope 2 (TSCP2): Q II-8] "This technology has a narrowly specified commercial application."

9. The degree of endogenous uncertainty
   (1) [Endogenous uncertainty 1 (ENÜN1): Q IV-18] "During the actual commercialization, there may be new findings (e.g. related technologies, know-how of product development, better skills, etc.) that further boost up the economic potential of this technology."
   (2) [Endogenous uncertainty 2 (ENUN2): Q IV-22] "What is being (or will be) learned during the actual commercialization process will further increase the upside potential of its economic success."

Control variables:

1. University policy supportiveness in new venture creation
   (1) [University policy 1 (UPOL1): Q VI-27] "In general, this university supports new ventures by its faculty members."

2. Department level understanding of entrepreneurial activities by faculty members
   (1) [Dept. support (DPSP): Q VI-28] "In my department, people openly discuss ideas of entrepreneurship in relation to commercializing technologies."

3. Community level supportiveness of entrepreneurial activities
   (1) [Community support (CMSP): Q VI-29] "Necessary support systems for the creation of new ventures – such as incubating facilities, capital, and human resources – are available in this community (city level)."

4. Academic orientation of reward perception
(1) [Reward perception (RWPC): Q VII-31] "Academic rewards (i.e., publishing, reputation among scientists, etc) are more important to me than the commercial success of my technology."

(2) [Title (TITLE): Q VII-32] "My position is: Professor/Associate Professor, Assistant Professor, Research Scientist, Graduate student, Other."

(3) [Tenure status (TNST): Q VII-33] "Are you tenured in the above position?" (Yes/No)

5. Prior exposure to entrepreneurial activities
(1) [Prior exposure 1 (PREX): Q VII-30] "The amount of my industry experience as consultant, engineer, manager, etc. is:" (1-5 points from "Very little" to "Very rich")

6. Field of patent
(1) [Patent field (PATF): Q I-3] "The broad category that the patented technology falls into is:" Biotechnology (including biotech in medical/chemistry), Medical (other than biotech), Chemistry/Physics (other than biotech), Engineering/Instrumentation/Manufacturing (other than biotech), Other.

The following note was attached to help differentiate the biotechnology from the other categories.
"Note: Biotechnology is a broad category that includes genetic engineering, molecular biology, bioinformatics, and related fields. It is broadly defined as a collection of scientific tools and methods that use living organisms or cells and their molecules to make or modify products, improve plants or animals, or solve problems for humans. "Biotech products" primarily contribute to the areas of human therapeutics, human diagnostics, and agriculture."

(2) [Statutory category of this patent (PATS): Q I-4] "Statutory category of this patent is: "Process", "Machine", "Composition of matter", "Manufacture", "Other, or a combination of more than one categories above." Note: "Manufacture" is a term generally used to embrace inventions that do not fall under the other statutory categories. It includes products as varied as building structures, sound recordings, and organisms resulting from or substantially changed by genetic engineering."
August **, 1999

Dear Dr. **:

I am conducting research for my dissertation on university technology transfer and new venture creation under the supervision of Professor Jay B. Barney at The Ohio State University.

You were selected to receive this survey because your name appears as the primary inventor of the patented technology: “**” (US patent #) on the US PTO database. I obtained your e-mail address from the directory on your institution’s home page.

If your patented technology was, is being, or is likely to be transferred to the private sector either by licensing to existing firms or to new ventures, I would like you to visit our web site below and answer a short survey about the technology and its commercialization.

SURVEY ADDRESS: www.cob.ohio-state.edu/~okada/survey/

This all-multiple-choice survey takes approximately 5 minutes to complete. You can send your answers back to us on-line just by clicking a button at the end. Your answers will be strictly confidential. This research is purely academic, and not sponsored by any commercial organization.

If you are interested in the results of this survey, please send me a separate e-mail indicating your interest. I will send you the results when the survey has been completed.

I really appreciate your cooperation!

Sincerely,

Masahiro Okada
Ph.D. candidate in Business Administration
Fisher College of Business, The Ohio State University
1775 College Rd., Columbus, OH 43210
614-292-0837
okada.6@osu.edu
APPENDIX D: Zero order correlation matrix

|       | ASPL  | ASPU  | IMTB  | HUNW  | TEAM  | TPDP  | TSUB  | STTC  | TCCN  | VOPV  | ENUN  | TSCP  | UPOL  | DPSP  | CMSP  | RWPC  | PREX  | MKSGF |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| ASPL  |       | .005  | .025  | 1.000 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| ASPU  | .005  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| IMTB  | .025  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| HUNW  | 1.000 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| TEAM  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| TPDP  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| TSUB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| STTC  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| TCCN  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| VOPV  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| ENUN  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| TSCP  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| UPOL  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| DPSP  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| CMSP  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| RWPC  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PREX  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| MKSGF |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |


Std. Dev: .873 1.249 .957 1.030 1.134 .960 1.039 1.310 .997 .943 .672 1.155 1.248 1.191 1.226 1.314 1.055