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Assessment Framework For The Evaluation And Prioritization Of University Technologies For Licensing And Commercialization

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ASSESSMENT FRAMEWORK FOR THE EVALUATION AND PRIORITIZATION OF UNIVERSITY TECHNOLOGIES FOR LICENSING AND COMMERCIALIZATION

by

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ABSTRACT

US corporations have long recognized university related scientific research as an important source of long term economic growth and technological innovation. This dynamic involvement with industry has drastically increased the university technology transfer and licensing activities, and has stretched the human and financial resources of Technology Management and Licensing Offices of many US universities.

This research provides a mechanism that can aid in the complex process of properly assessing university-owned technologies and intellectual properties, to identify those with licensing and commercialization potential for the pursuit of truly important breakthrough discoveries. This research focuses on the university technology licensing and commercialization process from the perspectives of those licensing professionals whose firms' activities are engaged in licensing-in university technologies. The objectives of this research are to:

1. Identify the decision factors and licensing determinants that influence or impact the licensing and commercialization of university technologies.

2. Build and conduct a survey among those licensing professionals involved in the technology licensing process to determine the relative importance of each of the licensing determinants identified in the literature review, and their most current and up to date selection criteria for technologies they license, and

3. Develop a framework to assist the University Technology Management & Transfer Office's personnel and other stakeholders in the assessment of the potential viability of the university technologies[1] for licensing and commercialization.

[1] The interest of this research is in the licensing issues and their determinants in general, and not in any specific area, sector, or disciplines.

DEDICATIONS

I dedicate this research in memories of my father and my mother. I also dedicate this research for my beloved wife Leila, and my two children Dania and Alexander who without their support and sacrifices this achievement would not have been possible. I love you all.

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LIST OF DEFINITIONS

These definitions were adopted from the Product Development Management Association's (PDMA) website.

Applied Research: Utilizing pure research to develop real-world products.

Basic Research: is when technology development is pursued for its inherent scientific value and is investigator driven and focuses on long term radical innovation processes.

Benchmark: A standard by which something can be measured or judged.

Benchmarking: A process of collecting process performance data, generally in a confidential, blinded fashion, from a number of organizations to allow them to assess their performance individually and as a whole.

Benefit: A product attribute expressed in terms of what the user gets from the product rather than its physical characteristics or features. Benefits are often paired with specific features, but they need not be.

Best Practice: Methods, tools or techniques that are associated with improved performance. In new product development, no one tool or technique assures success; however a number of them are associated with higher probabilities of achieving success. Best practices likely are at least somewhat context specific. Sometimes called "effective practice".

Brand: A name, term, design, symbol, or any other feature that identifies one seller's good or service as distinct from those of other sellers. The legal term for brand is *trademark*. A brand may identify one item, a family of items, or all items of that seller.

Champion: A person who takes a passionate interest in seeing that a particular process or product is fully developed and marketed. This informal role varies from situations calling for little more than stimulating awareness of the opportunity to extreme cases where the champion tries to force a project past the strongly entrenched internal resistance of company policy or that of objecting parties.

Commercialization: The process of taking a new product from development to market. It generally includes production launch and ramp-up, marketing materials and program development, supply chain development, sales channel development, training development, training, and service and support development.

Concept: A clearly written and possibly visual description of the new product idea that includes its primary features and consumer benefits, combined with a broad understanding of the technology needed.

Concept Optimization: A research approach that evaluates how specific product benefits or features contribute to a concept's overall appeal to consumers. Results are used to select from the options investigated to construct the most appealing concept from the consumer's perspective.

Core Competence: That capability at which a company does better than other firms, which provides them with a distinctive competitive advantage and contributes to acquiring and retaining customers. Something that a firm does better than other firms. The purest definition adds "and is also the lowest cost provider."

Criteria: Statements of standards used by decision-makers at decision gates. The dimensions of performance necessary to achieve or surpass for product development projects to continue in development. In the aggregate, these criteria reflect a business unit's new product strategy.

Critical Success Factors: Those critical few factors that are necessary for, but don't guarantee, commercial success.

Customer Needs: Problems to be solved. These needs, either expressed or yet-to-be articulated; provide new product development opportunities for the firm.

Customer Perceived Value (CPV): The result of the customer's evaluation of all the benefits and all the costs of an offering as compared to that customer's perceived alternative. It is the basis on which customers decide to buy things.

Early Adopters: For new products, these are customers who, relying on their own intuition and vision, buy into new product concepts very early in the life cycle. For new processes, these are organizational entities that were willing to try out new processes rather than just maintaining the old.

Entrepreneur: A person, who initiates, organizes, operates, assumes the risk and reaps the potential reward for a new business venture.

Feasibility Determination: The set of product development tasks in which major unknowns (technical or market) are examined to produce knowledge about how to resolve or overcome them or to clarify the nature of any limitations sometimes called exploratory investigation.

First-to-Market: The first product to create a new product category or a substantial subdivision of a category.

Forecast: A prediction, over some defined time, of the success or failure of implementing a business plan's decisions derived from an existing strategy.

Framework: A simplified description of a complex entity or process

Grant-back Provision: a provision in a patent license that requires the licensee to grant back to the licensor patented improvements in the licensee's original technology; grant-back provisions have generally been looked upon with hostility by United States antitrust enforcement agencies, especially where the grant-back is exclusive

Incremental Improvement: A small change made to an existing product that serves to keep the product fresh in the eyes of customers.

Incremental Innovation: An innovation that improves the conveyance of a currently delivered benefit, but produces neither a behavior change nor a change in consumption.

License-in: The acquisition from external sources of novel product concepts or technologies for inclusion in the aggregate NPD portfolio.

Innovation: Innovation is the successful entry of a new science or technology-based product into a particular market.

Intellectual Property (IP): Information, including proprietary knowledge, technical competencies, and design information, which provides commercially exploitable competitive benefit to an organization.

Internal Rate of Return (IRR): The discount rate at which the present value of the future cash flows of an investment equals the cost of the investment. The discount rate with a net present value of 0.

Introduction Stage: The first stage of a product's commercial launch and the product life cycle. This stage is generally seen as the point of market entry, user trial, and product adoption.

Invention: A commercially promising product or service idea, based on new science or technology that is protectable (though not necessarily by patents or copyrights)

Life Cycle Cost: The total cost of acquiring, owning, and operating a product over its useful life. Associated costs may include: purchase price, training expenses, maintenance expenses, warrantee costs, support, disposal, and profit loss due to repair downtime.

Market Development: Taking current products to new consumers or users. This effort may involve making some product modifications.

Market-Driven: Allowing the marketplace to direct a firm's product innovation efforts.

Market Research: Information about the firm's customers, competitors, or markets. Information may be from secondary sources (already published and publicly available) or primary sources (from customers themselves). Market research may be qualitative in nature or quantitative (see entries for these two types of market research).

Market Segmentation: Market segmentation is defined as a framework by which to sub-divide a larger heterogeneous market into smaller, more homogeneous parts. These segments can be defined in many different ways: demographic (men vs. women, young vs. old, or richer vs. poorer), behavioral (those who buy on the phone vs. the internet vs. retail, or those who pay with cash vs. credit cards), or attitudinal (those who believe that store brands are just as good as national brands vs. those who don't). There are many analytical techniques used to identify segments such as cluster analysis, factor analysis, or discriminate analysis. But the most common method is simply to hypothesize a potential segmentation definition and then to test whether any differences that are observed are statistically significant

Market Share: A company's sales in a product area as a percent of the total market sales in that area.

Maturity Stage: The third stage of the product life cycle. This is the stage where sales begin to level off due to market saturation. It is a time when heavy competition, alternative product options, and (possibly) changing buyer or user preferences start to make it difficult to achieve profitability.

Metrics: A set of measurements to track product development and allow a firm to measure the impact of process improvements over time. These measures generally vary by firm but may include measures characterizing both aspects of the process, such as time to market, and duration of particular process stages, as well as outcomes from product development such as the number of products commercialized per year and percentage of sales due to new products.

New Product: A term of many opinions and practices, but most generally defined as a product (either a good or service) new to the firm marketing it. Excludes products that are only changed in promotion.

Opportunity: A business or technology gap that a company or individual realizes, by design or accident, that exists between the current situation and an envisioned future in order to capture competitive advantage, respond to a threat, solve a problem or ameliorate a difficulty.

Payback: The time, usually in years, from some point in the development process until the commercialized product or service has recovered its costs of development and marketing. While some firms take the point of full-scale market introduction of a new product as the starting point, others begin the clock at the start of development expense.

Product Development: The overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product.

Product Development Process: A disciplined and defined set of tasks, steps, and phases that describe the normal means by which a company repetitively converts embryonic ideas into salable products or services.

Product Life Cycle: The four stages that a new product is thought to go through from birth to death: introduction, growth, maturity, and decline. Controversy surrounds whether products go through this cycle in any predictable way.

Product Life-Cycle Management: Changing the features and benefits of the product, elements of the marketing mix, and manufacturing operations over time to maximize the profits obtainable from the product over its lifecycle.

Product Management: Ensuring over time that a product or service profitably meets the needs of customers by continually monitoring and modifying the elements of the marketing mixes, including: the product and its features, the communications strategy, distribution channels and price.

Product Positioning: how a product will be marketed to customers. The product positioning refers to the set of features and value that is valued by (and therefore defined by) the target customer audience, relative to competing products.

Product Superiority: Differentiation of a firm's products from those of competitors, achieved by providing consumers with greater benefits and value. This is one of the critical success factors in commercializing new products.

Prototype: A physical model of the new product concept. Depending upon the purpose, prototypes may be non-working, functionally working, or both functionally and aesthetically complete.

Quantitative Market Research: Consumer research, often surveys, conducted with a large enough sample of consumers to produce statistically reliable results that can be used to project outcomes to the general consumer population. Used to determine importance levels of different customer needs, performance ratings of and satisfaction with current products, probability of trial, repurchase rate, and product preferences. These techniques are used to reduce the uncertainty associated with many other aspects of product development.

Return on Investment (ROI): A standard measure of project profitability, this is the discounted profits over the life of the project expressed as a percentage of initial investment.

Risk: An event or condition that may or may not occur, but if it does occur will impact the ability to achieve a project's objectives. In new product development, risks may take the form of market, technical, or organizational issues. For more on managing product development risks.

Speed to Market: The length of time it takes to develop a new product from an early initial idea for a new product to initial market sales. Precise definitions of the start and end point vary from one company to another, and may vary from one project to another within a company.

Stage: One group of concurrently accomplished tasks, with specified outcomes and deliverables, of the overall product development process.

Target Market: The group of consumers or potential customers selected for marketing. This market segment is most likely to buy the products within a given category. These are sometimes called "prime prospects."

Technology Transfer: The process of converting scientific findings from research laboratories into useful products by the commercial sector. May also be referred to as the process of transferring technology between alliance partners.

Time to Market: The length of time it takes to develop a new product from an early initial idea for a new product to initial market sales. Precise definitions of the start and end point vary from one company to another, and may vary from one project to another within the company.

CHAPTER 1: INTRODUCTION

This chapter provides information about university technology transfer and licensing, its economic impact, and its importance for both the university and the industry. It also discusses the statement of the problem, the research question, the relevance, the contributions, and the objectives of this research.

1.1. Introduction

To cope with the impact of the many years of corporate downsizing and the dynamics of transformation of the US economy from a manufacturing based[1] to a service and knowledge based economy[2], and in their desire to reduce costs, their need to increase revenues, their hunger for new technologies due to the ever decreasing product life cycle and faster technological obsolescence, the pressure to speed up new product delivery, and in their quest to survive and gain an advantage in a competitive landscape, US corporations have been forced to look outside their boundaries and look at technology licensing-in as an attractive solution to gain insight into new technology innovations to improve their competitive edge.

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[1] "For much of the 20th century, the United States had an industrial economy based on large-scale production and manufacturing. In 1960, manufacturing output was 27% of U.S. GDP and manufacturing jobs accounted for 31% of total employment in the U.S. However by 1997 the manufacturing output has dropped to 17% of GDP, and in 1998 manufacturing jobs accounted for 14.9% of total employment". Knetter, Michael (Spring 2000), "Trade Deficit and the US Economy, Part II".http://mba.tuck.dartmouth.edu/paradigm/spring2000/articles/knetter-economy2.html

[2] "Industries remaining in the U.S. are more reliant and focused on scientific and technological innovation". Atkinson, Robert D., and Randolph H. Court (1998),"The new Economy Index: Understanding America's Economic Transformation". Available at http://www.neweconomyindex.org/index_nei.html

U.S. corporations have long recognized university related scientific research and inventions[3] as an important source of long term economic growth and technological innovation[4], and have significantly increased their sponsorship and financial support for universities and academic research[5]. As a result, university technology licensing-in was increasingly looked at as a complementary and an attractive option in the make-vs.-buy decisions of corporate business-development strategies[6]. "This dynamic involvement with industry has created new demands on the university to manage these activities so that the institution's primary goals of education, research and dissemination of knowledge are not compromised but rather augmented, with conflicts minimized and managed"[7].

1.2. The University Technology Transfer Process

Technology has been described as the engine of progress, wealth creation, and economic growth since the first industrial revolution (Dorf and Worthington, 1987). It is a critical element of a company's success (Eisenhardt and Martin, 2001) and could either be developed internally, or acquired externally when these technologies are unavailable

[3] Invention is a commercially promising product or service idea, based on new science or technology that is protectable (though not necessarily by patents or copyrights).

[4] Innovation is the successful entry of a new science or technology-based product into a particular market.

[5] In 1980, private industry funding accounted for 4% of university research expenditures. See General Accounting Office, Patent Policy: Universities' Research Efforts under Public law-517, at 3 (1986). AUTM survey reported that 8% of their 2001 research expenditures came from private industry. See 2001 AUTM survey. In 1997, U.S. companies spent $1.7 billion on science and engineering research at universities, an increase of five-fold over 1977 numbers. See David Shenk,"Money Science=Ethics Problems on campus," The Nation, March 22, 1999. Available at http://www.thenation.com/doc.mhtml?i=19990322&s=shenk

6 Michael F. Allan "A review of best practices in University Technology Licensing Offices", The Journal of the Association of University Technology Managers, Volume XIII (2001).
http://www.autm.net/pubs/journal/01/bestpractices.html

7 The Council on Governmental Relations, COGR 2000.

within their firm's boundaries or when technologies can not developed internally due to barriers such as capabilities, cost, or time factors (Trippas, 1997; Cohen and Levinthal, 1990; Chesebrough and Teece, 1995).

The University technology transfer is the process by which basic understanding, information, and innovations move from universities to the private sector, which may happen through various channels such as cooperation in research and development between academia and industry, university seminars, faculty consulting, high technology firm spin-offs, scholarly journal publications, and technology licensing. The major steps[8] (figure 1) in the technology transfer process include:

- An invention or technology disclosure which represent a recognition of the information about a new technology developed by a faculty member, a graduate student, or a staff member in a university that is conveyed to the university's office of technology licensing who in turn will perform a technical and an economic evaluation of innovations;
- The patenting of innovation concurrent with publication of scientific research; and
- Licensing the rights to innovations to industry for commercial development.

[8] Rogers, E.M.; Jong Yin; and Joern Hoffman (2000). "Assessing the Effectiveness of Technology Transfer Offices at U.S. Research Universities". The journal of the Association of University Technology Manager, Vol XII. Pg. 60

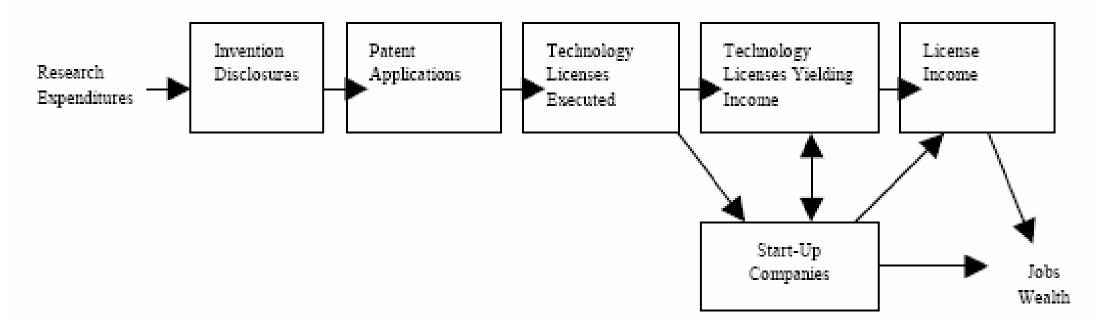

Figure 1- The Process of University Technology Transfer (Roger, E.M)

This process enhances the university's role as a major player in the development of their local economy through the commercialization and exploitation of the technological breakthroughs of the university's research findings, and leads to royalties and licensing income back to the inventor and the university with social and economic benefits for the community and society at large (Muir 1997, Rogers 2000).

1.3. The Importance of the University Technology Transfer Program to Academia

University technology transfer programs are important to the academic institutions' mission of education, research, and public service in that they provide:

- A mechanism for important research results to be transferred to the public and promote economic growth;
- A service to faculty and inventors in dealing with industry arrangements and technology transfer issues;
- A method to facilitate and encourage additional industrial research support;
- A source of unrestricted funds for additional research;

- A source of expertise in licensing and industrial contract negotiations;
- A method by which the institution can comply with the requirements of laws such as the Bayh-Dole Act to turn discoveries from federally funded research into products and services[9]; and
- A marketing tool to attract students, faculty, and external research funding.

1.4. Bayh-Dole Legislation Act

The Bayh-Dole legislation Act (P.L. 96-517, Patent and Trademark act amendments of 1980) governs the commercialization of inventions and innovations resulting from research funded by the federal government. It was a response to an increase in global competition in technology-related fields, and was also seen as a way for taxpayers to enjoy the benefits of the investment they made in university-based research.[10]

The Association of University Technology Managers (AUTM) credits the success of the university technology transfer and the resulting increase in the commercialization

[9] Association of University Technology Manager Licensing Survey FY 1991 - FY 1995

[10] "Simply put, American efforts at innovation, in which we were once the undisputed leader, were stagnating and falling behind other nations. There were a number of theories on the various causes of these problems, but clearly the United States needed to develop a more effective overall technology transfer policy. Senator Dole and I agree that there was an opportunity in one particular area where we could begin this process of providing a comprehensive technology transfer policy for the United States. This was the area of federally funded research conducted by universities and small business…. The taxpayers were getting almost no return on their investment. We came to the realization that this failure to move from abstract research into useful commercial innovation was largely a result of the government's patent policy and we sought to draft legislation which would change this policy in a way to quickly and directly stimulate the development and commercialization of inventions." Hearing before the subcommittee on Patents, Copyrights and Trademarks of the senate judiciary committee, 103d Congress, 2d session (1994), available in 1994 WL 14185684 (testimony of Senator Birch Bayh). Gordon, M.L. (2004)," University Controlled Or Owned Technology: The State of Commercialization and Recommendation". Les Nouvelles, Volume XXXIX N0.4. December 2004. Page 152

of university research related new products to the Bayh-Dole act which "changed the rules governing the university management of intellectual property, established a uniform policy among federal agencies regarding patents, and eliminated many restrictions on licensing allowing universities to retain title to federally funded research's inventions"[11]. As a consequence, many universities adopted specific policies and procedures to encourage technology licensing resulting in rapid growth of university technology licensing, and a significant increase in technology transfer activities. The key elements in the Bay-Dole act success story include:

- Establishing a uniform Federal Invention Policy;
- Permitting universities to retain title to inventions developed through Federally-funded research;
- Encouraging universities to collaborate with industry in promoting the commercialization on inventions;
- Establishing preference for local manufacturing; and
- Retaining government march-in rights to ensure diligence in commercialization by patent licensees.

[11] Poyago-Theoky et al (2002)

1.5. Economic Impact of the University Technology Licensing and commercialization

The AUTM; which provides the most comprehensive statistical data on university technology transfer[12]activities and their impact on the local and national economy; reported that prior to the Bayh-Dole legislation act of 1980, the primary method for disseminating federally research was academic publications[13]. Also, fewer than 250 patents were issued to US universities each year, and those discoveries were seldom commercialized for the public's benefit. In the 2002 yearly survey, the AUTM reported:

- The submission of 7,741 new U.S. patent applications;
- The issuing of 3,673 U.S. patents (28,093 patents issued since 1993);
- The submission of 15,573 Invention Disclosures;
- The execution of 4,673 new licenses/options for a cumulative total of 37,090 licenses since 1991 (68.2% were issued to start-ups and small businesses, while the rest were licensed to large companies); and
- A total of 450 startup companies were formed bringing the total to 4,320 since 1980, out of which 2,741 were still operational for a survival rate of 63.45%.

As of fiscal year 2002, the AUTM members also reported that:

- 26,086 licenses/options (70.3% of the total executed since 1991) were still active, out of which 10,866 yielded income of $1.267 billion;

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[12] The AUTM defines the University Technology Transfer "as a formal transferring of new discoveries and innovations resulting from scientific research conducted at universities to the commercial sector".

[13] Mowery, David C., and Bhaven N. Sampat. 2001. "University Patents and Patent Policies: 1925-1980." Industrial and Corporate Change.

- 569 new product introductions and running royalties on product sales were $1.005 billion generated by 5,853 licenses/options; and
- A research expenditures of $37 billion (62% funded by federal government sources, 8% by industrial sources, and the balance was supported by state and local government, foundations, individuals, and the institutions themselves).

Table 1 below provides a summary of activities reported by the AUTM members since 1991.

Table 1- The Reported Activities by AUTM Members Since 1991

Year	Sponsored Research $Billions	Licensing Income $Millions	Invention Disclosure Disclosure	Licensing Activity Licenses
91	12.8	222	6,337	1,278
92	14.2	287	7,345	1,741
93	17.1	380	8,581	2,227
94	18.2	422	8,743	2,284
95	19.9	495	9,789	2,818
96	21.4	591	10,178	2,741
97	22.8	699	11,303	3,326
98	24.4	810	11,784	3,668
99	26.8	950	12,324	3,914
00	29.6	1,263	13,032	4,362
01	31.7	1,071	13,569	4,058
02	37.1	1,263	15,573	4,673
Total	276	8,453	128,558	37,090

1.6. Problem Statement

With increased activity in patents and technology transfer[14], and the high costs associated with such undertakings, many universities continue to search for a framework to aid the University Technology Transfer Office's personnel in the tricky process of

[14] In 1972, fewer than thirty universities had technology transfer programs. Dueker, Kenneth S., (1997),"Bio-business on Campus: Commercialization of University Developed biomedical Technologies". 52 Food & Drug L.J. 453, 454-61. "Today nearly every research university in the country has a technology-licensing office." Washburn, Jennifer "The Kept University" The Atlantic Monthly , March 2000 p.2, available at http://www.theatlantic.com/issues/2000/03/press.htm

properly assessing the licensing and commercialization potential of university-owned technologies and intellectual properties. Such a framework, will provide insights into the conditions under which universities will be able to use licensing to earn some financial return, and guide the University Technology Licensing Office’s personnel to properly assess or predict which of their university’s intellectual properties, inventions or technology discoveries, have a viable licensing and commercialization potential for a better allocation of human and financial resources, and for the pursuit of truly important or breakthrough discoveries.

1.7. Research Question

Research studies have covered most aspects of the university technology transfer and the university technology licensing process, from the universities’ perspectives. However, none has so far addressed this process from a buyer’s perspectives and provided a process or a framework to determine or to help predict the likelihood of licensing of university technologies or intellectual properties.

This research looks at the university technology assessment and licensing prediction from the perspectives of those licensing professionals whose firms’ activities are engaged in licensing-in university technologies.

Given the non-existence and the need for a tool that can assist in the technology licensing assessment process, it is the primary focus of this research is to answer the following question:

”Can we develop a repeatable process, a mechanism, or a framework that can take advantage of the current research’s findings and use it as an assessment tool to provide insights into the University Technology Transfer Office to predict the likelihood of the licensing and the commercialization viability of the university’s technologies and research discoveries?

1.8. Research Objectives

The objectives of this research are to:

- Identify the decision factors and licensing determinants that influence or impact the licensing and commercialization of university technology;
- Build and conduct a survey among those professionals involved in the technology licensing process to determine the relative importance of each of the licensing determinants identified in the literature review, and their current and up to date selection criteria for technologies they license; and
- Develop a framework or benchmark that can assist the University Technology Transfer and Licensing Office’s personnel, or any interested stakeholder in the assessment of the potential viability of the university technologies[15] for the licensing and commercialization.

[15] The interest of this research is in the licensing issues and their determinants in general, and not in any specific area, sector, or disciplines.

1.9. Research Relevance

Although the diffusion of university technology transfer has been overshadowed by blockbusters such as the $160 million earned by Michigan State University over the life of two cancer related patents, the $37 million earned by the University of Florida from the sport drink Gatorade, the $143 million for the DNA gene splicing, and the estimated $250 million for the Google earned by Stanford University, these types of winners have been more the exception than the rule, and only a relatively small number of institutions have experienced financial success in technology transfer[16].

It has been estimated that only a small portion of university patents ever generate any meaningful income, half never get licensed, and that the licensing activity is not randomly distributed across patents (Shane 2002, Jensen and Thursby 2001, Hsu and Bernstein 1997, Barnes et al. 1997). This is evident by a study[17] conducted by Yale University's Office of Cooperative Research (OCR) which determined that approximately 850 invention disclosures have been made by Yale between 1982 and 1996, and it was found that only ten disclosures (1.1 percent) were responsible for 70 percent of the $20.4 million received by the University from licensing, and that 33 disclosures (5 percent) accounted for 90 percent of the licensing income derived. The analysis also showed that only 102 disclosures (12 percent) generated more than $10,000 each, the approximate cost for processing an invention disclosure, while 88 percent of those disclosures did not generate any income. The data derived from the Yale

16 (United States General Accounting Office).
17 http://www.yale.edu/ocr/images/docs/ocr_Report_96-98.pdf

University's OCR study clearly shows that disclosures do not offer equal promise of success, and is consistent with the previous evidence on the distribution of returns from industrial innovation[18].These results may be attributed and caused by the absence of a mechanism, framework or a tool that might explains or help predicts which university inventions or technology discovery might get licensed and commercialized.

In addition, the meltdown of the stock market over the last few years and the absence of an Initial Public Offering window (figure 2), has dried up many sources of capital, and made it very difficult for investors[19] to commit or provide seed capital for many of the new and promising ideas due to their inability to free up some of the capital tied in the last round of investments, making the need for such an assessment tool a necessity and a must.

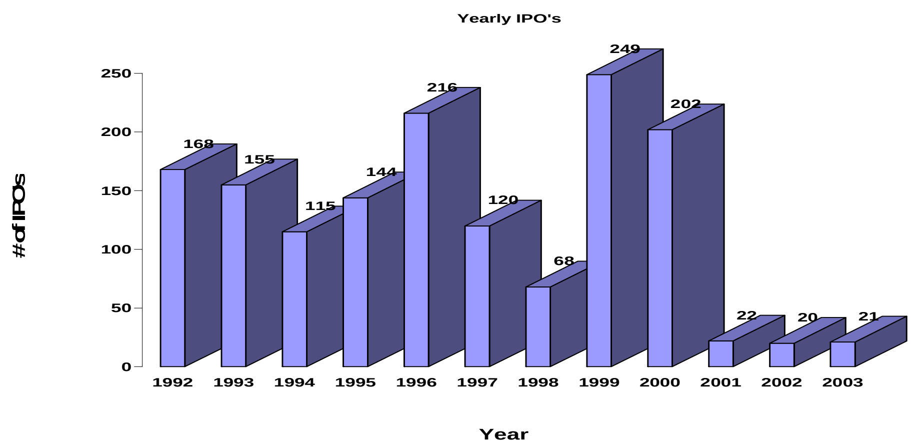

Figure 2- Venture Backed IPO 1992-2003[20]

18 Scherer, F.M., and Dietmer Harhoff. 2000. "Technology policy for a world of skew-distributed Outcomes." Research Policy 29:559-566

19 Angel investors provide the most significant source of early-stage technology development funding for individual technology entrepreneurs and small technology startups. Branscomb, Lewis M., and Auerswald, P. November (2002). "Between Invention and Innovation, An analysis of Funding for Early-Stage Technology Development". National Institute of Standards and Technology report (NIST GCR02-841).

20 Data Source: Venture One a private equity analyst

1.10. Research Contributions

Unlike the numerous theoretical modeling, empirical examination, and case studies[21] that have been conducted previously, this research was the first to create an assessment framework that looks at the university technology licensing and commercialization process from the licensees' perspectives, and reflected their most current technology licensing criteria and the latest market needs and conditions.

This research included the first and the most comprehensive technology licensing survey that directly targeted the actual practices and the latest up to date technology licensing criteria of those licensing professionals whose firms' activities are engaged in licensing-in or buying university technologies.

In addition, the framework developed in this research, represents the first attempt to build a knowledge management database or a decision support system using the logistic regression methodology. It also simplifies the assessment process for university technology licensing and commercialization, and assists university technology licensing personnel in identifying and prioritizing technologies with the best licensing and commercialization potential for the best allocation of the limited available resources, and the pursuit of truly important breakthrough discoveries.

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[21] A notable exception is a paper by Thursby et al. (2001), which is based on a survey of 62 university technology transfer offices.

CHAPTER 2: LITERATURE REVIEW

This chapter discusses the role of academic research and its impact on the US technological innovation and the new knowledge economy. It further discusses the current research undertaken by academia and stakeholders to identify the determinants that are crucial to the successful licensing and commercialization of university technologies and intellectual properties.

2.1. Introduction

The impact of academic research[22] on the US technological innovation and the economic system, has propelled the United States to world class leadership, and has been vital to the technological advances, economic development, and the improvements of the public health and the environmental sectors (Bessette, 2003). Recognizing the new role of academic research in furthering and stimulating the dynamic innovation system, "new partnership are emerging that would coalesce to change the roles of universities, industry, and government in the R&D enterprise"[23].

Industry collaboration with universities have multiplied and diversified enormously in recent years due to several factors[24]such as the university funding needs,

[22] By the end of 1990's, universities accounted for about 50% of all basic research and almost 5% of all domestic patent grants in the U.S. (National Science Board,2000

[23] Industrial Research Institute (IRI), Government-University-Industry Research Roundtable (GUIRR), Council on Competitiveness (CoC). Industry-University Research Collaborations: Report of a Workshop. Washington, D.C.: National Academy Press, 1996.

[24] International Workshop on Management and commercialization of Inventions and Technology. The World Intellectual Property Organization (WIPO) in cooperation with the Mexican Institute of Industrial Property (IMPI) and the Institute of Technology and Superior Studies of Monterrey (ITESM) Monterrey (Mexico), April 17 to 19, 2002

the diminishing growth in federal funding for research and development (R&D) confronted by US universities, the industrial competitiveness, the increased pressure faced by the industry to focus internal R&D on short-term payoffs, the community economic development, the rapid technological advancement, and the growth of science based and technology intensive industries. The benefits of the University-Industry collaboration as described by the Council on Governmental Relations (COGR 2000) take many different forms such as:

- Basic Research - Basic research is seen as a major role of universities, while applied research and development is more common in industrial laboratories. Research alliances with universities provide a growing proportion of industry's basic research as corporate R&D budgets are reduced by short-term competitive pressures;
- Graduate education – industry-funded university research and internships enhance graduate education by providing faculty and students with a better understanding of industrial problems;
- Increased Awareness - Collaboration with industry enhances academia's understanding of the challenges facing industry by exposing the university faculty to industrial concerns and industrial approaches to research. Conversely, collaboration with universities helps industrial scientists to keep abreast of the latest developments in broad areas of basic science that are of strategic interest to the company;

- Cost-effectiveness - Collaboration, whether singly or with several in consortia, provides a cost-effective means of doing research whereby funds invested are leveraged by the contributions of other participants. All parties are able to stretch limited resources;
- Government Funding - By design, alliances between university and industry partners are required for federal funding to be obtained in certain competitive situations. These programs are generally aimed at expediting development of the nation's critical technologies;
- Business Opportunities - The Bayh-Dole Act has spawned a university technology transfer industry in which universities protect the intellectual properties resulting from research and license them for commercial applications. In biotechnology and other science-based industries, universities are recognized as a primary source of new business opportunities[25].

In Tonatsky's (2000) InnovationU about new universities roles in knowledge economy, Walter Plosila reiterates that "The American University has set a world-class standard for fundamental, basic research. Less well known is that in the past 10 to 15 years a new model for the American University, as a partner in its regional and state economy, has also emerged".

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[25] Association of University Technology Managers, Inc. (AUTM), The AUTM Licensing Survey: Executive Summary and Selected Data, Fiscal Years 1993, 1992, and 1991 (Norwalk, CT: AUTM, 1994), p. 2. See also, Henderson, Rebecca, Adam Jaffe and Manual Trajtenberg, "Numbers Up, Quality Down? Trends in University Patenting, 1965-1992." Presentation at the Conference "University Goals, Institutional Mechanisms and Industrial Transferability of Research," Center for Economic Policy Research (Stanford, California) March 18-20, 1994.

However, the University-Industry partnership has been at the center of an ongoing debate as to its impact on basic academic research, and whether university technology licensing and commercialization has affected the faculty's attitude toward basic research[26] in favor of applied research. Some critics even argue that university researchers sometimes choose their research topics based on the short-term commercial potential[27] resulting in important areas of research with less commercial appeal being often ignored.[28] Another concern raised by the critics is that the "competition for financial support has encouraged many universities to accept grants from industries that demand delays in the publication and the sharing of ideas[29], and most often restrict[30]

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[26] Basic research is when technology development is pursued for its inherent scientific value and is investigator driven and focuses on long term radical innovation processes.

[27] A survey by Thursby and Thursby (2003) concluded that of all the universities inventions and technology licensed, only 17% were sponsored by industry as contract money for a clearly specified deliverable (applied research) rather than at a general research question, while 63% originated from activities in basic research that was federally funded, and 20% of those discoveries were un-sponsored.

[28] Some critics contend that the drive toward commercialization has skewed academic research away from basic research to applied research. National Science Foundation statistics show that this argument is weak, however. The composition of academic research has remained consistent sine the 1980 with about 66% of research being basic science, although this is down from 77% in the early 1970's. Richard Florida, "The Role of The University: leveraging Talent, Not Technology," Issues in Science and Tech., Summer 1999, available at http://www.issues.org/15.4/florida.htm

[29] "One of the basic tenets of science is that we share information in an open way. As biotech and pharmaceutical companies have become more involved in funding research, there has been a shift toward confidentiality that is severely inhibiting the interchange of information." (Quoting Steven Rosenberg, national Cancer Institute). Gordon, M.L. (2004)," University Controlled or Owned Technology: The State of Commercialization and Recommendation". Les Nouvelles, Volume XXXIX N0.4. December 2004. Page 152

30 "The 1998 strategic alliance between the Department of Plant and Microbial Biology at the University of California at Berkely and Novartis; a Swiss life sciences and pharmaceutical firm; grants first rights to Novartis to negotiate licenses on approximately one third of the department's inventions until 2003". Poyago-Theotoky, J.; Beath, J.; and Donald S Siegel." Universities and Fundamental Research: Reflections on the Growth of University-Industry Partnership". Oxford Review of Economic Policy; Spring 2002; 18, 1; ABI/INFORM Global pg. 10

access to results stemming from sponsored research results even though this policy is in direct conflicts with well-established academic norms"[31], hence causing potential degradation to "open science" that permeates institutions of higher learning[32].

Poyago-Theotoky et al. (2002) "found that academic scientists engaged in entrepreneurial activities are more secretive and are more likely to deny request from fellow academics for research results than other faculty member who were not involved in entrepreneurial activities". On the other hand, "Rosenberg (1982) and Stokes (1997) have argued, there are many instances where academically valuable results can emanate from research with practical goals and vice-versa, and commercially valuable knowledge can result from research with very academically oriented goals[33]. In addition, there are many cases when the output of such research endeavors; such as the Recombinant DNA; can be characterized as both commercially valuable and important from an academic viewpoint".[34]

In a study of over 3400 faculty members at 6 major research universities, Thursby and Thursby (2003) concluded that the basic/applied split in research did not change over

[31] Bottom-up versus top-down policies towards the commercialization of university intellectual property Brent Goldfarb, Magnus Henrekson. Research Policy. Amsterdam: Apr 2003. Vol. 32, Iss. 4; p. 639

[32] Nelson, R.R. (2001), 'Observations on the Post-Bayh-Dole Rise of Patenting at American Universities', Journal of Technology Transfer, 26(1-2), 13-19.

[33] "There is certainly great overlap between commercially valuable and practical knowledge. Although, there are exceptions. Consider the following case: a biotech firm with little more than an idea could be sold, and hence be commercially valuable, but the idea may yet be far from practical. But even here such knowledge has the potential to be useful in the foreseeable future. And if the idea originated from a university, its commercialization would likely require the inventor's continuing involvement". Bottom-up versus top-down policies towards the commercialization of university intellectual property Brent Goldfarb, Magnus Henrekson. Research Policy. Amsterdam: Apr 2003. Vol. 32, Iss. 4; p. 639

[34] Bottom-up versus top-down policies towards the commercialization of university intellectual property Brent Goldfarb, Magnus Henrekson. Research Policy. Amsterdam: Apr 2003. Vol. 32, Iss. 4; p. 639

the period 1983-1999 even though licensing had increased by a factor of greater than ten. Poyago-Theotoky et al. (2002) finds that “evidence appears to contradict the conventional wisdom that university technology licensing reduces the quality and quantity of basic research performed by academics”. This is in agreement with a study of licensed technologies at the University of California, Stanford and Columbia, which similarly concluded that there has been little affect on the content of academic research (Mowery et al. 2001). Blumenthal et al. (1996) argued that the university technology commercialization has actually had a positive impact in the biomedical field, as the biomedical faculty who were involved in technology commercialization taught no less, published more, and produced more patented discoveries than faculty not involved in technology transfer activities[35]. Similarly, Louis et al. (2001) found that “entrepreneurial faculty has higher scholarly productivity than non-entrepreneurial faculty”, and Zucker and Darby (1996) reported that “star scientist in biotechnology had excellent research performance after becoming involved in commercialization”.

“In a series of case studies of Stanford and Columbia technologies questioning whether the promise of financial incentives associated with licensing have diverted faculty from basic to more applied research, there was no evidence showing that financial return to inventors played a significant role in the motivation behind research”(Colyvas et al. 2002).

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[35] Blumenthal, David at al. “University Industry Research Relationship in Biotechnology: Implications for the University,” 232 Sci. 1361 (1986).Gordon, M.L. (2004),” University Controlled or Owned Technology: The State of Commercialization and Recommendation”. Les Nouvelles, Volume XXXIX N0.4. December 2004. Page 152

On whether faculty involvement and their efforts in a university-industry technology licensing had diverted them from their role in basic research, Thursby and Thursby (2003) reported that faculty orientation in the growth of university licensing is not a fundamental shift away from basic research.

Another positive impact stemming from the university-industry partnership, is that researchers might use the fund obtained or gained from applied research and use it toward their basic research[36]. However some critics have also asserted that faculty involved in technology commercialization may spend less time teaching hence negatively impacting the content and the quality of education.

These studies give enough evidence that contrary to the belief that applied research has not had a negative impact on basic research. On the contrary, Poyago-Theotoky (2002) argues that "universities can also benefit from reverse technology transfer (i.e. technology transfer that flows from firms to universities), enabling academic scientists to conduct better experiments, as a result of their interactions with industry scientist"[37].

[36] "Faculty members involved in commercialization project re-invest their money in laboratory equipment to further conduct additional research". .Siegel, D.; D. Waldman; and A. Link, 1999, "Assessing the Impact of Organizational Practices on the Productivity of University Technology Transfer Offices: An Exploratory Study". NBER Working Paper 7256, Cambridge, MA: National Bureau of Economic Research.

[37] See Siegel, Waldman, and Link (1999) for some anecdotal evidence supporting this assertion.

Table 2[38] provides a summary of the several benefits and potential drawbacks of an increase in University-Industry partnership.

Table 2- Trade-Offs Associated with the Increase in University-Industry Partnerships

Benefits	Drawbacks
Additional Revenue for the University	Negative Impact on Culture of Open Science
More Rapid Technological Emphasis	Negative Impact on Student/Adviser Relations
Choices Regarding Technological Emphasis	Could Reduce the Quantity of Basic Research
Positive Effects on Curriculum	Could Reduce the Quality of Basic Research
Local/Regional Economic Development	Could Affect Types of Research Questions Addressed
Two Way-Knowledge Transfer	Academics Could Spend Less Time on Teaching

In his paper titled ”Faculty Conflicts of interest in an Age of Academic Entrepreneurialism”, Harrington (2001) concluded that “Given the current trend in the University-Industry relationship, it appears that the technology transfer programs are bound to grow, and universities should try to accommodate those critics by devising and implementing conflict of interest policies to avoid tainting their research outcomes”.[39]

38 Poyago-Theotoky, J.; Beath, J.; and Donald S Siegel.” Universities and Fundamental Research: Reflections on the Growth of University-Industry Partnership”. Oxford Review of Economic Policy; Spring 2002; 18, 1; ABI/INFORM Global pg. 10

39 Harrington, Peter (2001),”Faculty Conflicts of interest in an Age of Academic Entrepreneurialism: An Analysis of the Problem, the Law and Selected University Policies,” Gordon, M.L. (2004),” University Controlled or Owned Technology: The State of Commercialization and Recommendation”. Les Nouvelles, Volume XXXIX N0.4. December 2004. Page 152

2.2. University Technology Licensing Determinants

Picking potential winners from a vast range of opportunities presented by research is a tricky and risky business with high failure rate leading to the conclusion that both the producers (licensors) and the acquirers of the technology (licensees) would benefit from a framework that could help assess the likely successful technology, and identify those technologies with above average potential for commercial application (Dorf and Worthington, 1987).

Extensive research has been undertaken to identify the success determinants that affect or influence the university technology licensing. Theoretical modeling (Macho-Stadler, Perez-Castrillo, Veugelers, 2004; Bercovitz, Feldman, Feller, Burton, 2001; Lach, and Schankerman 2003), and empirical examinations and studies (Taylor and Silberston 1973; Caves, Crookwell, and Killing 1983; Anand and Khanna 2000; Ziedonis 2001; Shane 2002; Nerkar and Shane 2002; Kim and Vornatas 2004) have been the main themes of research in the area of the university industry technology transfer and licensing. Thursby et al (2003) reported that to date, "technology transfer from university to industry has been largely understood from studies of spillovers through citations to patents or publications with a notable exception of a paper by Thursby et al. (2001), based on a survey of 62 university technology transfer offices".

Literature review of theoretical modeling and empirical studies, have identified several determinants to be crucial to the successful licensing and commercialization of university technologies. These determinants are classified into the following classes:

- Institutional determinants;
- Inventor related determinants;
- Technology related determinants;
- Market and Commercialization related determinants;
- And intellectual property related determinants.

2.3. The Institutional Determinants

The Institutional determinants are classified in two different classes. The technology transfer office related determinants, and the institutional prestige and licensing policies related determinants.

2.3.1. Technology Transfer and Licensing Office Related Determinants:

The objectives of the University Technology Transfer and Licensing Office is to bring university-generated intellectual properties into public use as rapidly as possible while protecting academic freedoms an generating a financial return to the university, inventors and their departments. To achieve these objectives, most universities are willing to trade off profits to ensure that the technology gets into the market place (Elfenbein 2000).

Several research topics such as the determinants of productivity, effectiveness and influence of the university technology transfer office on the university discoveries licensing and commercialization process (Siegel, Waldman, and Link 1999), and many models (statistical and mathematical) have been addressed to predict the patenting of university technologies.

Rogers (2000) utilizes six measurable outputs to measure technology transfer effectiveness from a research university:

- The number of invention disclosures received;
- The number of U.S. patents filed;
- The number of licenses/options executed;
- The number of licenses/options yielding income;
- The number of start-up companies; and
- The gross licensing income received.

Using key determinants such as the university research expenditures, faculty quality rating, and resources provided for the technology transfer office, Hauksson (MIT 1998) assessed the influence and efficiency of the University Technology Transfer and Licensing Office in the process of commercializing university discoveries, and built regression models to make predictions about the number of licenses, patents, and invention disclosures. The research' results implied that technology transfer help the university accomplish its mission as a purveyor of knowledge, benefit the society by pushing discoveries out of the university laboratories and into the market place, and the results also suggested a strong positive correlation between investment and success in technology transfer.

Muir (1993, 1997) proposed a method to calculate a Technology Transfer Office Performance Index (TTOP Index) a single, composite number characteristic of Technology Transfer Office associated outputs. He suggested the Index can be calculated periodically for comparative purposes, and used to spotlight strengths and weaknesses in services, and could also provide a fair assessment of the technology transfer office's performance. Five performance indicators were utilized in the index:

- Invention disclosures;
- Comprehensive evaluations of inventions performed by licensing candidates in industry;
- Income generating and industrial R&D support agreements;
- Patentability opinions, patent applications and issued patents; and
- Institutional support for the technology transfer office.

Sandelin (2003) discussed that a key attribute of a successful technology transfer office is in the ability to view the technology transfer process from a marketing perspective and develop policies and operating procedures that recognize and provide incentives to the inventor as a critical determinant to the licensing and success of the commercialization process[40].

In a National Bureau of Economic Research paper, Lach and Schankerman (2003),"in one of the first paper to analyze theoretically the incentives effects of various

[40] Innovation Matters, 2003 " Success factors in university technology transfer through patenting and licensing", June 2003, Vol 1, Issue 1

award schemes ever, showed that economic incentives to inventors affect the number and commercial value of inventions generated in universities and determined that universities which give higher royalty shares to academic scientists generate more inventions and higher license income”. This is in agreement with Lazear (1997) that points out that” even research with direct marketability will not be undertaken at the appropriate rate unless the inventor is entitled to the full rents from the resulting advance”.

2.3.2. The Institutional Prestige and Licensing Policies Determinants:

Hsu and Bernstein (1997) examined the decision policies that dictate the managing of the university licensing process and identified the efforts on the part of the licensee, the value (nature and stage) of the technology, the financial issues, and the university licensing policies such as a university’s prompt research publications requirements versus a licensee’s preference toward secrecy of invention and publications delays, as the most important determinants contributing to a successful technology transfer and licensing.

Sine, Shane, De Gregorio (2003) empirically examined the influence of the institutional prestige on the licensing of university inventions. The importance of this determinant factor in the technology transfer process is attributed to several reasons such as:

- The institutional prestige signals the quality of organizations' goods, and the positive external perception about the general organization influence the external perception of its goods (Shenkar and Yuchtman-Yaar 1997, Perrow 1961).
- Buyers form rational expectations of the quality of goods and services by observing the sellers' past products and actions, and these reputations influence subsequent purchasing decisions (Wilson 1985), and attribute their positive perception of a high prestige organization to its outputs, thereby increasing the outputs' perceived value through a "halo effect" (Crane 1965, Perrow 1961).
- Past performance and prestige are positively correlated (Podolny 1993) and similarly, prestige and affiliations are positively correlated.
- The licensee may be drawn to more prestigious universities because university's prestige will help them attract additional resources to commercialize technology.

The authors concluded that this study provides support for an organizational perspective and suggests that technical attributes alone may be insufficient to explain the likelihood of technology transfer, and that prestigious universities may be better able to license their inventions than less prestigious universities not because the technology produced is better, but because the universities that produce them are perceived as more prestigious.

The institutional related determinants and their relevant criteria identified by the literature review could be summarized as:

1. Technology Transfer Office determinant;

2. Universities licensing policies determinant; and
3. Institutional prestige influence determinant.

2.3.3. The Inventor Determinants

Thursby and Thursby (2000, 2003) surveyed a sample of the Licensing Executive Society's[41] members, and identified personal contact or involvement (social factor) between university inventors and industry as the most important source of technology transfer and commercialization success, concluding that by "establishing and nurturing such a relationship through some sponsored research, a company may develop an ongoing awareness of university research activity while the research group gains an efficient channel for marketing news results"[42].

Jansen and Dillon (1999) found that relationship with inventors is a critical factor to licensing-in university technology. Their conclusion is in total agreement to a research survey conducted by Thursby and Thursby (2000) which determined that "industry licensing executives overwhelmingly identified personal contact between their R&D staff and university personnel as the most important source of university technology licensing". In addition, many firms view sponsored research as mechanisms for obtaining access to realistic technology champion's faculty for consulting purposes or graduate students for positions in the firm's R&D labs.

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[41] A professional society comprised of over 5,000 members engaged in the transfer, use, development, manufacture and marketing of intellectual property. Membership includes business executives, lawyers, licensing consultants, engineers, academicians, scientists and government officials.

42 AUTM Journal Volume XI I (2000): Industry Perspectives on licensing University Technologies: Sources and Problems. Jerry G. Thursby and Marie C. Thursby

Jensen and Thursby (2001) find that at least 71 percent of inventions require further involvement by the academic researcher if they are to be successfully commercialized. 48 percent of the ideas are in proof of concept stage, 29 percent have a prototype available on a lab scale and for only 8 percent is manufacturing feasibility known. The authors also suggest that there is a moral hazard problem in which the inventor is likely to provide too little effort for the development of the technology. This moral hazard problem can be partially solved by offering the university royalties on sales resulting from the invention or equity in the licensing firm (Elbenfein 2003).

Literature review has also identified that the inventor's credibility in the technological field, his ability to deliver the technology know-how, the realistic goals of the research, and the strength of relationship and ties between the parties (Allen, 1997; Berry & Broadbent, 1984, 1987; and Galbraith 1990) as crucial variables that can affect technology transfer and licensing.

The inventor's related determinants and their relevant criteria identified by the literature review are summarized as:

1. Inventor's involvement & cooperation as a team player;
2. Inventor is a technology leader;
3. Inventor's credibility in the field;
4. Inventor's realistic expectations; and
5. Incentives paid to inventor

2.4. Technology Determinants

Given the rapid explosion of new technologies and their impact on new markets and business opportunities, a multi-stage process of technology trend mapping; consisting of technology evaluation and market assessment; should be implemented to determine the most logical potential for success, identify those technology determinants that will impact the technology and its commercialization, and identify those factors required to ascertain what the true opportunity may be (Udell 2000).

Technology mapping is used to "identify users or technology changes that are altering the target market"[43]. Questions; such as those listed below; addressing the state of the technology, its concept, uniqueness, risks, technical and economic feasibility, potential target market, the competitive landscape, customer needs and values, barriers to entry, technology features and benefits, are the initial steps in the technology evaluation process:

- What are the state, nature, purpose, scope, and useful life of this technology?
- What development stage is the technology in?
- Is the technology a total system, or a sub-system of an existing system?
- Is the technology technically achievable and economically feasible?
- What are the unique features of this technology?
- When will this technology be ready?

[43] The PDMA tool book for new product development / edited by Paul Belliveau, Abbie Griffin, and Stephen Somermeyer. John Wiley & Sons, C2002

- Is this technology created based on a market need and demand (technology pull) or it must create demand in the market (technology push)?
- How, where, when, and who is the intended buyer and user of this technology?
- Is this a new technology or a substitution for an older technology, and why should the user switch to this technology? Is it cheaper, better, and /or more efficient?
- What are the advantages and disadvantages of this technology over the current solutions?
- How is this technology superior to other alternatives available on the market?
- Will the current infrastructure support this technology and its expected growth?
- What is the current user level of technology and will training be needed?
- Can this technology grow with the user?
- What is the health, safety, and environmental risks associated with the technology?
- What value does this technology bring to the market, the society, and the user?
- Does this technology overcome any technical barriers or solve any problems not addressed by the competition?
- What are the technological, political, social, economic, and cultural barriers to this technology?

Depending on the level of innovation, newly created technologies can be classified as either (Bradford 2004):

- An incremental change in an existing technology as with most technologies,
- a breakthrough that significantly advances a technology field, or
- a revolutionary advancement that creates an entirely new technology

Rogers (1995) describes five characteristics of a technology that can influence the rate at which an innovation is transferred and diffused into the society or organization. Those characteristics are Relative advantage[44], Compatibility[45], Complexity[46], Trialability[47], and the Observability[48]:"

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44 The degree to which an innovation is perceived as better than the idea it supersedes as measured in economic terms, social prestige, convenience, and satisfaction. It does not really matter if the new technology is an advantage as long as it is perceived as one. The greater the perceived advantage, the more rapid the adoption is.

45 The degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. An idea that is incompatible with values and norms of a social system will not be adopted as rapidly as an idea that is compatible.

46 The degree to which an innovation is perceived as difficult to understand and use. New ideas that are simpler to understand are adopted more rapidly than ideas that require new skills and understandings.

47 The degree to which an innovation may be experimented with on a limited basis. An innovation that is trialable represents less uncertainty to the individual who is considering adopting the technology and therefore is more likely to be accepted.

48 The degree to which the results of an innovation are visible to others. The easier it is for individuals to see others using the innovation with positive results, the more likely they are to adopt it

Jensen and Thursby (2001) surveyed 62 universities about invention characteristics, licensing procedures, and licensing objectives in their universities, and found that the vast majority of university inventions licensed are so embryonic[49] or early stage-technologies[50], and no one knows their commercial potential because they are in such an early stage of development (the survey determined that only 12% of licensed inventions were ready for commercial use, while 75% lacked working prototype). It was also determined that the continued effort by the inventor is a critical determinant for the further development and for commercial success, and tying the inventor's compensation to the licensee's output, would guarantee his continued involvement.

A survey of 300 licensing executives member by Thursby et al. (2000) identified the early stage of the university technology development or its irrelevance to their firm's business objectives (figure 3[51]) as the main factor[52] for not licensing-in university technology due to the nature of university research is despite the fact that 24% stated university patents had been critical[53] for their companies research.

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[49] Even the most lucrative university patents tend to be embryonic when licensed. Neil Reimer (1987) note the importance of the cohen-boyer patents was clear at the beginning, but the commercial application was viewed as decades away.

50 Early-stage technology is a commercially promising invention that might become a successful innovation.

51 Between Invention and Innovation, An Analysis of Funding for Early-Stage Technology Development Economic Assessment Office, Advanced Technology Program, National Institute of Standards and Technology, 2002 , NIST GCR 02–841

52 AUTM Journal Volume XII (2000). "Industry perspectives on Licensing University Technologies: sources and Problems" by Jerry G. Thursby and Marie C. Thursby.

[53] Critical is when the product or the process could not have been developed without substantial delay.

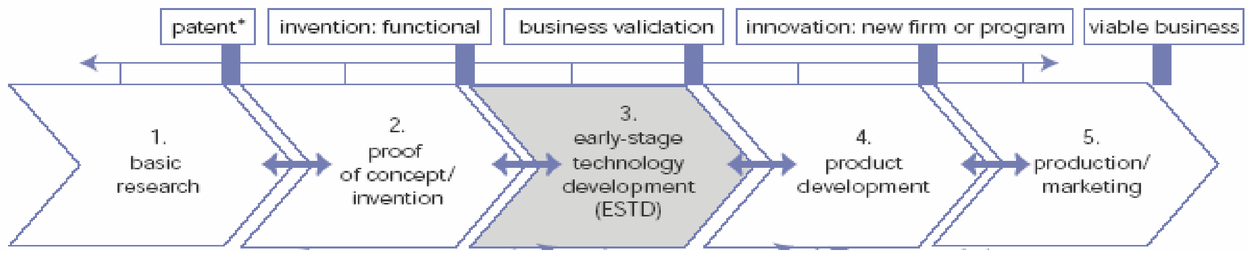

Figure 3- Stages and Milestones in the Development of a Science-Based Innovation

Nerkar and Shane (2002) presented four characteristics of new technology that would increase the likelihood of commercialization:

- The scope of the technology where multiple successful applications might emerge from a technology with broader scope,
- The pioneering nature of the invention, where pioneering inventions enhances the chances of commercialization hence greater returns, while incremental inventions provide a more constrained intellectual property,
- Exclusivity of invention which protects against imitation thus providing economic incentives,
- Age of the invention where protection of new technology shortens (Gabrowski and Vernon, 1986), the possibility of substitutes emerges (Agarwal and Gort, 2001), and the law of diminishing return kicks in with time passage.

In addition, to the literature review, several universities' Invention Disclosure forms (IDF) have been checked to identify the important technology determinants that universities require the inventor to provide answers to, to determine the technology's technical viability.

As a result, the most important technology related determinants to the licensing and commercialization of university technologies are summarized in the following list[54]:

1. The nature and sophistication of technology (high or low tech);
2. The scope of technology (future uses);
3. Technology uniqueness and superiority;
4. Technology's significant benefits and advantages as identified and perceived by the user;
5. Technology's quantifiable benefits and advantages as perceived by the user and compared to current competing products;
6. Technology 's sustainable competitive advantages & superiority as perceived by the user;
7. The technology development time to market;
8. The stage of development of technology;
9. Barriers to entry;
10. The Newness and the non-obviousness in the technology;
11. The availability of a functioning prototype;
12. The technical feasibility (technical problems are solvable);
13. The technology's degree of dependability on other necessary technologies ;
14. The technology's degree of compatibility to other necessary technologies; and

[54] Few of the technology related determinants identified in the literature review were split into two or more determinants due to their compound nature as this will enhance and simplify the research outcome.

15. The technology’s quantifiable and identifiable technological Risks and Weaknesses.

2.5. Market Analysis and Commercialization Determinants

A commercially viable technology must demonstrate economic benefit. The greater the benefit, the more desirable and marketable the technology is. On the other hand technology commercialization is a process of acquiring ideas and augmenting them with complementary knowledge, developing and manufacturing saleable goods, and selling the goods in the market (Mitchell and Singh 1996). Successful technology commercialization allows firms to satisfy markets needs by introducing new innovative and quality products in a speedy manner, and at competitive pricing. Meseri and Maital (2001) studied how Israeli universities’ project were being evaluated and sought to examine the criteria for choosing technology transfer projects in Israeli universities and whether those criteria were compatible with the industry. It was found that the most important determinants in the project’s evaluation were:

- Market needs and size;
- The existence of a patent;
- The success chances in R&D;
- The level of innovation; and
- The maturity of the idea.

Kim and Vornatas (2004) in an empirical study of licensing transactions involving United States companies across all sectors during the 1990's, identified the following as the most important determinants of technology licensing:

- The licensor company's prior licensing experience;
- The rate of growth of its primary industry;
- The technological knowledge of the licensor;
- The strength of the intellectual property protection in that industry; and
- The nature of the new technology produced by the licensor

Cooper (1993) noted the characteristics of successful new products are related to high levels of market attractiveness, sophisticated technology, business and technology synergy, market synergy and competitive advantage. A study of about 200 projects classified as success or failure, determined that the main keys to an innovation that would lead to a successful commercialization are:

- A unique, superior and a differentiated innovation that delivers unique benefits to the user tended to be more successful than imitated and moderate advantage products, and will capture a higher market share with better profit margins. The common features of a superior innovative products/technologies were:

    1. Unique products/technologies not available in competitive products / technologies;

2. Met customer needs better than competitive products/technologies;
3. Solved a problem the customer had with competitive products /technologies;
4. Reduced the customer's total costs;
5. Higher relative quality than the competition; and
6. Innovative as the first of their kind on the market.

- An innovation that will lead to a well defined product's concept on what the product would be and what it should do, a defined target market with a thorough understanding of the intended customer needs, wants, and preferences,
- A detailed market studies to determine the user's choice criteria, and the relative weight of each criterion,
- Define who the competitors are, their strengths and weaknesses, and their market share,
- The market size, growth, and trends,
- The market segments, their size, growth, and trends,
- The competitive situation.
- A technical feasibility assessment to establish the technical features, the intended final product's performance objectives, and identify the technical risks and solutions.
- A financial analysis assessment

Another investigation of new product and technology practices by Booz, Allen & Hamilton, in the 1980's has identified the characteristics that will impact the technology success rate:

- Technology fit with market needs;
- Technology superiority;
- Technology's clear identifiable benefits;
- Technology's major quantifiable benefits;
- Technology's distinct advantages;
- Favorable competitive environment;
- Regulation compliance;
- A well defined and achievable time to market;
- Technology quality and reliability; and
- Potential market attractiveness such as growth rate, growth trend, and the competitive landscape.

The market analysis and commercialization related licensing determinants and their relevant criteria, identified by the literature review are summarized as:

1. Technology's identifiable current and immediate market needs;
2. The absence of a dominant player/ competitor in the technological field;
3. Technology's expected potential market;
4. Technology's expected market growth anticipation;
5. Technology's expected market trend;

6. Technology's expected time to reach target market penetration;
7. Market accessibility (no dominant technology);
8. The technology's competitive pricing;
9. Technology's probability of market success;
10. Technology's early mover advantage;
11. Research and Development necessary to reach the product development stage;
12. Technology's expected payoff period;
13. The technology's ability to attain a positive return on investment within a specified period; and
14. The technology's degree of financial risk.

2.6. Intellectual Property Determinants

Many companies strive to have a first mover advantage in a specific technological field (where a prior claim to the technology does not exist), to get an early mover advantage in an emerging technology and new markets, and the opportunity to establish an unchallenged and a dominant market share.

A patent will help the competitive advantage of the intellectual property by restricting and excluding unauthorized entities from the protected technology, and help recover returns from the research and development when commercializing a new technology.

Shane (2002) examined the influence of patent effectiveness on the licensing and commercialization using historical data of 1,397 MIT patents between 1980- 1996. This empirical study provided a conceptual framework to explain which university inventions are most likely to be licensed, commercialized, and generates royalties, and who will undertake that commercialization using historical data, a regression model was built to predict licensing rate, licensing termination, commercialization and first sale, effectiveness of the patent, source of funding, and the technology field. This study concluded that university patents are more likely to be licensed when patents are effective, the effectiveness of patents increases royalties earned when inventions licensed to non inventors, and licensing back to inventors increasing the likelihood of license termination, and reduces the likelihood of invention commercialization. In addition, Shane found that five key determinants played an important role on whether a new invention will be commercialized by a startup:

- Observability,
- Tacitness of knowledge in use,
- The age of the field
- Tendency of the market toward segmentation,
- And the effectiveness of the patent.

Intellectual property surveys by McGavock, Haas, and Patin (1992), and Degnan, Horton (1997) were both in agreement and have determined the following important intellectual property determinants:

- Patentability of the Intellectual property,
- Exclusivity,
- Utility over old methods, and
- Commercial success.

The U.S. Courts; in a landmark case listed several important factors in the evaluation of reasonable royalty rates for technology licensing (*Georgia –Pacific vs. U.S. Plywood Corp, subsequently modified in Honeywell v. Minolta*):

- The Nature and scope of the intellectual property,
- The strategic needs and fit,
- The involved risks,
- The stage of development,
- The level of innovation,
- Alternatives methods,
- The degree of competition and availability of alternative technologies,
- The market potential,
- The strength of the license and the exclusivity of rights.
- Comparable License rates

From the literature review, the intellectual property related determinants and their relevant criteria could be summarized as:

1. Literature search completed, and clean
2. Patent search completed, clear and clean
3. Technology remain confidential (no oral or written disclosures)
4. No prior claims to technology
5. Strength of Intellectual Property
6. Exclusivity of Intellectual Property

2.7. Summary

In this chapter, theoretical research, empirical analysis studies, a court landmark case, and surveys undertaken by academia, stakeholders, and the court system, have identified several determinants and related criteria that are crucial to the successful licensing of university intellectual properties and technologies. These determinants were used to develop a questionnaire and survey the target sample (see chapter 3) to determine their relative importance to the licensing decision making process to create a benchmark/framework which can be used as a decision support system to assist will help guide the university the technology transfer office personnel, licensing executives, and investors assess and predict the likelihood of the potential viability of the university technologies for licensing and commercialization.

<u>University's Institutional determinants</u>

1- Licensing Policies

2- Technology Transfer office effectiveness

3- Institutional Prestige influence

Inventor's related determinants:

4- Inventor Involvement & cooperation as a team player

5- Inventor is a technology leader

6- Inventor credibility in the field

7- Inventor has realistic expectations

8- Incentives to inventor

Technology Determinants

9- Nature and sophistication of technology (high or low tech.)

10- Scope of technology (Future uses)

11- Technology uniqueness and superiority

12- Technology perceived to have significant, and identifiable benefits and advantages by the user

13- Technology perceived to have quantifiable benefits and advantages by the user compared to current competing products

14- Technology perceived to have sustainable competitive advantages & superiority by the user

15- Technology development time to market

16- Stage of development of technology

17- Barriers to entry

18- New and non obvious technology

19- Availability of a functioning Prototype

20- Technical feasibility (technical problems are solvable)

21- Technology's degree of dependability on other necessary technologies.

22- Technology's degree of compatibility to other necessary technologies.

23- Quantifiable and identifiable technological Risks and weaknesses

Market Analysis and Commercialization Determinants

24- Identifiable current Market needs

25- Absence of a dominant player/ competitor

26- Large definable potential market

27- Market growth anticipation

28- Market trend

29- Time to reach target market penetration

30- Market accessible (no dominant technology)

31- Competitive pricing

32- Reasonable probability of market success

33- First to Market (early mover)

34- Research and Development necessary to reach product development

35- Expected payoff period

36- Expected positive return on investment within a specified period

37- Low financial risk

Intellectual property determinants and related criteria

38- Literature search completed, and clean

39- Patent search completed, clear and clean

40- Technology remain confidential (no oral or written disclosures)

41- No prior claims to technology

42- Strength of Intellectual Property

43- Exclusivity of Intellectual Property

CHAPTER 3: RESEARCH METHODOLOGY

This chapter describes the techniques used and the planned research methodology. It also discusses the measures, data collection, and the analysis process of the survey questionnaire to determine the importance and weights of each of the licensing determinants identified in the literature review. Also this chapter describes the development of a multivariate framework model to be used as a decision support tool in the university intellectual property licensing assessment process.

3.1. Introduction

In an ever changing world that is impacted by daily technological advances, managers understand that their organization's future will be shaped by today's decision, and those decisions must be based on extensions of today's knowledge (Porter et al, 1991). So it is essential that we explore the available techniques and tools to determine the best course of action. This survey research will be divided into four steps[55]:

- Planning and survey design
- Data collection
- Data management and analysis methods
- Modeling and deployment

[55] "The how's and why's of survey research: GETTING THE MOST VALUE THROUGH AN EFFECTIVE SURVEY RESEARCH PROCESS. SPSS technical report HMVSWP-1203.

3.2. The Planning and Survey Design

3.2.1. Survey Goals and Objectives

As described in the previous chapter, the objectives of this research are to:

- Identify the decision factors and determinants that influence or impact the licensing and commercialization of university technology;
- Build and conduct a survey among those professionals involved in the technology licensing process to determine the relative importance of each of the licensing determinants identified in the literature review, and their current and up to date selection criteria for technologies they license; and
- Develop a framework or benchmark that can assist the university technology management & transfer office personnel and other stakeholders in the assessment of the potential viability of the university technologies[56] for licensing and commercialization.

The following steps were taken to accomplish the objectives of this research.

3.2.2. Survey's Population

The survey's population and target respondents are members of the Licensing Executives Society (LES), an international professional society with eleven thousands worldwide members engaged in the transfer, use, development, manufacturing and marketing of intellectual property. The LES membership includes a wide range of

[56] The interest of this research is in the licensing issues and their determinants in general, and not in any specific area, sector, or disciplines.

professionals, including business executives, lawyers, licensing consultants, engineers, academicians, university and corporate licensing professionals, scientists, government officials, and students.

For the purpose of this research, the target respondents will be limited to the corporate licensing professionals of the USA Chapter, with membership mixture of corporate licensing executives, consultants, venture capitalists, and some angel investors as these groups can give a good and up to date representation of the technology licensing trends and processes.

3.3. Method of Data Collection

A web-based survey questionnaire was used to elicit data from those designated licensing professionals whose firms' activities are engaged in licensing-in university technologies, as this is a low cost survey method, with faster transmission time, rapid response, and an effective method to collect information regarding their expertise and opinions about their technology licensing selection criteria. The findings from the survey questionnaires can then be generalized to the larger population the sample is supposed to represent (Gall, Borg, & Gall, 1996). The questionnaire were designed and constructed in a straightforward easy to understand instructions to minimize the measurement error and to reduce non-response rate.

The respondents will be asked to specify the existence or lack there of, and the level of importance for each of the determinants identified in the literature review as influential in the licensing of the intellectual property. This will be accomplished using a

5 points Likert scale design, and questions with dichotomous outcome as shown in the questions sample below (see figures 4 and 5). Also, to understand why and how the respondents make decisions on whether to license or not to license specific technologies, the respondents will be asked to assign a grade for each determinant for two different scenarios. The first involving a technology where the licensing process was a success (licensed), while the second involved another technology where the licensing process was a failure (did not license).

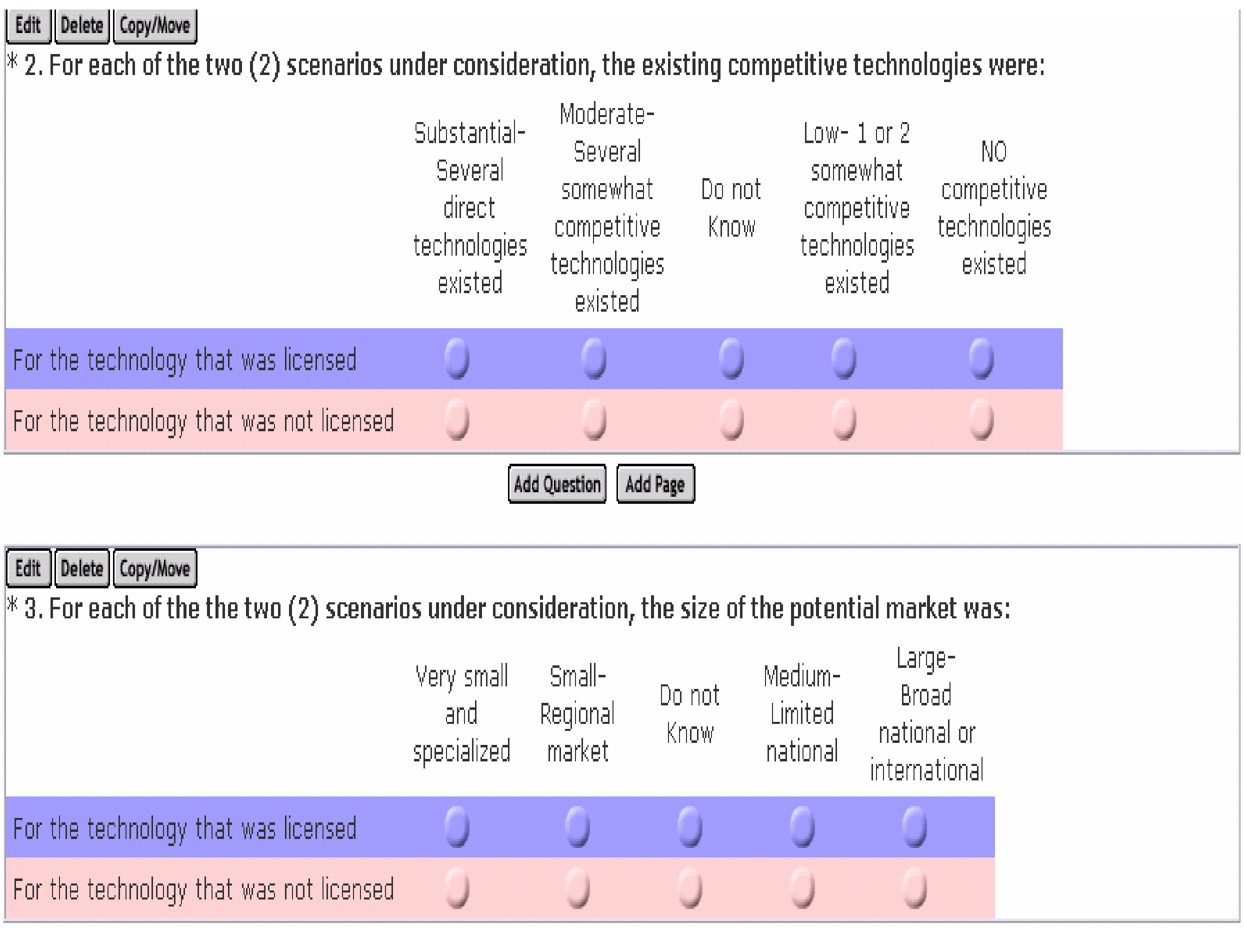

Figure 4-A Five Points Likert Scale Design Questions

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* 25. The technology assessment showed that for the technology that was licensed:

	Agree	Disagree
No dominant technology existed yet in the field	○	○
Had an early mover advantage	○	○
The inventor was involved and willing to cooperate	○	○
Technology was perceived to have quatifiable benefits	○	○
The Inventor was perceived to be a technology leader	○	○
Inventor has credibility in the field	○	○
Inventor had realistic expectations about the technology	○	○
Inventor was a stakeholder	○	○
The technology was perceived to have quantifiable benefits	○	○
The technology has sustainable competitive advantages	○	○
The technology was new and non-obvious	○	○
The technology's literature search was complete and clean	○	○
The technology's patent search was clean and clear	○	○
The technology was still confidential (no past or future disclosures)	○	○
The technology had no prior claims	○	○

Figure 5- Sample Questions with Dichotomous Outcomes

To gain a better understanding of the breadth of the respondents expertise, and of the industry they are associated with, the survey will have demographic questions about the respondents, their positions, their employers, their industry classifications, their level of involvement in the licensing process, and their industry of expertise.

The collected data will then be divided into experimental and validation data sets. The first will be used to develop the framework model for the intended application, while the second set will be used to validate this framework to assure reliability.

3.4. Data management and Analysis methods

The goal of the analysis is to use the survey responses as a set of predictors, to correctly predict the category of the outcome (licensed / not licensed). The first step is to collect, verify, code the responses, and then export them in a structured form into analytical software for processing to establish that there is a relationship between the outcome and the set of predictors. If a relationship is found, the model will then be simplified by eliminating some predictors while still maintaining strong prediction. Once the reduced set is found, the model can be used to predict outcomes for new cases on a probabilistic basis.[57]

However we also need to evaluate the validity and reliability of the survey measurements or observations to determine if we are measuring what we intend to measure, and whether the same measurement process will yield the same results.

Validity refers to the extent to which a test measures what we think we are measuring. A valid measure should satisfy the following four criteria:

1. Face Validity: This is an assessment of whether a measure, on the face of it, appears to measure the intended concept.
2. Content Validity: The content validity of an instrument is the extent to which it provides adequate coverage of all facets of a concept.
3. Construct validity: Refers to the judgment about the appropriateness of inferences that are drawn from a survey scores regarding individual standings on certain kinds of variables or constructs (Yin, 1994).

[57] Tabashnick, B.G., and Fidell, L.S. (2001). Using Multivariate Statistics 4th ed. Boston, Allyn and Bacon

4. Criterion-Related Validity: reflects the success of measures used for prediction or estimation.

Reliability refers to precision accuracy and consistency where measurement processes yield consistent responses when repeated at different times. Measures of high reliability exhibit the following criteria:

1. Stability: When consistent results are achieved by administering the same test to the same subjects twice over an interval of less than six month (Test-Retest reliability).
2. Internal consistency: Is the degree to which instrument items are homogeneous and reflect the same underlying construct. Techniques used for this type of reliability are the split-half, the Kuder-Richardson, and the Cronbach's Alpha.
3. Equivalence: This type of reliability is concerned with variations at one point in time among observers and samples of items.

3.4.1. Logistic Regression Analysis

The logistic regression is a statistical technique similar to multiple linear regressions in that it analyzes the relationship between multiple independent variables and a single dependent variable, and yields a predictive equation. Further, it is used as an estimator for categorical dichotomous binary coded dependent variables that takes only two values (0 or 1, success/failure), and produces a meaningful predicted probabilities by assuring that the predicted values do not break the laws of probability[58].

The logistic regression was used to classify cases with respect to the categorical dependent variable, thereby providing a mechanism for evaluating the success of the model. If the probability of an event is greater than a pre-determined cut-off value for example 0.50, the case is classified as a positive (1, success) case, otherwise it is negative or unacceptable (0, failure). The logistic regression is based on the assumption that the underlying relationship among the variables can be represented as an S-shaped probabilistic function (see figure 6).

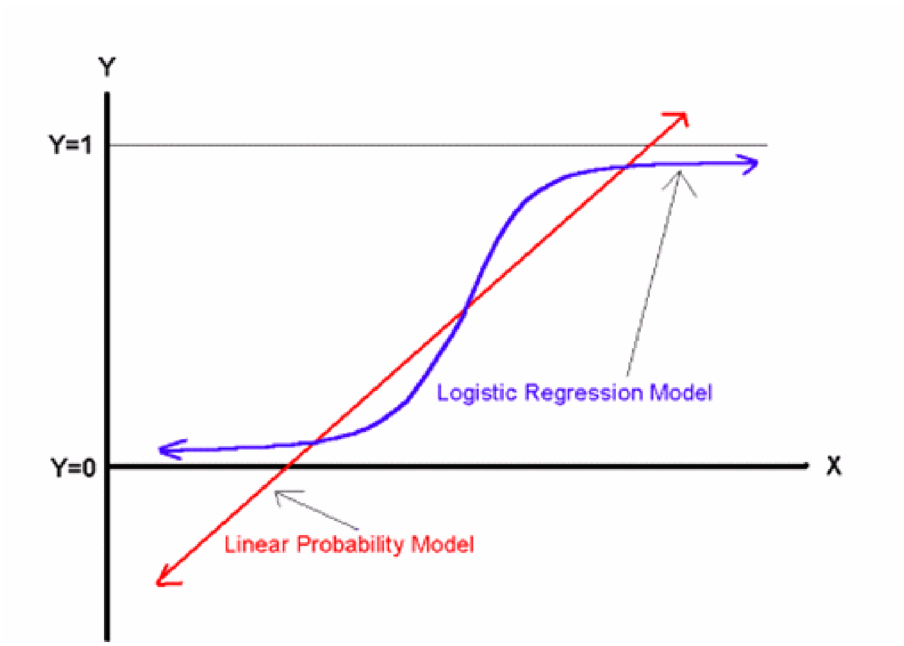

Figure 6- The logistic and the Linear Regression Models

[58] When the response variable is binary, or a binomial proportion, the response is bounded between 0 and 1 that is $0 \le E(Y_i / X_i) = \pi_i \le 1$.

The logistic regression is relatively free of restrictions, has no assumptions[59] about the distributions of the predictor variables (such as multivariate normality) or the homoscedasticity (or equal variances), and can be any mix of continuous, discrete and dichotomous variables. “The estimation of parameters is based on the maximum likelihood estimation method which finds estimates of the model parameters that are most likely to give rise to the pattern of observations in the sample data” (Pample 2000).

The dependent variable is then transformed to the natural log of the odds, called “logit” (short for logistic probability unit), and ranges from minus to plus infinity. The maximum likelihood is then used to estimate the coefficients of the independent variables, with the logit as a continuous dependent variable. The logistic regression model can be written as:

$$\text{Ln}\left[\frac{\Pr ob(event)}{\Pr ob(no\_event)}\right] = b_0+b_1X_1+\ldots\ldots+B_k X_k$$

Where b_0= constant

K= number of independent variables

B_1 to b_k = coefficient estimated by the data

X_1 to X_k= values of the k independent variables.

Further simplification yield to the probability of an event leads to

$$\Pr obability(event) = \pi_j = \frac{e^{bo+b1x1+....+bk\,xk}}{1+e^{e^{bo+b1x1+....+bk\,xk}}}$$

Where e=the base of natural logarithms (approximately 2.7183).

[59] The predictors do not have to be normally distributed, linearly dependent, of or equal variance within each group.

3.4.1.1. Associated Statistics and Significance Tests in Logistic Regression

Several statistics are available for assessing the performance of a logistic regression. The likelihood index is the probability of the observed results, given the parameters estimated by the analysis. If the model fits perfectly, the likelihood is 1.00. However, since the likelihood is always a small number, the index is transformed by multiplying it by -2 the log of the likelihood (-2LL) where a small index number refers to good fit for the model; while the model is considered to be perfect when the -2LL is zero. A chi-square is also used to test the null hypothesis that all the b_0 to b_k coefficients are zero. The chi-square value is derived by computing the difference between -2LL for the model with only the constant term and -2LL for the model being tested to determine its significance. The Wald statistic defined as the square of the ratio of the coefficient divided by its standard error and has a chi distribution, is used to assess the significance of individual predictor variables in the logistic model.

3.5. Data Modeling and Deployment

Once the data has been analyzed a valid computer model will then be presented in the form of regression equation, with regression coefficients associated with each significant predictor. An assessment questionnaire including only those significant variables will then be devised and its answers will be used in the regression model to test, validate, classify, and predict the university technology in question as potential success or failure.

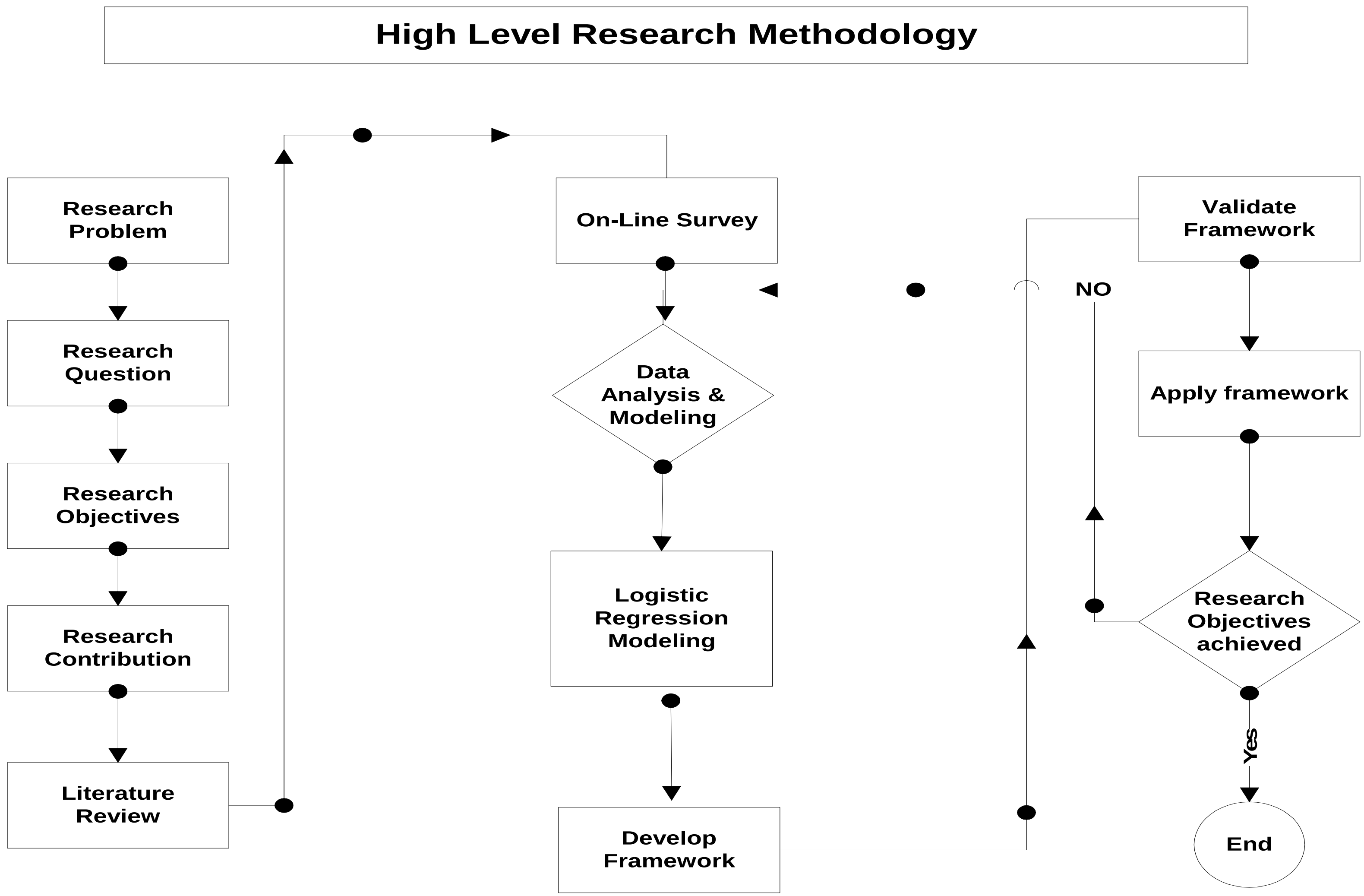

Figure 7- High level Research Methodology

CHAPTER 4: RESULTS

4.1. Introduction

The primary focus of this research was to provide an answer to the following research question:

"Can we develop a repeatable process, or a framework that takes advantage of the research's findings and use it as an assessment tool to provide insights into the University Technology Transfer and Licensing Office's personnel, to predict the likelihood and viability of the licensing and commercialization of the university's technologies and research discoveries?

To achieve the objectives of this research, the literature review process (chapter 2) identified forty three variables (determinants) that influence or impact the licensing and commercialization of university technologies. These determinants were used to build and conduct a web-based survey (see appendix A) among the corporate professional members of the Licensing Executive Society to determine the relative importance of each of theses licensing determinants, and to also determine the current and most up to date technology licensing selection criteria applied that these licensing professionals.

An email invitation to participate in the survey, was sent to 1,583 corporate licensing professionals as classified by the Licensing Executives Society's membership list. One hundred fifty five (155 about 10%) started the survey, however only 108 responses (about 7%) were completed and were used in the analysis.

4.2. Survey Analysis

The survey showed that the respondents are actively involved in the licensing process in different technology related fields, with the majority from companies with health and biotech related business application focus (see figure 8).

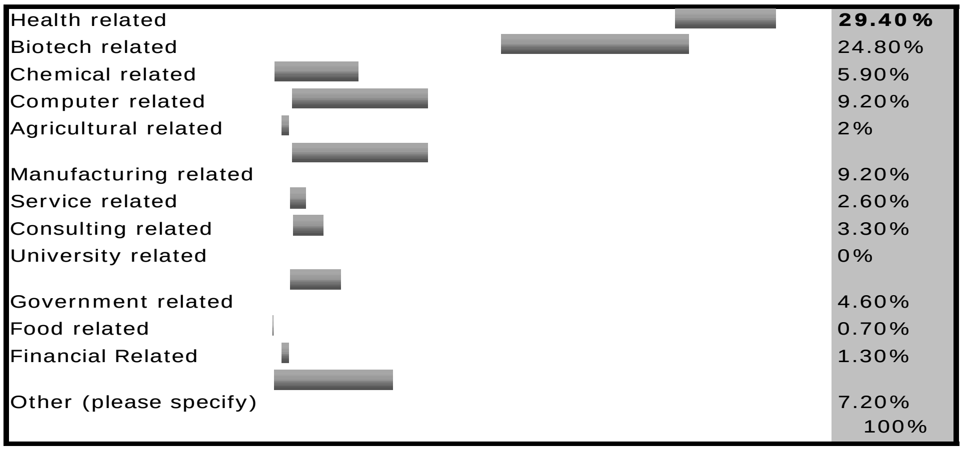

Figure 8- Respondents Companies' Main Business Application Focus

The majority of the respondents classified their employers (Appendix D) as either large with more than 5000 employees (45.5%) or small with less than 100 (26.6%) with the rest employed by medium size companies (see figure 9).

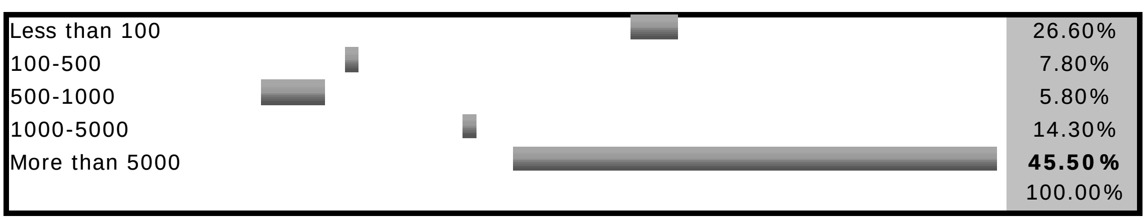

Figure 9- Number of Employees at the Respondents' Companies

Yearly sales for the respondents' companies were widely spread with the majority (51%) exceeding one billion dollars and about 12.4% not exceeding a million dollars (see figure 10).

This distribution should give us a credible and a good representation of the technology licensing market.

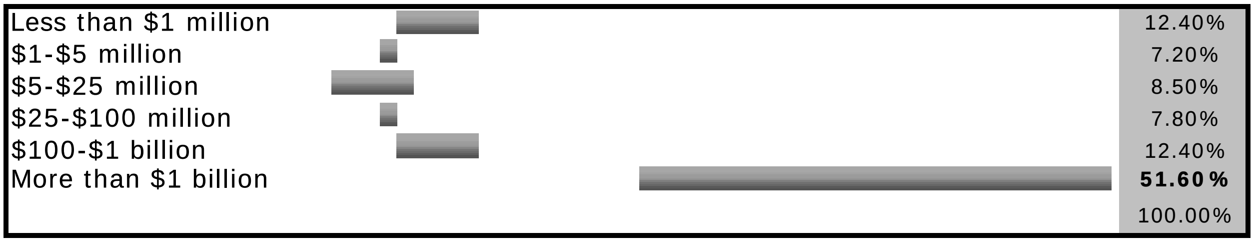

Figure 10- Respondents' Employers Yearly Revenues

As to the respondents' positions in their companies, the survey has shown (see figure 11) that the majority (about 83%) are decision makers in either in a top or middle management position, and are clearly aware of their employers licensing practices and policies. Hence we can safely assume that their replies are credible and representatives of their peers.

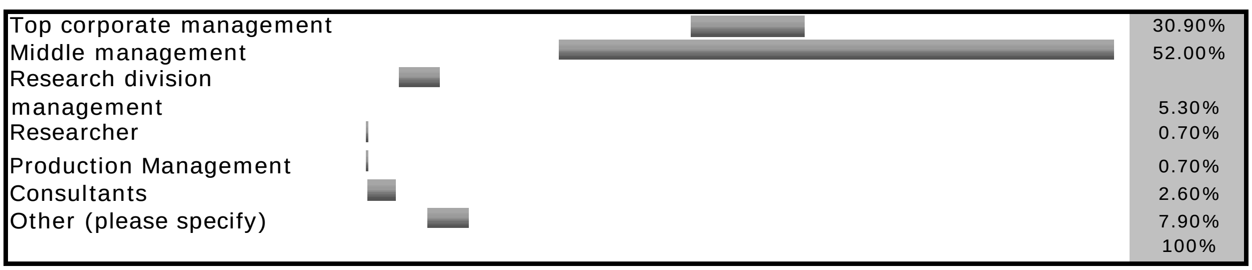

Figure 11- Respondents' Positions at their Companies

4.2.1. Reliability, and Content Validity of the Survey

The two constructs in the survey involved questions related to two technologies that the respondents or their teams assessed and decided to license the first and to reject the second. The Cronbach's coefficient alpha was used to judge the reliability and the internal consistency or homogeneity among each of the constructs' items. The survey data was exported to analytical software (SPSS V12.0) and the reliability of each construct were determined to be at an acceptable level (Cronbach's alpha > 0.8) as shown in figure 12.

Reliability Statistics

Outcome	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0	.816	.781	40
1	.833	.837	40

Figure 12- Reliability Statistics

The reliability of the constructs was also tested by removing the variables (one at a time) from the analysis. The reliability of each of the constructs was also acceptable as the value of the Cronbach's alpha was at or above the 0.8 (figure 13). Hence we can fairly assume that the survey instrument is reliable.

As a measure of content validity, the survey instrument provided adequate coverage of the most important elements (licensing determinants) of the technology licensing process as defined by the experts in the field. Thus we can assume that the content of the survey have already been validated.

Outcome		Cronbach's Alpha if Item Deleted	Outcome		Cronbach's Alpha if Item Deleted
0	Scope	0.818	1	Scope	0.830
	Uniqueness	0.805		Uniqueness	0.826
	Barriers	0.810		Barriers	0.830
	Stage	0.810		Stage	0.836
	RD	0.818		RD	0.836
	Nature	0.807		Nature	0.825
	Feasibility of Production	0.812		Feasibility of Production	0.826
	Alteration	0.804		Alteration	0.823
	Safety & Risks	0.808		Safety & Risks	0.825
	Assessment	0.814		Assessment	0.832
	Market needs	0.809		Market needs	0.830
	Competition	0.814		Competition	0.824
	Market size	0.803		Market size	0.824
	Market Growth rate	0.799		Market Growth rate	0.823
	Demend Trend	0.801		Demend Trend	0.822
	Odds of Success	0.807		Odds of Success	0.826
	Dependibility	0.806		Dependibility	0.823
	Time Market Pen	0.807		Time Market Pen	0.826
	Payback	0.806		Payback	0.823
	Time for ROR	0.808		Time for ROR	0.825
	Capital	0.810		Capital	0.830
	Dev time	0.810		Dev time	0.827
	IP Strength	0.808		IP Strength	0.826
	No dominant technology	0.816		No dominant technology	0.832
	Early mover	0.817		Early mover	0.832
	INV Involved	0.815		INV Involved	0.833
	Quant Benefits	0.819		Quant Benefits	0.831
	INV Tech leader	0.816		INV Tech leader	0.832
	INV credibility	0.817		INV credibility	0.833
	Inv Realistic	0.818		Inv Realistic	0.835
	INV Stake	0.815		INV Stake	0.831
	Quanlifiable benefits	0.819		Quanlifiable benefits	0.831
	Sustainable advantages	0.818		Sustainable advantages	0.833
	New- non-obvious	0.817		New- non-obvious	0.832
	Lit clean	0.817		Lit clean	0.833
	Pats clean and clear	0.817		Pats clean and clear	0.833
	Confidentiality	0.813		Confidentiality	0.831
	No prior claims	0.817		No prior claims	0.833
	Prototype	0.816		Prototype	0.831
	Exclusivity	0.811		Exclusivity	0.830

Figure 13- Cronbach's Alpha if Item Deleted

To determine the characteristics of a licensable technology, and to understand the reasons of why some technologies get licensed while many others do not, the survey asked the target respondents to evaluate two different technologies under two different scenarios using the licensing determinants identified in the literature review. The first involving a technology that the respondent or his team evaluated and decided to license, and the second involving a technology that was evaluated but was not licensed.

The classifications of the respondents concerning both the licensed and the unlicensed technologies are summarized in tables 4 and 5, where in table 4 the respondents classified some of the variables (licensing determinants) on a 1 to 5 scale, while in table 5 they either agreed or disagreed with a statement concerning some other variables.

Table 3- Respondents' Licensing Determinants Classifications (1 to 5 Scale) of the Licensed and Unlicensed Technologies (percent)

	Licensed Technology Respondents' Classifications						Unlicensed Technology Respondents' Classifications					
	<1>	<2>	<3>	<4>	<5>	Average	<1>	<2>	<3>	<4>	<5>	Average
Scope	15%	29%	24%	18%	14%	2.85	28%	30%	25%	11%	5%	2.35
Uniqueness	1%	5%	22%	54%	19%	3.85	10%	25%	40%	17%	7%	2.86
Barries	1%	15%	39%	44%	1%	3.29	3%	25%	32%	36%	5%	3.15
Dev-Satge	5%	21%	29%	32%	13%	3.28	18%	39%	26%	8%	8%	2.49
R&D complexity	6%	18%	32%	28%	15%	3.27	5%	9%	36%	32%	18%	3.5
Nature and sophistication	3%	9%	39%	36%	13%	3.47	8%	15%	49%	20%	8%	3.06
Tech Feasibility (Production)	0%	12%	41%	34%	13%	3.48	6%	35%	42%	11%	6%	2.78
Alteration on other tech	1%	6%	32%	34%	27%	3.79	10%	31%	33%	14%	12%	2.86
Safety & Risks	2%	1%	17%	40%	40%	4.17	4%	4%	31%	36%	26%	3.76
Claims Assessment	3%	6%	14%	13%	64%	4.29	8%	26%	25%	25%	17%	
Market Needs	0%	3%	13%	45%	40%	4.21	0%	19%	45%	22%	15%	3.33
Existing Competition	2%	17%	42%	32%	7%	3.24	6%	18%	51%	21%	4%	2.99
Size of Potential Market	0%	6%	16%	45%	34%	4.07	1%	22%	41%	26%	11%	3.24
Expected Market Growth	0%	2%	23%	49%	26%	3.99	4%	19%	44%	22%	12%	3.19
Expected Demand Trend	0%	5%	17%	55%	22%	3.95	3%	21%	41%	25%	11%	3.2
Odds of Market Success	0%	7%	29%	37%	27%	3.84	9%	37%	42%	6%	7%	2.65
Dependebility on other techs	1%	14%	36%	35%	15%	3.49	6%	25%	48%	16%	6%	2.91
Expected Time for Market Penetration	1%	10%	26%	54%	9%	3.6	8%	26%	46%	17%	4%	2.83
Time to reach Payback	1%	9%	38%	45%	8%	3.5	8%	34%	46%	10%	3%	2.66
Time for ROR	2%	6%	45%	42%	6%	3.44	10%	35%	41%	12%	3%	2.63
Capital	0%	13%	37%	38%	13%	3.5	16%	30%	34%	17%	4%	2.63
Tech Dev Time to reach market	2%	6%	45%	42%	6%	3.44	7%	38%	37%	13%	6%	2.73

Table 4-Respondents' Licensing Determinants Classifications of the Licensed and Unlicensed Technologies

	Licensed Technology		Unlicensed Technology	
	Agree	Disagree	Agree	Disagree
No dominant technology existed yet in the field	59%	41%	41%	59%
Early mover advantage	61%	39%	38%	62%
Inventor Involved	86%	14%	72%	28%
Quantifiable benefits	97%	3%	73%	27%
Inventor a technology leader	64%	36%	54%	46%
Inventor credible	79%	21%	64%	36%
Inventor realistic	71%	29%	43%	57%
Inventor Stakeholder	60%	40%	53%	47%
Inventor crucial to success	47%	53%	38%	62%
Quanlifiable benefits	96%	4%	80%	20%
Sustainable competitive advantages	87%	13%	56%	44%
New and non-obvious	82%	18%	60%	40%
Literature search was complete and clean	68%	32%	57%	43%
Patent search was clean and clear	68%	32%	55%	45%
Confidentiality	51%	49%	58%	42%
No prior claims	71%	29%	53%	47%
A functioning prototype	73%	27%	48%	52%
License Exclusive or some restrictions	45%	55%	41.60%	58%

To determine how the licensed and the unlicensed technologies compared to each other (see figures 12 to 33), the respondents' classifications for both technologies were plotted on the same graphs. For example, looking at the variable "Scope" graph (Figure 12 on the next page), we can see that 18% of the respondents classified (or graded) the scope of a licensed technology as a 4 (with 5 being a maximum), while 14% classified it as a category 5. On the other hand only 11% of the respondents classified the scope of the unlicensed technology as a 4 category and only 5% classified as a category 5, leading us to believe that licensed technologies in general have a wider scope. The same explanations hold for the rest of the variables which shows that licensed technologies tend to score better than the unlicensed technologies with respect to every licensing determinant; hence they are more appealing to the licensees. However please note that in some graphs such as R&D complexity a lower classification is better.

Legend: Blue = Licensed Technology   Red= Unlicensed Technology

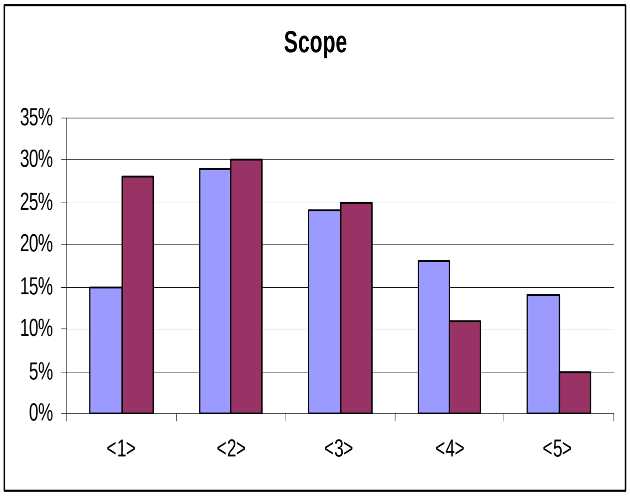

Figure 14-The Scope Variable

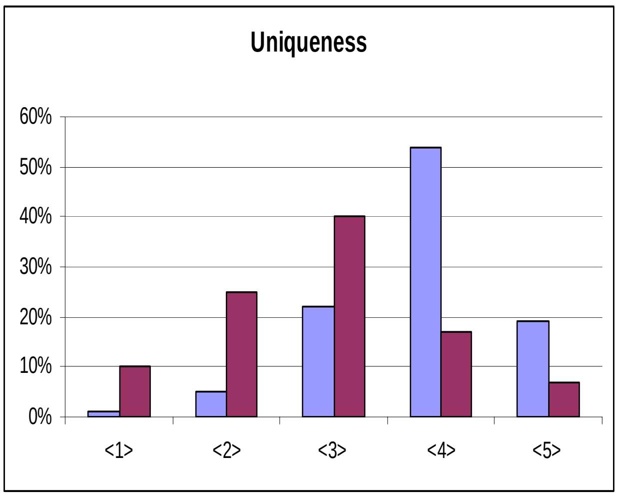

Figure 15-The Uniqueness Variable

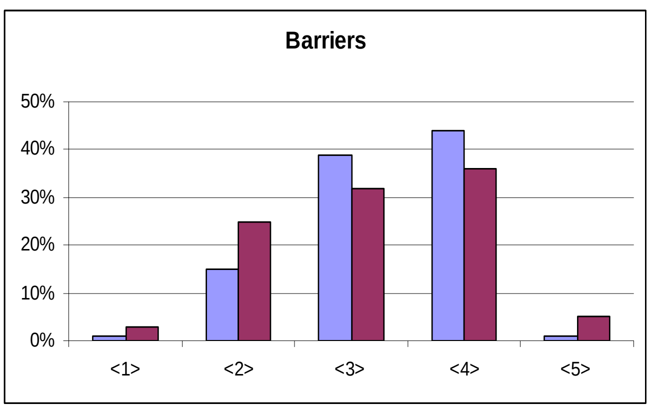

Figure 16- The Barriers Variable

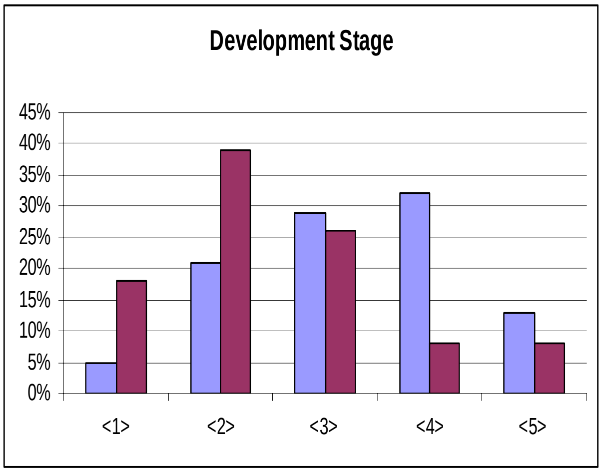

Figure 17-The Dev-Stage Variable

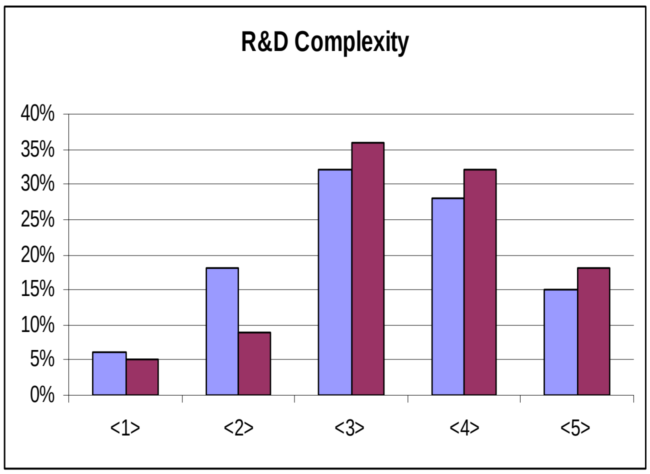

Figure 18-The R&D Classification Variable

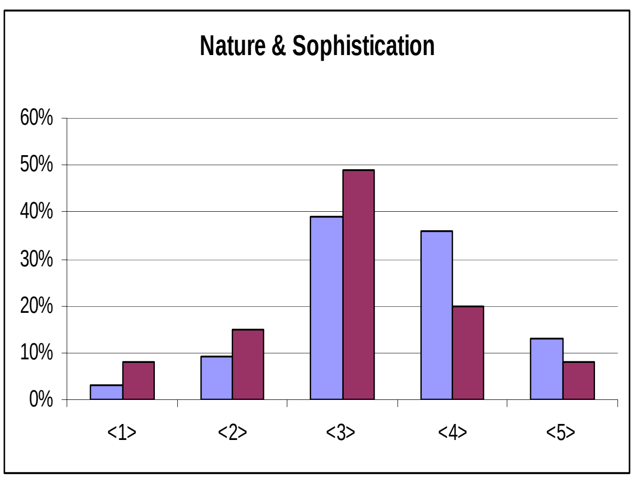

Figure 19-The Nature & Sophistication Variable

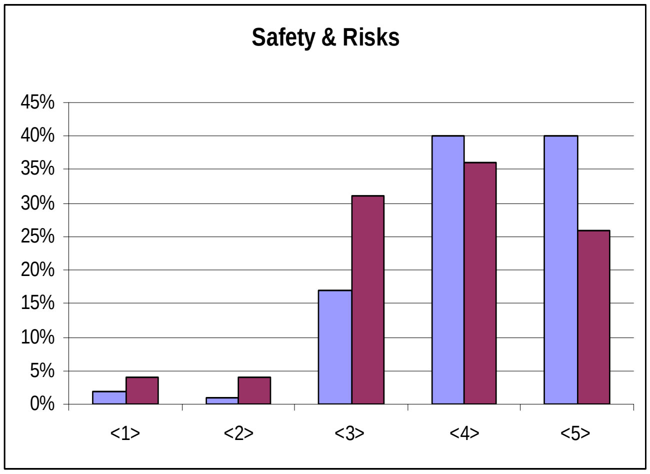

Figure 20- The Safety &Risks Variable

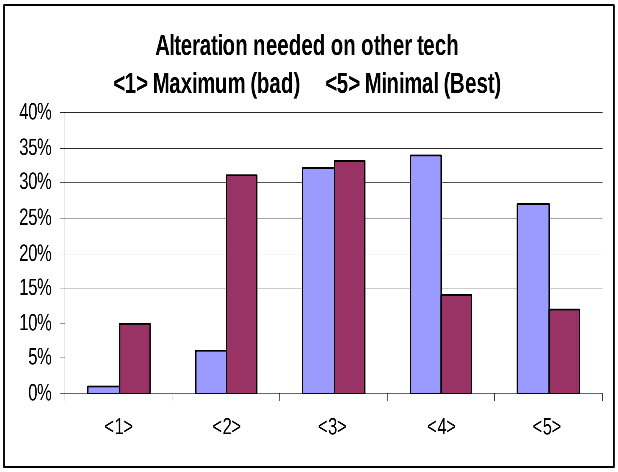

Figure 21- The Alteration Variable

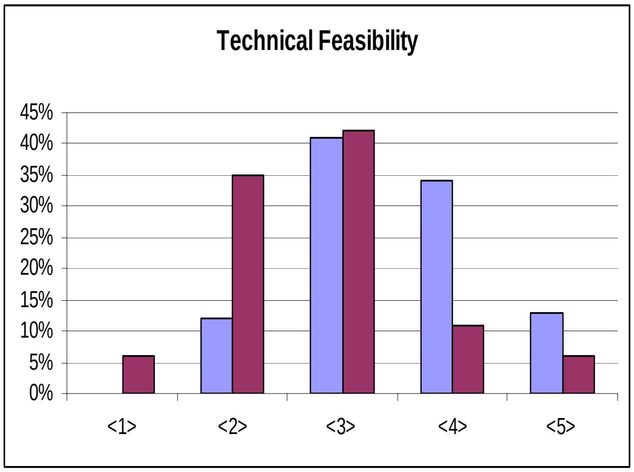

Figure 22-The Technical Feasibility Variable

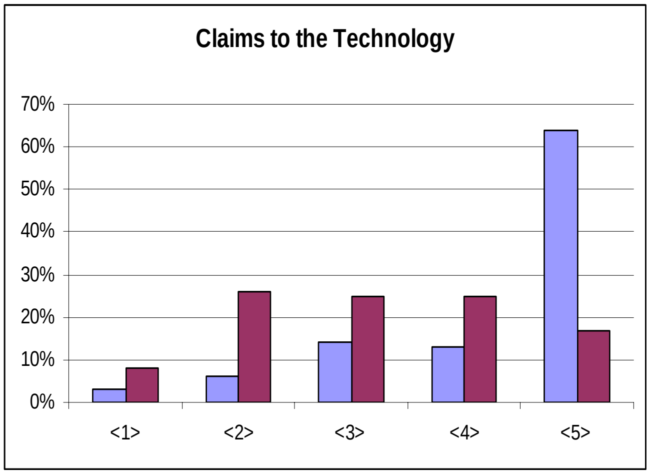

Figure 23-The claims to the Technology Variable

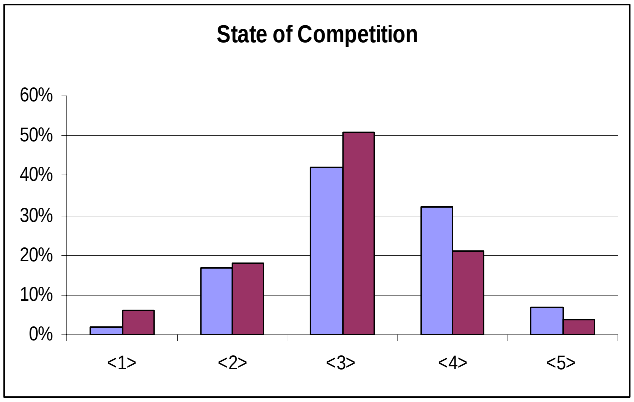

Figure 24- The State of the Competition Variable

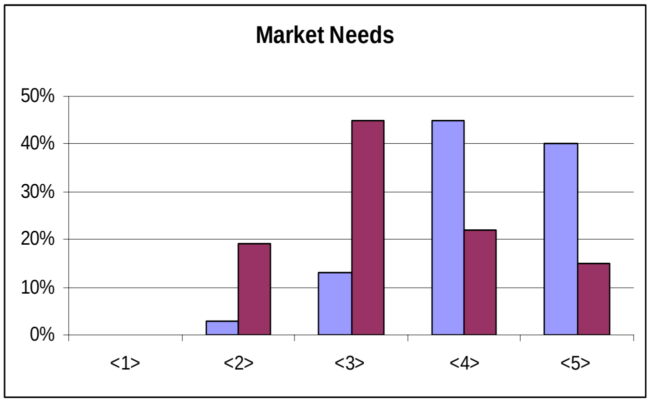

Figure 25- The Market Needs Variable

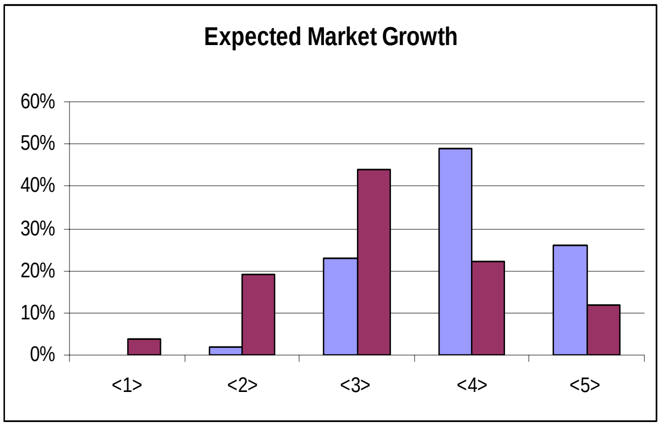

Figure 26-The Expected Growth Variable

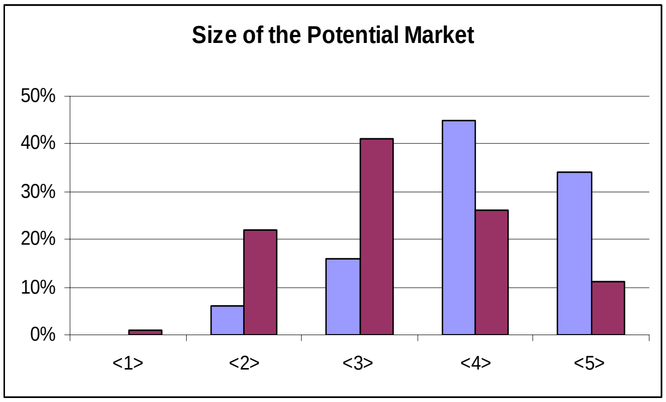

Figure 27-The Size of Potential Market Variable

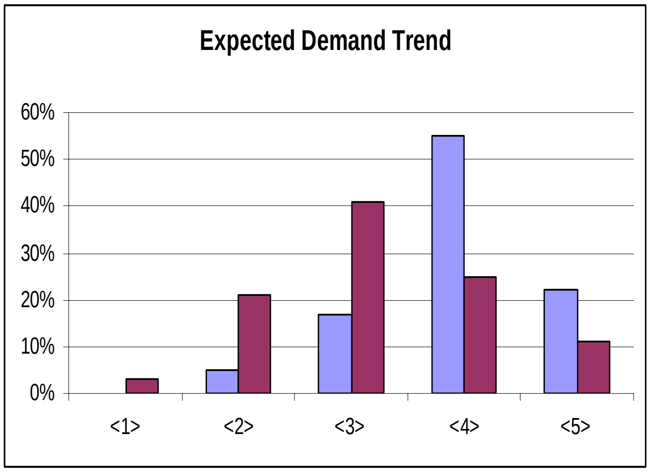

Figure 28- The Expected Demand Variable

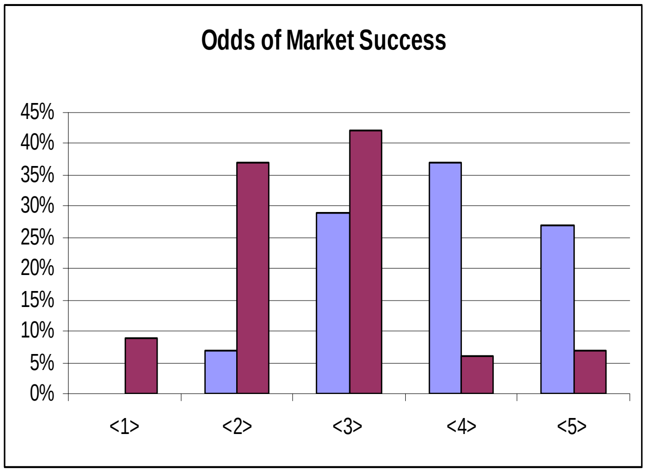

Figure 29-The Odds of Market Success Variable

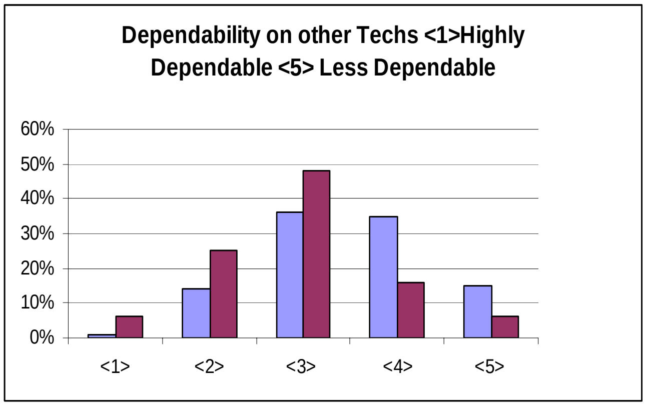

Figure 30- The Dependability Variable

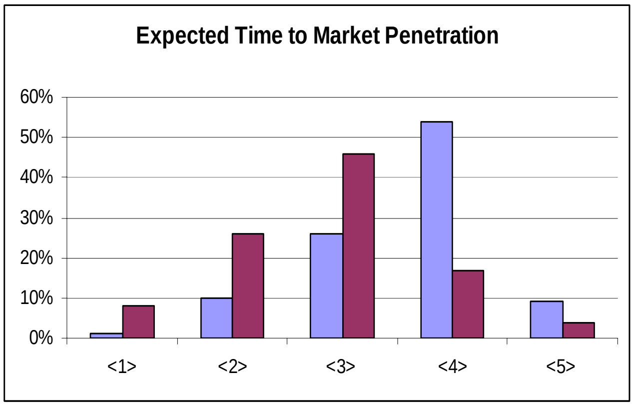

Figure 31-The Time to Market Penetration Variable

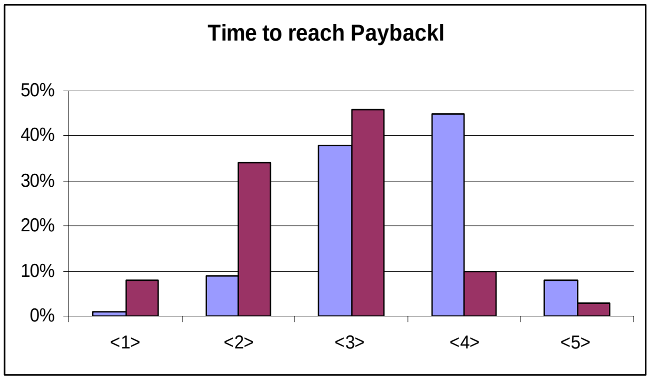

Figure 32- The Time to Reach Payback Variable

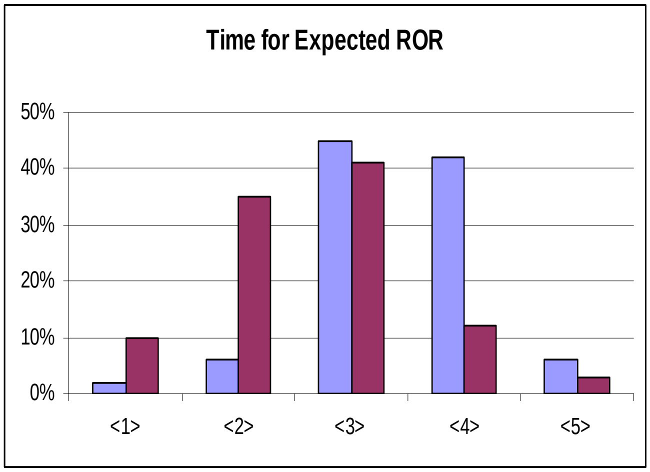

Figure 33-Time to Reach Expected ROR Variable

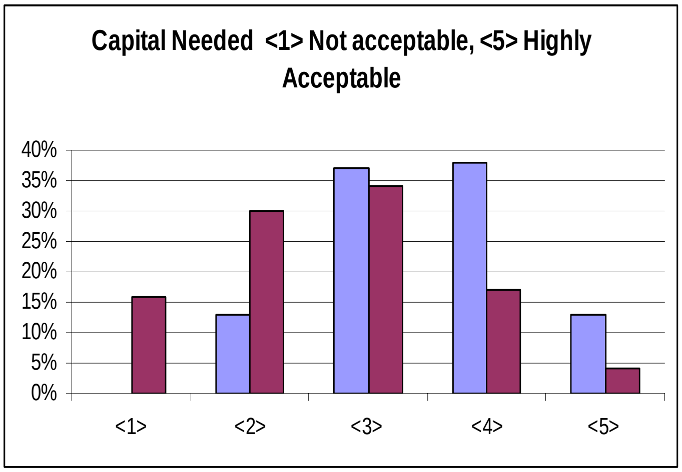

Figure 34- The Needed Capital Variable

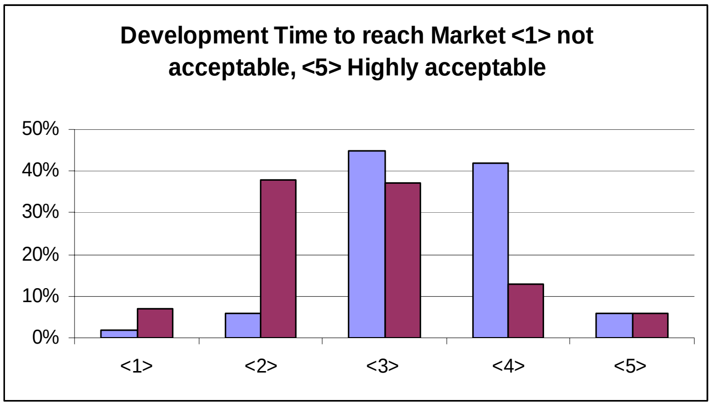

Figure 35- The Dev-Time to Reach Market Variable

Table 5 provides a summary of some of the attributes of both the licensed and the unlicensed technologies, for example figure 34 (next page) shows that 71% of the licensed technologies had “No claim to the technology” versus only 53% for the unlicensed technology. This clearly shows a trend of superiority of the licensed technologies when compared to other unlicensed technologies.

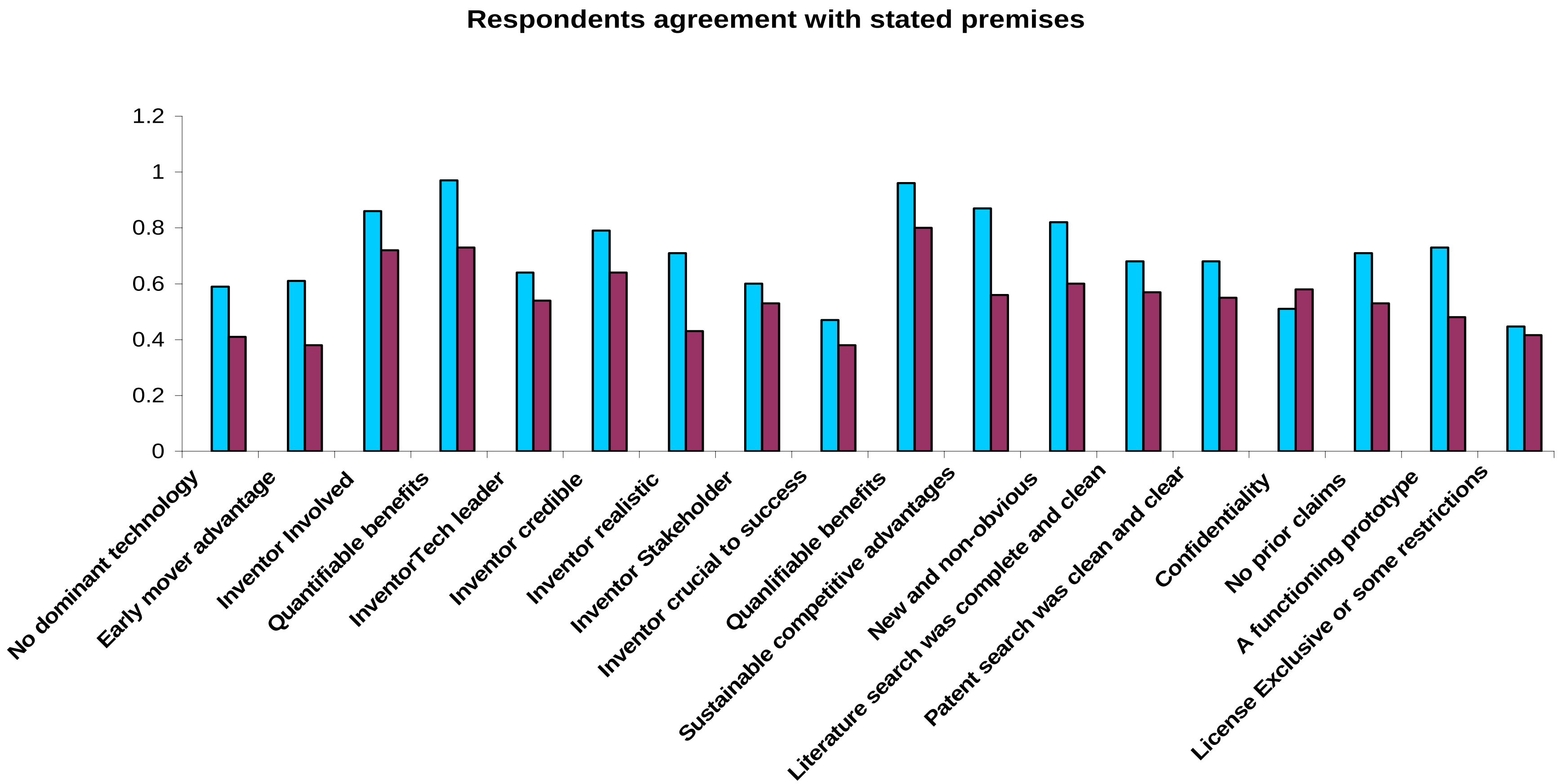

Figure 36- Classifications of Dichotomous (Agree/Disagree) Variables for Licensed (Blue) and Unlicensed (Red) Technologies

4.3. The Computer Model (Framework)

In the survey, the respondents were asked to classify or grade each variable (licensing determinant or predictor) as it pertains to both the licensed and the unlicensed technologies. In addition, the respondents were asked to rate the importance and impact of each of these variables on their licensing decision. A weighted score[61] was then assigned for each variable per respondent by multiplying its rating by the value of its importance and impact. This process was repeated for every respondent and variable.

The data was then exported into an analytical software (SPSS Version 12.0) for processing to establish a relationship between the outcome (Licensed/ Not licensed) and the set of predictors. The logistic regression was used due to the binary (dichotomous) state of the outcome were a one (1) was assigned to the licensed technology, while a zero (0) was assigned to the unlicensed one. The standard logistic regression formula for a multi-variable model is given by the following equation:

$$\Pr obability(event) = \pi_j = \frac{e^{bo+b1x1+....+ bk\, xk}}{1+e^{e^{bo+b1x1+....+ bk\, xk}}}$$

Further simplifications reduced the equation to:

$$\Pr obability(event) = \pi_j = \frac{1}{1+\exp\ (-(b_0+b_1X_1+b_2X_2+...+b_iX_i)}$$

Where b_0 represent the intercept representing the value of the dependent variable, and the b's coefficients represent the change in the dependent variable associated with a unit change in the independent variable.

---

[61] The use of a weighted score per variable per respondent is based on the fact that licensees value the importance of innovations' attributes differently. Although a variable (determinant) may be very important to a licensing decision, its impact on the licensing decision will depend on its importance

The Binary Logistic Regression procedure uses the iterative Maximum Likelihood Estimation (MLE) fitting procedure to find those coefficients that have the greatest likelihood of producing the pattern of the observed data. Initially, a trial estimate of the coefficients are proposed, tested, and then re-estimated until a convergence has been reached. The optimal solution is reached by maximizing the log-likelihood (LL) or minimizing the -2 log-likelihood (-2 LL) function which indicates how probable, how likely, or the odds on how to obtain the observed values of the dependent variable (outcome 0 or 1), given the observed values of the independent variables (determinants) (Menard 1995).

The statistical software (SPSS V12) features an “Automated Variable Selection” with several methods for stepwise selection of the "best" predictors that contribute significantly to the model using either a backward elimination or a forward inclusion stepwise logistic regression. If both methods choose the same variables, we can be fairly confident that it's a good model (SPSS Manual).

In the backward elimination logistic regression, all the independent variables are initially assumed to be a part of the solution, and the insignificant variables that contribute the least are eliminated one at a time at each step, until all of the predictors in the model are significant. On the other hand, the forward inclusion stepwise regression method, starts by assuming that the constant is the only variable in the model, and then only the independent variables deemed significant are added to the model The inclusion or exclusion of an independent variables are based on the likelihood ratio chi-square test (errors are assumed to follow a binomial distribution) which assigns a P value to each variable, where the smaller the P-value the more important the variable is. However the inclusion or exclusion of the independent variables is determined by and based upon P values set by the researcher, and known as $P_{inclusion}$ or $P_{exclusion}$. For our case, the default settings of $P_{inclusion}$ of 0.05, and $P_{exclusion}$ of 0.10 were chosen.

To classify whether the outcome is a success or a failure, a cutoff probability of 0.5 was used (Hosmer and Lemeshow 1989). The data was then exported to SPSS and the forward inclusion regression stepwise method was used and yielded the variables and coefficients listed in table 5 below. These variable were retained in the regression model as they proved be significant to the model (P values<0.05), while those that were eliminated had P values greater than 0.05 (P>0.05).

Variables in the Equation		B	S.E.	Wald	df	**P- Value** Sig.	**Odds** Exp(B)	95.0% C.I.for EXP(B) Lower	Upper
Step 10(j)	Uniqueness	0.152	0.046	11.154	1	0.001	1.165	1.065	1.274
	Assessment	0.116	0.039	9.006	1	0.003	1.123	1.041	1.212
	Odds_of_Success	0.195	0.044	20.003	1	0.000	1.216	1.116	1.325
	Dev_time	0.155	0.047	10.723	1	0.001	1.168	1.064	1.282
	No_dominant_technology	-0.183	0.093	3.861	1	0.049	0.832	0.693	1.000
	INV_Involved	-0.369	0.135	7.491	1	0.006	0.691	0.531	0.901
	Quant_Benefits	-0.579	0.181	10.235	1	0.001	0.560	0.393	0.799
	Confidentiality	0.291	0.109	7.170	1	0.007	1.337	1.081	1.654
	Prototype	-0.217	0.107	4.092	1	0.043	0.805	0.652	0.993
	IP_Strength	-0.135	0.045	8.916	1	0.003	0.874	0.800	0.955
	Constant	-1.658	1.417	1.368	1	0.242	0.191		

a. Variable(s) entered on step 1: Odds_of_Success.
b. Variable(s) entered on step 2: Assessment.
c. Variable(s) entered on step 3: Dev_time.
d. Variable(s) entered on step 4: Quant_Benefits.
e. Variable(s) entered on step 5: Uniqueness.
f. Variable(s) entered on step 6: INV_Involved.
g. Variable(s) entered on step 7: No_dominant_technology.
h. Variable(s) entered on step 8: IP_Strength.
i. Variable(s) entered on step 9: Confidentiality.
j. Variable(s) entered on step 10: Prototype.

Table 5-Variables' Coefficients (B) Using the Forward Stepwise Logistic Regression Method

The logistic regression coefficients denoted as B or are also known as the logit coefficients, are used to construct the prediction equation and generate prediction values.

They are the natural log of the odds ratio defined as the probability of an event divided over the probability of no event. When the odds ratio is above 1.0, the odds of getting a "1" on a dependent dichotomous outcome are greater for the given than the reference category.

The logistic regression model is represented by the equation

$$Probability(event) = \pi j = \frac{e^{bo+b1x1+\ldots+bkxk}}{1+e^{bo+b1x1+\ldots+bkxk}}$$

Where e (Exponential) is the base of natural logarithms (equal approximately 2.7183) and the regression coefficient are as shown in the column named B in table 5, while the variables are shown in the first column (Variables in the equation).

4.4. Statistical Inference

Logistic regression has two types of inferential tests:

- Test of models; and
- Test of individual predictors

4.4.1. Model's Goodness of Fit Test

Assessing the fit of a logistic regression (Hosmer 1991), suggested that any assessment of the goodness of fit, should begin with the evaluation of the deviance, Pearson's chi-square, and a deciles based Goodness of fit Statistic.

Two forms of error components for a fitted regression equation and their aggregate statistics were also discussed:

1. The deviance (D) statistic defined as:

$$D = \sum_{i=1}^{n} d_i^2$$

Where d_i , the deviance residuals is given by

$$d_i = \sqrt{2\left|\ln(\hat{Y})\right|}$$

When the observed value Y=1 or

$$d_i = \sqrt{2\left|\ln(1-\hat{Y})\right|}$$

When the observed value Y=0

2. The Pearson chi-square statistic defined as:

$$\chi^2 = \sum_{i=1}^{n} r_i^2$$

Where r_i is called Pearson residuals and given by

$$r_i = \frac{Y-\hat{Y}}{\sqrt{\hat{Y}(1-\hat{Y})}}$$

With each having degrees of freedom equal to n-(p+1), where n= number of cases, and p= number of column (variables under consideration).

A comparison of the values of the Deviance, and the Pearson's chi square with their degrees of freedom (if close to each other in value) should give a good indication about the goodness of fit of the logistic model (Hosmer 1991). For our case the deviance and the Pearson's chi square were determined as

D= 165.0384

χ^2=178.0171

df =176

Hence, the results of this test give a good indication about the goodness of fit of the model.

The Hosmer and Lemeshow Goodness of Fit Test (a deciles based test), tests the following Hypotheses:

$H_{0:}$ no significant difference between observed and model predicted values of the dependent variable.

$H_{a:}$ There is a difference between observed and the model predicted values of the dependent variable.

The test[62] divides the subjects into deciles (10 groups based on percentile ranks) and computes a Pearson chi square that compares the predicted to the observed frequencies. Then a probability P value (denoted as Sig. in the SPSS output shown in table 6) is computed from the chi-square distribution with 8 degrees of freedom to test the fit of the logistic model. The null hypothesis will be rejected, If the Hosmer and Lemeshow test statistics is .05 or less, concluding that the model's predicted values are significantly different from the observed value".[63]

For our case, we fail to reject the null hypothesis (P=0.365> 0.05, table 6 step 10) concluding that there is no significant difference between the observed and model predicted values of the dependent variables implying that the model's estimates fit the data at an acceptable level.

62 Tabashnick, Barbara G. and Linda S. Fidell. Using Multivariate Statistics. 4th ed. 2000.

[63] http://www2.chass.ncsu.edu/garson/pa765/logistic.htm

Table 6- Hosmer-Lemeshow Test of Goodness of Fit

Step	Chi-square	df	Sig.
1	18.911	7	.008
2	2.012	8	.981
3	5.038	8	.754
4	6.962	8	.541
5	3.691	8	.884
6	3.120	8	.927
7	16.068	8	.041
8	9.014	8	.341
9	10.946	8	.205
10	8.741	8	.365

Based on these suggested tests results, we can fairly assume that our model is appropriate as it passed all the recommended goodness of fit.

To identify those cases that are poorly fit or highly influential, four plots representing of the change in deviance (figure 37), the Pearson's chi square (figure 38), the Leverage (figure 39), and another showing the Influence (figure 40) versus the predicted probability were created.

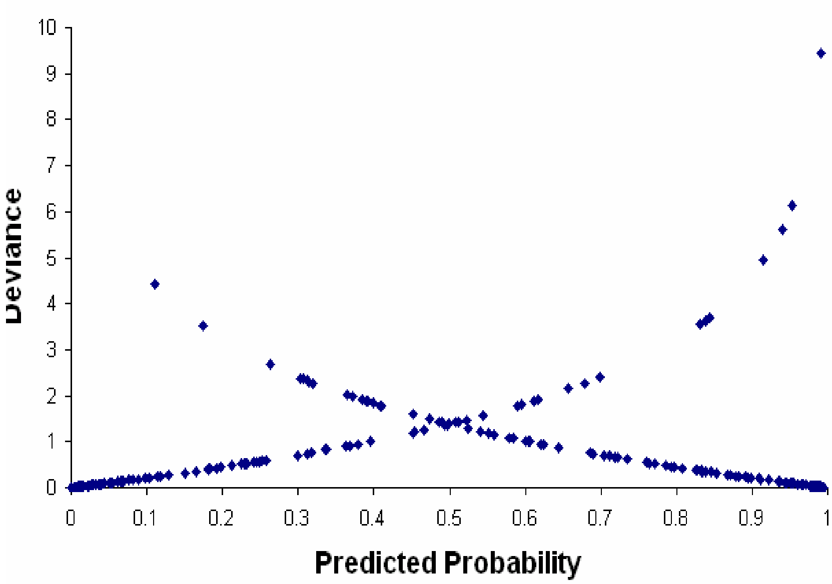

Figure 37- Change in Deviance vs. Predicted Probability

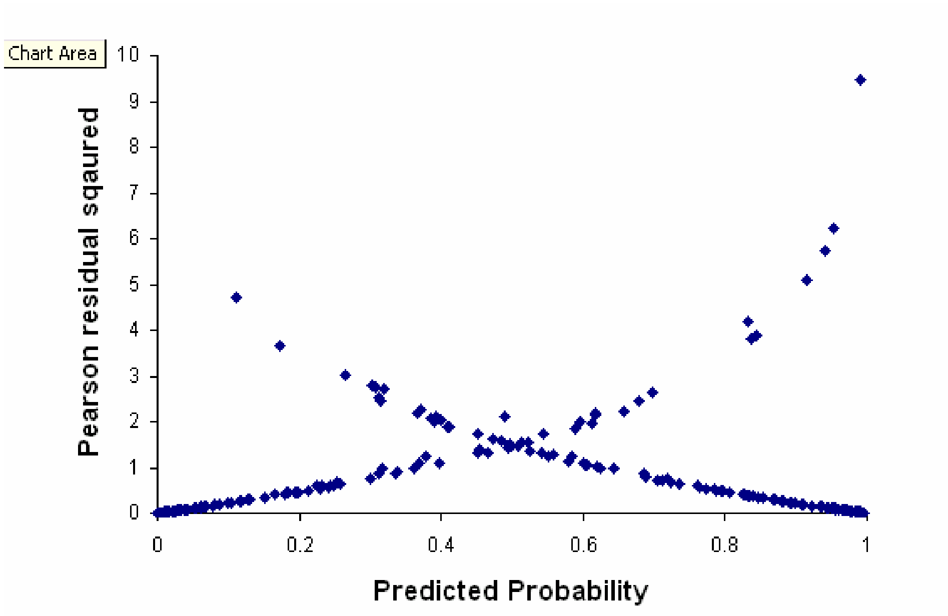

Figure 38 The Pearson's Chi Square vs. Predicted Probability

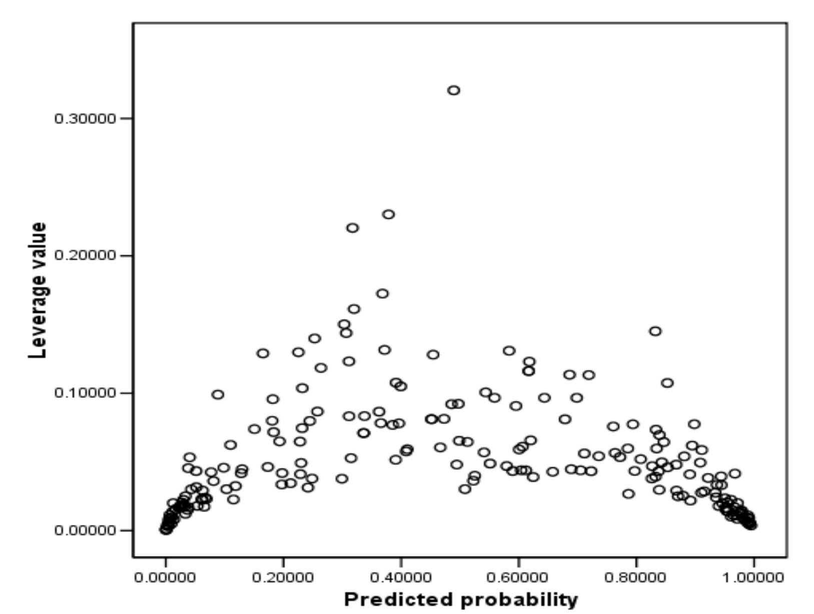

Figure 39- Leverage Value vs. Predicted Probabilities

Figure 39 shows that the points with highest leverage have moderate predicted probabilities; however the leverage decreases to zero as the predicted probabilities approach 0.

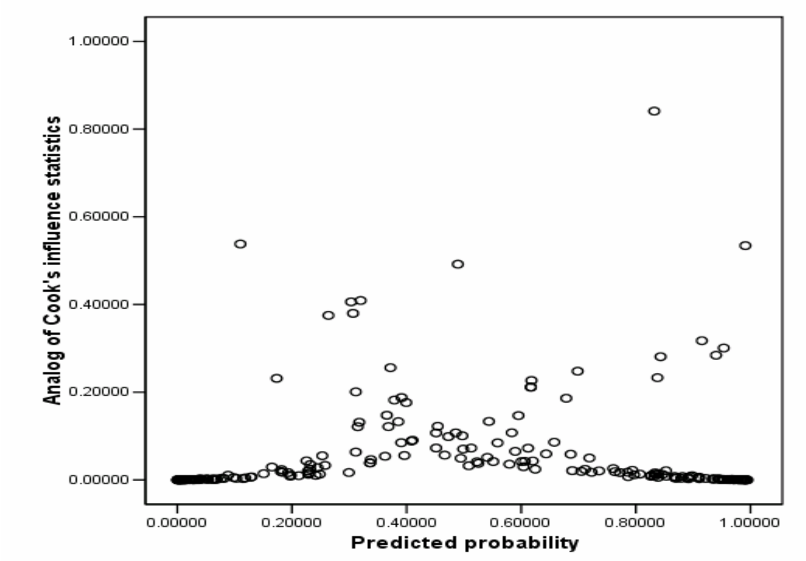

Figure 40- Cooks Influence vs. Predicted Probabilities

4.4.2. Tests of Individual Variables

To test the significance of independent variables, we use the Likelihood ratio test where each predictor is evaluated by testing the improvement in the model fit when that predictor is added to the model when using the stepwise forward logistic regression, or the decrease in model fit when that predictor is removed as is the case with the stepwise backward logistic regression.

Using the stepwise forward logistic regression, the initial -2 Log Likelihood has a value of 299.4 as shown in table 7.

Table 7-Initial Model Summary

Block 0: Beginning Block

Iteration History[a,b,c]

Iteration		-2 Log likelihood	Coefficients
			Constant
Step 0	1	299.440	.000

a. Constant is included in the model.

b. Initial -2 Log Likelihood: 299.440

c. Estimation terminated at iteration number 1 because parameter estimates changed by less than .001.

The introduction of significant variables into the model has the decreased the -2LL[64] (Chi- Square) thus showing a significant improvement over the previous model (see table 8 step 1). This process is continued until all the significant variables have been added yielding a better model with every variable addition. For example, the addition of the variable “Odds-of Success” to the initial model (table 8), decreased the -2LL by 47.483 (from 299.4 to 251.956) and hence improved the prediction model from an initial probability of 50% to 68.1%. This process was

[64] A Log Likelihood is calculated, based on the summing of the probabilities associated with the predicted and actual outcomes for each case under consideration. The Log Likelihood (LL) is given by

$$LL = \sum_{1}^{n} [Y \ln \hat{Y} + (1-Y)\ln(1-\hat{Y})]$$

Where n= number of cases under consideration, $\hat{Y}$ is the predicted probability, Y is the observed outcome, and the Chi square is defined as χ^2 =-2 [(Log Likelihood for the bigger model)-(log Likelihood for the smaller model)] Where the bigger model is the one to which predictors have been added to the smaller model. Models must be nested to be compared, and all the components of the smaller model must also be included in the bigger model.

continued until the model converged to an optimal solution after 10 iterations with an optimal prediction accuracy probability of 81%.

Table 8- Incremental Improvements Due to the Variables' Introduction

Step	Improvement			Model			Correct Class %	Variable
	Chi-square	df	Sig.	Chi-square	df	Sig.		
1	47.483	1	.000	47.483	1	.000	68.1%	IN: Odds_of_Success
2	20.572	1	.000	68.056	2	.000	75.0%	IN: Assessment
3	12.077	1	.001	80.133	3	.000	76.4%	IN: Dev_time
4	14.773	1	.000	94.906	4	.000	75.9%	IN: Quant_Benefits
5	9.067	1	.003	103.973	5	.000	79.6%	IN: Uniqueness
6	8.844	1	.003	112.816	6	.000	81.5%	IN: INV_Involved
7	5.874	1	.015	118.690	7	.000	81.9%	IN: No_dominant_technology
8	4.441	1	.035	123.131	8	.000	81.9%	IN: IP_Strength
9	6.992	1	.008	130.123	9	.000	80.6%	IN: Confidentiality
10	4.278	1	.039	134.401	10	.000	81.0%	IN: Prototype

a. No more variables can be deleted from or added to the current model.

Table 9 shows the comparison between the predicted and the observed values of each outcome. For example at step 1, the model correctly predicted 67.6% of the cases when the observed outcome was a "0" (73 cases out of a total of 105cases), and 68.5% of the cases when the observed outcome was a "1" (74 out of a total of 108) for an average accuracy rate of 68.1%.

Table 9-Classification Table

Observed			Predicted: Outcome 0	Predicted: Outcome 1	Percentage Correct
Step 1	Outcome	0	73	35	67.6
		1	34	74	68.5
	Overall Percentage				68.1
Step 2	Outcome	0	80	28	74.1
		1	26	82	75.9
	Overall Percentage				75.0
Step 3	Outcome	0	84	24	77.8
		1	27	81	75.0
	Overall Percentage				76.4
Step 4	Outcome	0	80	28	74.1
		1	24	84	77.8
	Overall Percentage				75.9
Step 5	Outcome	0	84	24	77.8
		1	20	88	81.5
	Overall Percentage				79.6
Step 6	Outcome	0	86	22	79.6
		1	18	90	83.3
	Overall Percentage				81.5
Step 7	Outcome	0	87	21	80.6
		1	18	90	83.3
	Overall Percentage				81.9
Step 8	Outcome	0	89	19	82.4
		1	20	88	81.5
	Overall Percentage				81.9
Step 9	Outcome	0	87	21	80.6
		1	21	87	80.6
	Overall Percentage				80.6
Step 10	Outcome	0	88	20	81.5
		1	21	87	80.6
	Overall Percentage				81.0

a. The cut value is .500

The accuracy of prediction improved and reached an optimal accuracy of 81.5% for the observed “0” outcome, and 80.6% for the observed “1” outcome. Figure 41 shows the plot of observed groups and predicted probabilities after 10 steps, for the logistic regression model which illustrate the accuracy of the predictive model.

```
               Observed Groups and Predicted Probabilities

      20 +                                                            +
         |0                                                           |
         |0                                                           |
F        |0                                                           |
R     15 +0                                                           +
E        |0                                                           |
Q        |0                                                           |
U        |0                                                        111|
E     10 +00                                                       111+
N        |00                                                       111|
C        |00 0                                                    1111|
Y        |0000         0                                    1     1111|
       5 +0000         0    1    1     1      1            11 1   1111+
         |00000     1  0    1    1   1 1      11         1 11 111 1111|
         |00000000 000 000  1101011  0 00111 000   111 1 1 101111 1111|
         |00000000 0000000 00000001  010000110001000111111100111010010|
Predicted ---------------+--------------+--------------+---------------
  Prob:   0             .25            .5             .75             1
  Group:  000000000000000000000000000000111111111111111111111111111111

          Predicted Probability is of Membership for 1
          The Cut Value is .50
          Symbols: 0 - 0
                   1 - 1
          Each Symbol Represents 1.25 Cases.
```

Figure 41-Observed Groups and Predicted Probabilities

4.4.3. Strength of the Association of the Model

Although several measures are available to measure the strength of association of a logistic regression model, there does not seem to be an agreement on which approach is best, and none has the same variance interpretation as R^2 for linear regression, but all approximate it (Tabashnick 2000). The SPSS Logistic regression provides Pseudo R^2 statistics measures devised by Nagelkerke[65] and Cox & Snell[66], where larger pseudo r-square statistics indicate that more of the variation is explained by the model (minimum 0 to a maximum of 1). The model summary in table 10 below shows a Nagelkerke R^2 of 61.8%.

Table 10-Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	251.956	0.197	0.263
2	231.384	0.270	0.360
3	219.307	0.310	0.413
4	204.533	0.356	0.474
5	195.467	0.382	0.509
6	186.623	0.407	0.542
7	180.750	0.423	0.564
8	176.309	0.435	0.579
9	169.316	0.453	0.603
10	165.038	0.463	0.618

4.5. Model Validation

To validate our model, a new survey (Appendix B) was emailed to those respondents who failed to answer our first surveys. As in the first survey (Appendix A), this survey asked the respondents to again consider two different scenarios. The first involving a technology that the respondent evaluated and decided to license, while the second involving a technology that the respondent evaluated but decided not to license. The respondents were asked to evaluate these two scenarios for only those 10 variables included in the logistic regression model. A total of 36 responses were received, with only 18 respondents completing the survey, giving us a total 36 cases to validate our model, as each respondent supplied information about two cases the licensed and the unlicensed. The model predicted 34 cases accurately (see table 11), and missed only 2 cases for a prediction accuracy rate exceeding 94%.

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[65] http://www.upa.pdx.edu/IOA/newsom/da2/ho_logistic3.doc

[66] The maximum value of the Cox and Snell r-squared statistic is actually somewhat less than 1; the Nagelkerke r-squared statistic is a correction of the Cox and Snell statistic so that the maximum value is 1 (SPSS manual)

Table 11- Forward Logistic Regression Model Validation Table

	Outcome	Uniquness	Assessment Claims	Odds of Success	Dev-Time	IP Strength	No dominant	INV Inv	Quant Ben	Confidentiality	Prototype	Licensing Probability	Predicted Outcome	Observed Outcome	Difference Backward Model
1	0	2	2	2	2	3	1	1	1	2	1	26.38%	0	0	0
2	0	1	2	1	1	1	1	1	2	2	2	0.58%	0	0	0
3	0	3	3	3	2	3	2	1	1	2	2	39.65%	0	0	0
4	0	3	3	4	4	4	1	1	1	2	1	92.02%	1	0	1
5	0	3	2	3	3	2	2	2	2	2	1	7.54%	0	0	0
6	0	3	2	2	2	2	1	2	2	2	2	1.76%	0	0	0
7	0	3	1	1	1	1	2	1	2	2	1	1.38%	0	0	0
8	0	2	2	4	2	3	2	2	2	2	2	1.38%	0	0	0
9	0	2	4	2	2	4	2	1	2	2	1	2.17%	0	0	0
10	0	3	4	4	4	5	2	1	2	2	1	30.44%	0	0	0
11	0	2	3	2	4	3	1	1	1	1	1	41.17%	0	0	0
12	0	2	3	2	3	5	1	1	1	2	2	13.74%	0	0	0
13	0	2	2	2	2	2	1	1	1	2	1	39.68%	0	0	0
14	0	2	3	4	2	2	1	2	1	2	1	66.68%	1	0	1
15	0	2	2	2	1	3	2	1	1	1	1	3.25%	0	0	0
16	0	2	2	3	3	2	2	1	1	2	2	41.81%	0	0	0
17	0	3	3	1	2	2	2	1	1	1	1	13.56%	0	0	0
18	1	5	5	4	3	5	2	1	1	2	1	94.46%	1	1	0
19	1	4	3	4	5	3	2	1	1	2	1	97.52%	1	1	0
20	1	4	4	4	4	4	1	2	1	1	1	81.13%	1	1	0
21	1	4	5	3	3	3	2	1	1	2	1	92.81%	1	1	0
22	1	5	5	5	5	5	1	1	1	1	2	97.82%	1	1	0
23	1	3	4	3	3	4	1	1	1	2	1	81.29%	1	1	0
24	1	4	4	3	5	4	1	1	1	2	1	96.71%	1	1	0
25	1	5	4	4	4	4	1	1	1	2	2	97.16%	1	1	0
26	1	4	4	4	2	3	1	1	1	2	1	94.99%	1	1	0
27	1	4	4	3	3	4	1	1	1	2	1	89.32%	1	1	0
28	1	4	4	4	2	5	1	1	1	2	1	84.91%	1	1	0
29	1	5	5	5	4	5	2	1	1	1	1	96.18%	1	1	0
30	1	3	4	4	3	4	1	1	1	2	1	90.95%	1	1	0
31	1	5	4	3	4	3	1	1	1	1	1	94.97%	1	1	0
32	1	4	4	5	4	4	2	1	1	2	1	97.73%	1	1	0
33	1	4	3	3	3	3	1	1	1	2	1	90.39%	1	1	0
34	1	5	4	3	2	2	1	1	1	1	1	90.80%	1	1	0
35	1	4	4	5	4	4	1	1	1	2	1	98.82%	1	1	0
36	0	3	3	4	2	3	2	2	1	2	2	34.59%	0	0	0
														Missed	2
														Model Success Rate	94.44%

4.5.1. Model Validation Using The Backward Logistic Regression

As a further measure to check the goodness of the stepwise forward logistic regression model, a backward stepwise logistic regression model was built and compared to the previous forward stepwise model. The backward model (table 12) included a total of 12 variables (the same 10 variables included in the forward method, and two additional variables defined as the "Alteration" and "Risk_Safety".

The model passed the goodness of fit test of Homer and Lemeshow, and all the logistic coefficients were significant. In addition, the SPSS manual clearly states that another goodness of fit that can be used is to compare the models created by the stepwise_forward and the backward regression. "If the two methods choose the same variables, you can be fairly confident that it's a good model", hence we can assume that our model if fairly good.

Again using the validation data to test and validate this model, we determined that it also accurately predicted 34 out of the 36 cases, and missed the other two (the missed cases are the same for both models).

4.5.2. Conclusion

Based on goodness of fit test and the validation of the model, we can fairly assume that the logistic regression model is appropriate and is a representative of the sample data, and therefore is a statistically good and acceptable predictive model.

Table 12- Backward Logistic Regression Model Validation Table

	Outcome	Uniquness	Alteration	Claims	Success	Dev-Time	IP Strength	Safety	No dominant	INV Inv	Quant Ben	Confidentiality	Prototype	Probability	Outcome	Outcome	Backward Model
1	0	2	2	2	2	2	3	4	1	1	1	2	1	17.00%	0	0	0
2	0	1	1	2	1	1	1	4	1	1	2	2	2	0.21%	0	0	0
3	0	3	2	3	3	2	3	4	2	1	1	2	2	26.83%	0	0	0
4	0	3	1	3	4	4	4	3	1	1	1	2	1	86.49%	1	0	1
5	0	3	2	2	3	3	2	4	2	2	2	2	1	3.58%	0	0	0
6	0	3	2	2	2	2	2	4	1	2	2	2	2	0.68%	0	0	0
7	0	3	1	1	1	1	1	4	2	1	2	2	1	0.50%	0	0	0
8	0	2	1	2	4	2	3	4	2	2	2	2	2	0.46%	0	0	0
9	0	2	1	4	2	2	4	4	2	1	2	2	1	0.92%	0	0	0
10	0	3	5	4	4	4	5	4	2	1	2	2	1	41.15%	0	0	0
11	0	2	2	3	2	4	3	4	1	1	1	1	1	28.90%	0	0	0
12	0	2	2	3	2	3	5	4	1	1	1	2	2	7.13%	0	0	0
13	0	2	2	2	2	2	2	4	1	1	1	2	1	27.86%	0	0	0
14	0	2	4	3	4	2	2	4	1	2	1	2	1	71.03%	1	0	1
15	0	2	2	2	2	1	3	4	2	1	1	1	1	2.20%	0	0	0
16	0	2	4	2	3	3	2	4	2	1	1	2	2	44.43%	0	0	0
17	0	3	1	3	1	2	2	4	2	1	1	1	1	6.26%	0	0	0
18	1	5	4	5	4	3	5	4	2	1	1	2	1	95.33%	1	1	0
19	1	4	4	3	4	5	3	4	2	1	1	2	1	97.71%	1	1	0
20	1	4	3	4	4	4	4	4	1	2	1	1	1	75.79%	1	1	0
21	1	4	3	5	3	3	3	4	2	1	1	2	1	91.97%	1	1	0
22	1	5	3	5	5	5	5	4	1	1	1	1	2	97.06%	1	1	0
23	1	3	3	4	3	3	4	4	1	1	1	2	1	78.46%	1	1	0
24	1	4	5	4	3	5	4	4	1	1	1	2	1	97.68%	1	1	0
25	1	5	3	4	4	4	4	4	1	1	1	2	2	95.77%	1	1	0
26	1	4	4	4	4	2	3	4	1	1	1	2	1	96.08%	1	1	0
27	1	4	4	4	3	3	4	4	1	1	1	2	1	90.35%	1	1	0
28	1	4	4	4	4	2	5	4	1	1	1	2	1	87.32%	1	1	0
29	1	5	4	5	5	4	5	4	2	1	1	1	1	97.02%	1	1	0
30	1	3	3	4	4	3	4	4	1	1	1	2	1	89.99%	1	1	0
31	1	5	1	4	3	4	3	4	1	1	1	1	1	87.73%	1	1	0
32	1	4	3	4	5	4	4	4	2	1	1	2	1	97.44%	1	1	0
33	1	4	3	3	3	3	3	4	1	1	1	2	1	87.78%	1	1	0
34	1	5	1	4	3	2	2	4	1	1	1	1	1	81.02%	1	1	0
35	1	4	4	4	5	4	4	4	1	1	1	2	1	99.02%	1	1	0
36	0	3	2	3	4	2	3	4	2	2	1	2	2	21.24%	0	0	0
																Missed	2
																Model Success Rate	94.44%

4.6. The Institutional Determinants' Response Analysis

The majority of the respondents have licensed university technologies at different stages over the last 5 years. With the majority being involved with technologies at the early stages, while only less than 40% have licensed university technologies at the Product Development, and only 22% at the market ready stages (see Figure 42). However around 80% of these technologies failed to materialize or reach their stated objectives.

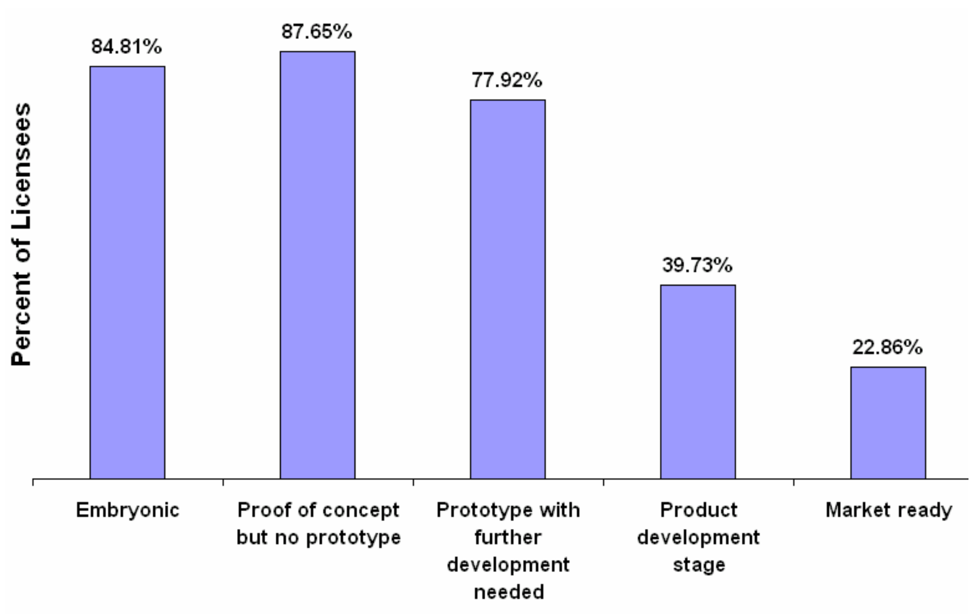

Figure 42- Survey's Respondents vs. University Technology's Different Development Stages

When asked about the reasons for failure[67] (see figure 43), about 43% blamed the failure on the technology itself, while about 23% the lag of time to market application was the main reason. Some blamed either the inventor failure to deliver the know-how or his lack of

[67] Similar results were published by Thursby and Thursby (2003)

cooperation, while others blamed the institution (as one respondent puts it:" Inability of the University to recognize pressures of time, and money -- They just don't get it"), or the viability of the technology itself.

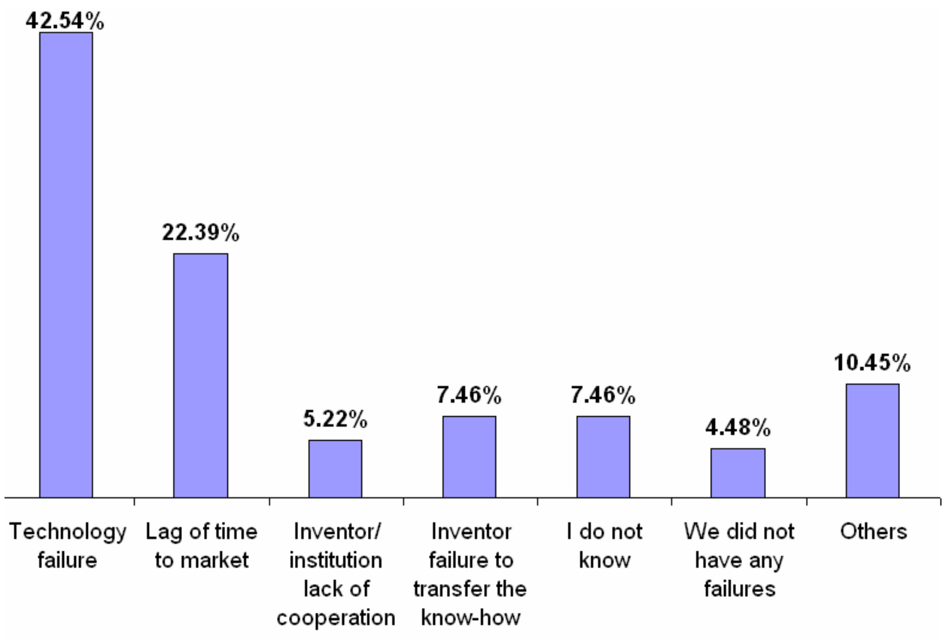

Figure 43-University Technology Commercialization Failure Reasons

As to how the licensees find the university technology they license (figure 44), it was found that a combinations of University Licensing Office's marketing efforts[68], and inventor contacts in the field of research play an important role in technology licensing. About 28% of the licensees determined that personal contact has been very important in finding those university technologies, while others used journal publications and trade shows.

[68]As expected, the University Licensing Office's marketing efforts were found to be important to the licensing of university technology, hence accomplishing the objectives of this research in predicting the technologies' licensing probability may guide in the allocation of the limited resources toward those technologies with the highest probabilities of being commercialized.

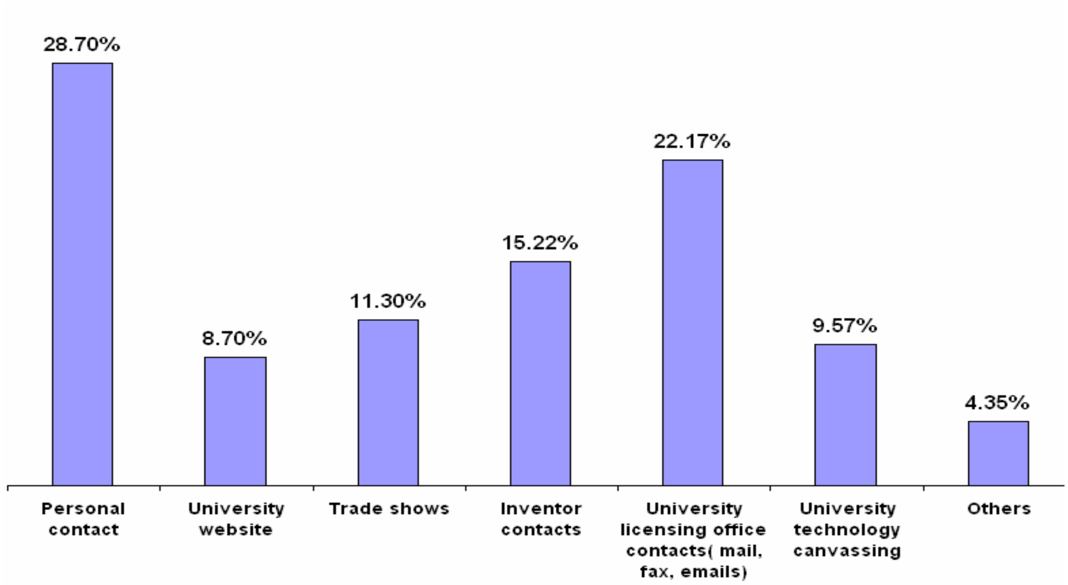

Figure 44-How Do Licensees Know About University Technologies

When asked on what can universities do to improve their technology licensing chances with the respondents' companies, the main theme was that universities should be less greedy more realistic, have reasonable expectations, understand the technology development risks, devise a broader and well targeted dissemination of information and marketing efforts, upgrade their licensing professional competencies, conduct better assessment of the requirements to commercialization.

About the impact of the Halo effect of the university on the licensing decision (figure 45), about 45.7% did not agree with the statement that "prestigious universities are able to license more technologies than less prestigious universities", while the rest agreed for many reasons. 15% agreed that technologies of prestigious universities are better and more reliable. Only 8.76 % agreed that the main reason for licensing technologies from more prestigious universities was that funding was easier, while about 11.68% agreed that licensing will give them access to highly regarded faculty.

Some other respondents justified that the reasons of why prestigious universities are better to license more technologies, was because of their abilities to market their technologies better than less prestigious universities, have a more organized and a well developed technology transfer functions, and are better able to attract highly trained business oriented personnel with expertise that are determined to get the deal done in an efficient way, concluding that the institutional determinants play an important role in the university technology licensing and commercialization process success.

These results are in agreement with Sine, Shane, and Di Gregorio (2003) who empirically examined the influence of university prestige and concluded that the institutional prestige increases the licensing success positively.

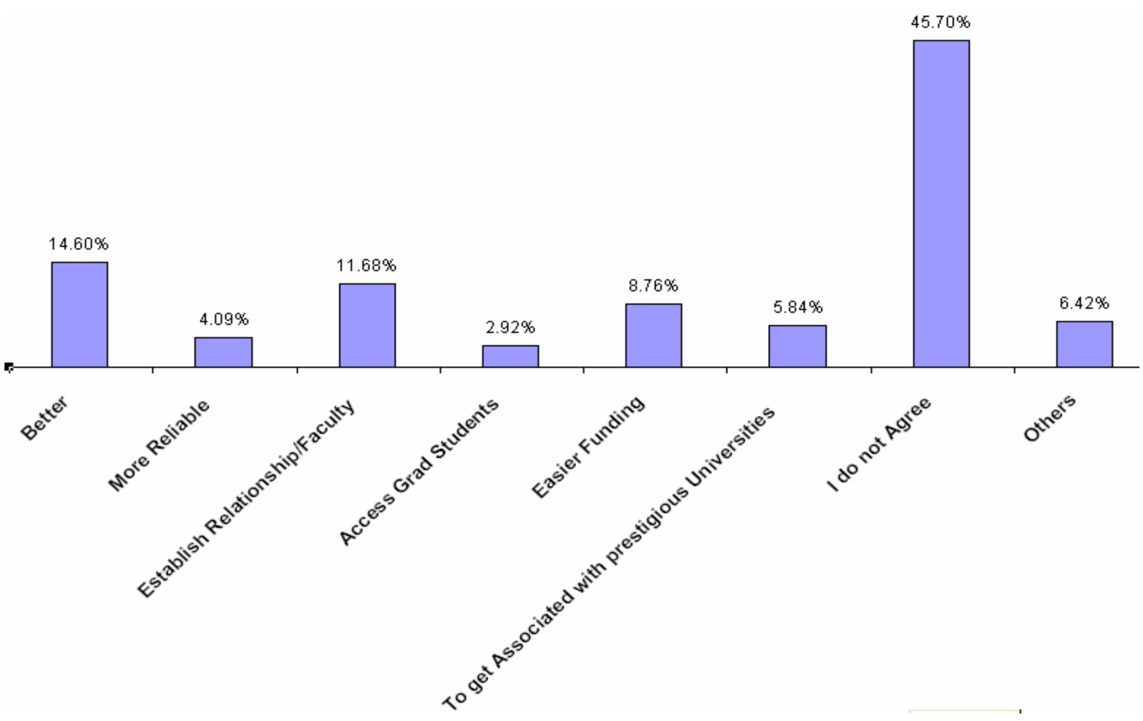

Figure 45- Why are Prestigious Universities Better Able to License More Technologies than Less Prestigious Universities

4.7. Summary

Despite the length and the complexity of the survey, the response rate, the diversity and the experiences of the respondents were beyond our expectations.

The analysis of the demographic data showed that the respondents are highly influential professionals in the technology licensing field, with the majority occupying either a top corporate level or a middle management position. About half of the respondents work for a very large companies such as, Boeing, General Electric, AT&T, Proctor & Gamble, Merck, Pfizer, Yahoo, AOL/Time Warner, Hewlett Packard, Monsanto, Conoco Phillips, Cargill, Delphi, DuPont, Bristol Myers-Squibb, Abbott Labs just to name a few.

Applying the survey's data into statistical software (SPSS V.12), and using the forward stepwise logistic regression, a statistically acceptable predictive model with 10 variables and an accuracy rate of 81% was achieved.

To validate and test the predictive model, a new survey was emailed to those licensing professionals who failed to answer first survey. The data was then applied to the model, and a prediction accuracy rate of 95% was achieved, concluding that the predictive model is very robust.

CHAPTER 5: CONCLUSION

This chapter provides an overview of this research, a summary of the final outcomes, conclusions, contributions, and recommendations for future research.

5.1. Overview

This exploratory study provides a framework to be used by the University Technology Transfer and Licensing personnel to properly assess, identify, and prioritize university-owned technologies or inventions with licensing and commercialization potential.

This research focuses; and unlike any previous research; on the university technology licensing and commercialization process from the perspectives of those licensing professionals whose firms' activities are engaged in licensing-in university technologies (buyers).

5.2. Research Summary and Conclusions

The literature review process identified 43 variables (licensing determinants) deemed important and relevant to the technology licensing process. To understand why some technologies get licensed while many others do not, and to determine those characteristics that differentiate technologies that are licensed from those that are not, email invitations (1,586) were sent to the corporate professional members of the Licensing Executive Society, asking for their participation in one of the most comprehensive (about 140 questions) web-based survey that has targeted specifically the licensing professionals.

Returned survey responses totaled 156 (10%), with only 108 (7%) were deemed acceptable and were included in the analysis.

The analysis of the demographic data of the survey, showed that the respondents are highly influential professionals in the technology licensing field, with the majority occupying either a top corporate level (30.7%), or a middle management position (51.6%). 45.5% of the respondents work for a very large fortune 500 companies (with more than 5000 employees) such as, Boeing, General Electric, AT&T, Proctor & Gamble, Merck, Pfizer, Yahoo, AOL/Time Warner, Hewlett Packard, Monsanto, Conoco Phillips, Cargill, Delphi, DuPont, Bristol Myers-Squibb, Abbott Labs, and many others, while 26.6% work for a small company (with less than 100 employees).

The data analysis, showed that the reliability and internal consistency of the survey's constructs was at an acceptable level (Cronbach's alpha>0.8).

The respondents were asked to grade or classify the variables (licensing determinants) under two different scenarios, the first involving a technology that the respondents or their team evaluated and decided to license (outcome=1), while the second involved another technology that was evaluated but was not license (outcome=0). In addition, the respondents were also asked to rate the importance of each of those 43 licensing determinants on their licensing decision (Appendix A, question 35).

This dichotomous outcome (License /Do not license) allows for the use of several solutions approaches and techniques such as Artificial Neural Network which provides a "black box" solution and have limited ability to explicitly identify possible causal relationships. However, the logistic regression can determine the variables that are more strongly predictive of an outcome based on the magnitude of the regression coefficients. It can also identify the relationship between multiple independent variables and a single dependent variable, and yields a predictive equation. Further, it is used as an estimator for categorical dichotomous binary coded dependent variables that takes only two values (0 or 1, success/failure), and produces a meaningful predicted probabilities by assuring that the predicted values do not break the laws of probability.

A stepwise forward inclusion logistic regression which uses the iterative Maximum Likelihood Estimation (MLE) fitting procedure was used to find those coefficients that have the greatest likelihood of producing the pattern of the observed data. The forward inclusion stepwise regression method, starts by assuming that the constant is the only variable in the model, and then only the independent variables deemed significant are added to the model based on a preset criteria. To classify whether the predicted outcome is a success or a failure, a cutoff probability of 0.5 was used (Hosmer and Lemeshow 1989).

The data yielded the variables and coefficients listed in below. These variables were retained in the regression model as they proved to be significant to the model (P values<0.05), while those that were eliminated had P values greater than 0.05 (P>0.05).

The logistic regression model is represented by the equation

$$\Pr obability(event) = \pi_j = \frac{e^{bo+b1x1+....+ bk\ xk}}{1+e^{e^{bo+b1x1+....+ bk\ xk}}}$$

Where e (Exponential) is the base of natural logarithms (equal approximately 2.7183). The coefficients b_0, represents the constant, while b_1, b_2, b_k where k=10, represent the coefficients of the variables (see table below).

Licensing determinant	Variables Symbol	Coefficient	Symbol
Uniqueness	Uniqueness	0.152	b_1
Technology Claims assessment	Assessment	0.116	b_2
Odds of Market Success	Odds_of_Success	0.195	b_3
Development Time	Dev-Time	0.155	b_4
No Dominant Technology in the field	No-dominant Technology	-0.183	b_5
Inventor Involvement	Inv_Involved	-0.369	b_6
Technology has Quantifiable Benefits	Quant-Benefits	-0.579	b_7
Technology's Confidentiality	Confidentiality	0.291	b_8
Availability of a Prototype	Prototype	-0.217	b_9
Itellectual Propert Strength	IP_ Strength	-0.135	b_{10}
Constant	Constant	-1.658	b_0

The Hosmer and Lemeshow Goodness of Fit Test was applied on the stepwise forward logistic regression model, and failed to reject the null hypothesis that there no significant difference between observed and model predicted values of the dependent variable, hence the model was deemed acceptable.

Another measure of the goodness of fit is to compare the models created by the stepwise forward and backward regression. “If the two methods choose the same variables, you can be fairly confident that it's a good model” (SPSS manual), hence we can assume that our model is a fairly good model. The backward model included 12 variables (the same 10 variables included in the forward method, and two additional variables defined as the “Alteration” and “Risk_Safety”. The model passed the goodness of fit test of Homer and Lemeshow, and all the logistic coefficients were significant leading to the conclusion that our model is statistically acceptable.

To validate and test our model, a new survey (Appendix B) was emailed to those respondents who failed to answer our first survey. The respondents of this survey were also asked to evaluate two technologies under two scenarios. The first involving a technology that the respondent evaluated and decided to license, while the second involving a technology that the respondent evaluated but decided not to license. However this time the survey only involved only those variables included in the logistic regression model. 36 responses were received, with only 18 respondents completing the survey, giving us a total 36 cases (2 cases per completed reply).

To validate our model, Both the forward and the backward logistic regression models predicted 34 cases accurately out of a total of 36 cases for a prediction accuracy rate exceeding 94%. Hence we can safely conclude that the logistic regression model is able to predict the licensing probability of university technologies with abut 95% accuracy rate.

The Framework requires answers to a set of questions that the technology assessor will need to provide (see Appendix C). As a result of these answers, the framework will then predict the licensing probabilities of the university technology under consideration. This process will assist the university's licensing personnel in identifying and prioritizing their university's technologies according to the licensing probabilities predicted by the framework, with the ultimate goal of concentrating their limited resources on only those technologies with the highest licensing and commercialization potential.

As to the institutional determinants, the survey's results agreed with the literature review that the expertise and the professionalism of the technology transfer office's personnel, and their ability to address the licensees' issues of concern increases the likelihood of the licensing and commercialization chances of university technology.

5.3. Research Contributions

This research; unlike any other; looked at the university technology licensing process from the buyers' perspectives, and included the first and the most comprehensive technology licensing survey that targeted specifically the actual practices and the latest up to date technology licensing criteria of those licensing professionals whose firms' activities are engaged in licensing-in or buying university technologies.

In addition, the framework developed in this research, represents the first attempt ever to build a knowledge management database or a decision support system using the logistic regression methodology.

The framework simplifies the university technology assessment process for licensing and commercialization, and assists university licensing personnel in identifying and prioritizing those technologies with licensing and commercialization potential for the best allocation of the limited available resources, and the pursuit of truly important breakthrough discoveries.

5.4. Recommendations for Future Research

Recommendations for future research include:

1. The development of a web-based national database that will help overcome some of the limitations faced in this research such as the limited response rate, and the generality of the framework as it addressed technology in general and did not address specific technology sectors.
2. Extend the capabilities of the assessment framework to identify potential technology shortfalls, and provide suggestions and recommendations on to how they could be overcome.
3. Explore the role of technology and inventor characteristics, the impact of the institutional policies, and the type of intellectual property protection on the licensing process.
4. Extend the framework's capabilities to accommodate product development and cost research roadmaps for the technology being assessed.

5. Improve the capabilities of the framework with simulation capable software to provide market assessment and analysis, including projection models such as the projected market demands, market needs, and the future growth trends for the technology under consideration.

6. Research and investigate the possibility of extending the framework by connecting it to a national database[69] that records all publicly announced alliances worldwide with the goal of providing:

   a. Information on the latest technology licensing activities.
   b. Projections about the growth in the technology field under consideration.
   c. Identification of potential licensees or acquirers for their technologies.
   d. Estimation of sector specific technology licensing pricing models by accommodating the use of real option theory
   e. Technology Risk assessment.

6. Incorporate Game theory analytical tools in the framework to examine the licensees' latest technology licensing strategies, and suggest a course of actions with the predicted likely outcome.

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69 Such as Thompson Financial's SDC database that records all publicly announced alliances worldwide This database is the largest available database on all kinds of alliances across all sectors tracked down in the Security Exchange Commission filings in the United States, newswires, press, trade magazines, professional journals, and many other venues, and provides information on contract type (i.e. licensing agreement, marketing agreement, joint venture, joint development or production, etc.), description of the deal, the date of agreement, identities of participant firms (primary SIC code, name, nation, parent companies, etc.), and the SIC code of the alliance. In addition, the SDC identifies different kinds of licensing agreements (i.e. exclusive, non-exclusive, cross-licensing) and the roles of the participants in them (licensor, licensee).

7. Extend the framework to investigate inter-firm technology licensing and determine the required firm level variables, as well as industry sector level variables.
8. Explore the utilization of other approaches and techniques such as the Artificial Neural Network, Analytic Network Process, Decision Tree, System Dynamics, Engineering Economy’s Discounted Cash Flow Models, and Real Options Theory in the evaluation of University Technologies for licensing and commercialization.

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APPENDIX A: DATA COLLECTION SURVEY

Objective:

The objective of this survey is to build a computer model to assess the licensing and the commercial viability of university technologies.

The participation in this survey is voluntary and you do not have to answer any question you do not wish to answer. However, your cooperation is important to ensure that the information collected is as accurate and as comprehensive as possible. Also please note that:

- The survey is solely used for educational purposes
- No information will be shared with any other entity to protect the participant's privacy;
- There is no immediate benefit to be expected as a result of participation in the survey;
- There is no compensation to be awarded as a result of participation in the survey;
- You are free to discontinue participation in the survey at any time without consequence;
- Amount of time expected for participation: 12 minutes;
- The data reported on this questionnaire will be treated in strict confidence, used for statistical purposes and published in aggregated form only.

And of course, we will share the results, implications, and conclusions of this study with all respondents.

Please click the survey link to begin the survey. Time is of the essence. It is important that we receive your response as soon as possible, and not later than (date).

Information about the survey:

Technology pundits have identified several technology assessment criterions as important to the technology licensing and commercialization decision making process. To determine the impact of these technology assessment criterions on your company's technology licensing and commercialization decision, the survey will ask you to evaluate them under two (2) different scenarios: the first involving a technology your company decided to license, and the second where it did not.

Technical support:

The survey is being administered by A. D. Rahal, a PhD candidate in the Industrial Engineering Department at the University of Central Florida whose Technology Incubator was recently named the 2004 Technology Incubator of the Year by the National Business Incubation Association

Results Summary

Show All Pages and Questions

Export... View

Filter Results

To analyze a subset of your data, you can create one or more filters.

Add Filter... **Total:** 0

Visible: 0

Share Results

Your results can be shared with others, without giving access to your account.

Configure... **Status:** Enabled

Reports: Summary and Detail

2. Demographics

1. What is your company's main business application focus?

	Response Percent	Response Total
Health related	0%	0
Biotech related	0%	0
Chemical related	0%	0
Computer related	0%	0
Agricultural related	0%	0
Manufacturing related	0%	0
Service related	0%	0
Consulting related	0%	0
University related	0%	0
Government related	0%	0
Food related	0%	0
Financial Related	0%	0
Other (please specify)	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

2. How many employees does your company employ?

	Response Percent	Response Total
Less than 100	0%	0
100-500	0%	0

	Response Percent	Response Total
500-1000	0%	0
1000-5000	0%	0
More than 5000	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

3. Your position with your company is best described as?

	Response Percent	Response Total
Top corporate management	0%	0
Middle management	0%	0
Research division management	0%	0
Researcher	0%	0
Production Management	0%	0
Consultant	0%	0
Other (please specify)	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

4. What were your company's last year estimated revenues?

	Response Percent	Response Total
Less than $1 million	0%	0
$1-$5 million	0%	0
$5-$25 million	0%	0
$25-$100 million	0%	0
$100-$1 billion	0%	0
More than $1 billion	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

5. Does your company License-In technologies?

	Response Percent	Response Total
Yes	0%	0
NO	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

3. The Scenarios

6. Using a 1 to 5 scale where "1 = Very narrow scope" and "5 =Broad Scope -New products and different technologies markets very likely ", how do (did) you rate the scope of the technologies for each of the two different scenarios ?

	<1>	<2>	<3>	<4>	<5>	Response Average
The scope of the technology that was **licensed** was classified as:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The scope of the technology that was **not licensed** was classified as:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

7. Using a 1 to 5 scale where "1 = Totally inferior to other technologies " and "5 =Unique and far superior to other technologies ", from a technological point of view, how do (did) each of the technologies under the two different scenarios compare to other available competitive technologies ?

	<1>	<2>	<3>	<4>	<5>	Response Average
The technology that was **licensed** was rated as:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology that was **not licensed** was rated as:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

8. From a technological point of view, how do (did) you classify the barriers to entry into the technological field for each of the technologies of the two scenarios ?

	Almost non-existent<1>	Low barriers <2>	Moderate barriers<3>	High barriers <4>	Unsurmountable barriers without know-how <5>	Response Average
The barriers to entry into the field for the technology that was **licensed** were:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The barriers to entry into the field for the technology that was **not licensed** were:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

9. From a technological point of view, how do (did) you classify the development stage at the time of assessment for each of the technologies under the two different scenarios ?

	Idea phase stage <1>	Proof of concept stage <2>	Early stage development stage <3>	Final prototype stage <4>	Market ready stage <5>	Response Average
The development stage of the technology that was **licensed** was classified at:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**

The development stage of the technology that was **not licensed** was classified at:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

10. Using a 1 to 5 scale where "1 = Very limited" and "5 =Highly sophisticated", how do (did) you rate the R&D complexity needed to bring each of the technologies under the two different scenarios to the development stage?

	<1>	**<2>**	**<3>**	**<4>**	**<5>**	**Response Average**
The R&D complexity needed to bring the technology that was **licensed** to the development stage was rated as:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The R&D complexity needed to bring the technology that was **not licensed** to the development stage was rated as:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

11. Using a 1 to 5 scale where "1 = Very limited" and "5 ="Highly sophisticated", how do (did) you rate the nature and sophistication level of each of the technologies under the two different scenarios ?

	<1>	**<2>**	**<3>**	**<4>**	**<5>**	**Response Average**
The nature and sophistication level of the technology that was **licensed** was rated as:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The nature and sophistication level of the technology that was **not licensed** was rated as:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

12. What are the possibilities of producing these technologies with regard to their technological requirements?

	Impossible to produce <1>	**Difficult to produce <2>**	**Had average difficulties to produce <3>**	**Had minor problems to produce <4>**	**Had no problem to produce <5>**	**Response Average**
Technology production with regard to the technological requirements for the technology that was **licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology production with regard to the technological requirements for the technology that was **not licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

13. How much alteration is needed on other required technologies for these technologies to work?

	Significantly altered <1>	Highly altered <2>	Moderately altered <3>	Slightly altered <4>	Alteration not needed <5>	Response Average
For the technology that was **licensed** to work, other technologies may have to be:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
For the technology that was **not licensed** to work, other technologies may have to be:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

14. Thinking of safety, environmental, and other risks and hazards, each of the technologies under the two different scenarios was classified as:

	Very unsafe when used as intended <1>	Relatively unsafe <2>	Do not know <3>	Safe when used as intended <4>	Very safe under all conditions <5>	Response Average
The technology that was **licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology that was **not licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

15. The technology assessment showed that the technologies under the two different scenarios had:

	Had prior claims to the technology <1>	Was weak <2>	Was strong but difficult to proof <3>	Do not know <4>	Was strong and enforceable <5>	Response Average
Technology assessment showed that the technology that was **licensed** :	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology assessment showed that the technology that was **not licensed** :	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

4. Questions about the Technology that was licensed

16. Using a 1 to 5 scale where "1 = Very low or highly unacceptable" and "5 =Excellent", and thinking about the technology that your company assessed and decided to **license**, how do (did) you classify each of the following:

	Highly Unacceptable<1>	<2>	<3>	<4>	Excellent/Highly acceptable<5>	Response Average
The market needs for that technology were?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The state of the existing competitive						

technologies were ?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The size of the potential market was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The expected market potential growth rate was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The expected demand trend was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The odds of market success was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology's dependability on other necessary technologies was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

17. Using a 1 to 5 scale where "1 = Highly unacceptable" and "5 =Excellent/Highly acceptable", and thinking about the technology that your company assessed and decided to license, how do (did) you classify each of the following:

	Highly unacceptable <1>	**<2>**	**<3>**	**<4>**	**Excellent/Highly acceptable <5>**	**Response Average**
The expected time to reach the required market penetration was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The time to reach Payback was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The time to reach an acceptable rate of return was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The amount of capital needed to bring this technology to a market ready stage was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology development time to market was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology's dependability on other necessary technologies was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

18. For the technology that your company assessed and decided to license, the technology assessment showed that:

	Agree	**Disagree**	**Response Average**
No dominant technology existed yet in the field	0% (0)	0% (0)	**0.00**
Technology has an early mover advantage	0% (0)	0% (0)	**0.00**
The inventor was involved and willing to cooperate	0% (0)	0% (0)	**0.00**
Technology was perceived to have quantifiable benefits	0% (0)	0% (0)	**0.00**
The Inventor was perceived to be a technology leader	0% (0)	0% (0)	**0.00**
Inventor has credibility in the field	0% (0)	0% (0)	**0.00**
Inventor has realistic expectations about the technology	0% (0)	0% (0)	**0.00**
Inventor was a stakeholder	0% (0)	0% (0)	**0.00**

Inventor involvement was crucial to the licensing decision	0% (0)	0% (0)	**0.00**
The technology was perceived to have quantifiable benefits	0% (0)	0% (0)	**0.00**
The technology has sustainable competitive advantages	0% (0)	0% (0)	**0.00**
The technology was new and non-obvious	0% (0)	0% (0)	**0.00**
The technology's literature search was complete and clean	0% (0)	0% (0)	**0.00**
The technology's patent search was clean and clear	0% (0)	0% (0)	**0.00**
The technology was still confidential (no past or future disclosures)	0% (0)	0% (0)	**0.00**
The technology has no prior claims	0% (0)	0% (0)	**0.00**
The technology has a functioning prototype	0% (0)	0% (0)	**0.00**
		Total Respondents	**0**
		(skipped this question)	**0**

19. Did any of the following restrictions apply to the licensed technology? (Check all that apply)

	Response Percent	**Response Total**
1-Non exclusive	0%	0
2-Field of use	0%	0
3-Geographic	0%	0
4-Grant-Back Prosivions	0%	0
5-Semi-Exclusive (fixed number of licenses)	0%	0
6-No restictions-Exlusive	0%	0
Other (please specify)	0%	0
Total Respondents		**0**
(skipped this question)		**0**

5. Questions Involving The Technology that was not Licensed

20. Using a 1 to 5 scale where "1 = Very low or highly unacceptable" and "5 =Excellent", and thinking about the technology that your company assessed and decided not to license, how do (did) you classify each of the following:

	Highly unacceptable <1>	**<2>**	**<3>**	**<4>**	**Excellent/ Highly acceptable <5>**	**Response Average**
The market needs for that technology were?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The state of the existing competitive technologies were ?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The size of the potential market was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**

The expected market potential growth rate was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The expected demand trend was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The odds of market success was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology's dependability on other necessary technologies was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

21. Using a 1 to 5 scale where "1 = Very low or highly unacceptable" and "5 =Excellent", and thinking about the technology that your company assessed and decided not to license, how do (did) you classify each of the following:

	Highly unacceptable <1>	**<2>**	**<3>**	**<4>**	**Excellent/ Highly acceptable<5>**	**Response Average**
The expected time to reach the required market penetration was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The time to reach Payback was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The time to reach an acceptable rate of return was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The amount of capital needed to bring this technology to a market ready stage was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology development time to market was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology's dependability on other necessary technologies was?	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

22. For the technology that your company assessed and decided not to license, the technology assessment showed that:

	Agree	**Disagree**	**Response Average**
No dominant technology existed yet in the field	0% (0)	0% (0)	**0.00**
Technology has an early mover advantage	0% (0)	0% (0)	**0.00**
The inventor was involved and willing to cooperate	0% (0)	0% (0)	**0.00**
Technology was perceived to have quantifiable benefits	0% (0)	0% (0)	**0.00**
The Inventor was perceived to be a technology leader	0% (0)	0% (0)	**0.00**
Inventor has credibility in the field	0% (0)	0% (0)	**0.00**
Inventor has realistic expectations about the technology	0% (0)	0% (0)	**0.00**
Inventor was a stakeholder	0% (0)	0% (0)	**0.00**
Inventor involvement was crucial to the licensing decision	0% (0)	0% (0)	**0.00**
The technology was perceived to have			

quantifiable benefits	0% (0)	0% (0)	**0.00**
The technology has sustainable competitive advantages	0% (0)	0% (0)	**0.00**
The technology was new and non-obvious	0% (0)	0% (0)	**0.00**
The technology's literature search was complete and clean	0% (0)	0% (0)	**0.00**
The technology's patent search was clean and clear	0% (0)	0% (0)	**0.00**
The technology was still confidential (no past or future disclosures)	0% (0)	0% (0)	**0.00**
The technology has no prior claims	0% (0)	0% (0)	**0.00**
The technology has a functioning prototype	0% (0)	0% (0)	**0.00**
		Total Respondents	**0**
		(skipped this question)	**0**

23. Did any of the following restrictions apply to the technology that was not licensed? (Check all that apply)

	Response Percent	Response Total
1-Non exclusive	0%	0
2-Field of use	0%	0
3-Geographic	0%	0
4-Grant-Back Prosivions	0%	0
5-Semi-Exclusive (fixed number of licenses)	0%	0
6-No restictions-Exlusive	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

24. Does your company License-In University technologies?

	Response Percent	Response Total
Yes	0%	0
No	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

6. University Technology Licensing

25. How often does your company License-In university technologies: (Please choose the answer that best describe your company's licensing practices):

Response Percent	Response Total

Never	0%	0
Rarely	0%	0
Sometimes	0%	0
Often	0%	0
Almost always	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

26. In your opinion why does your company License-In university technologies: (Please choose the answer that best describe your company's licensing practices):

	Response Percent	Response Total
To establish a relationship with the university	0%	0
To recruit graduate students	0%	0
To obtain access to faculty consulting	0%	0
Other (please specify)	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

27. Of the licensed university technologies your company was involved in during the last 5 years, what percentage was at each of the following stages of development?

	0 %	0 to 20%	20 to 40%	40 to 60%	above 60%	Response Average
Embryonic	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Proof of concept but no prototype	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Prototype with further development needed	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Product development stage	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Market ready	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

28. For each of the development stages listed below, what percentage of the university technologies your company was involved in during the last 5 years reached the commercialization stage?

	0 %	0 to 20%	20 to 40%	40 to 60%	above 60%	Response Average
Embryonic	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Proof of concept but no prototype	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Prototype with further development needed	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**

Product development stage	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Market ready	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

29. For the university technology that your company had licensed-In during the last 5 years, what was (were) the main cause (s) for failing to reach the commercialization stage? (check all that apply)

	Response Percent	Response Total
Technology failure	0%	0
Lag of time to market	0%	0
Inventor/ institution lack of cooperation	0%	0
Inventor failure to transfer the know-how	0%	0
I do not know	0%	0
We did not have any failures	0%	0
Other (please specify)	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

30. How does your company go about identifying university technologies for Licensing-In? (check all that apply)

	Response Percent	Response Total
Personal contact	0%	0
University website	0%	0
Trade shows	0%	0
Inventor contacts	0%	0
University licensing office contacts (mail, fax, emails)	0%	0
University technology canvassing	0%	0
Other (please specify)	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

31. What is your opinion about the perception that prestigious universities are able to license more technologies than less prestigious universities? (check all that apply)

	Response Percent	Response Total
I agree because their technologies are better	0%	0
I agree because their technologies are		

more reliable	0%	0
I agree because licensees would like to establish research relationship with highly regarded faculty	0%	0
I agree because licensees would like to get access to highly regarded graduate students for recruiting	0%	0
I agree because funding is easier when research involves prestigious universities	0%	0
I agree bacause licensees would like to be associated with prestigious universities	0%	0
I do not agree with the above premise as my company's licensing decisions are totally merit based	0%	0
Other (please specify)	0%	0
	Total Respondents	**0**
	(skipped this question)	0

32. With regard to your company, do you think that more prestigious universties have better chances of licensing their technologies than less prestigious universities?

	Response Percent	Response Total
Yes	0%	0
No	0%	0
	Total Respondents	**0**
	(skipped this question)	0

7. Reasons For Not Licensing University Technologies?

33. In your opinion, what are the reasons that your company does not license-in university technologies? (Check all that apply)

	Response Percent	Response Total
Because your company does not License-in technologies regardless	0%	0
Due to the embryonic stage of university technologies	0%	0
Due to the lag time to market application	0%	0
Due to the university's Licensing and technology transfer policies	0%	0
Due to the high failure rate of university technologies	0%	0
Due to the type of university research (general basic research)	0%	0
Due to the university's unacceptable demand	0%	0
Due to the inefficiencies of dealing with the university's licensing office	0%	0

The university technologies are not worth the time and efforts	0%	0
I do not know	0%	0
Other (please specify)	0%	0
	Total Respondents	**0**
	(skipped this question)	**0**

8. Survey- The last page

34. In your opinion, what can universities do to improve their technology licensing and commercialization chances with your company?(please provide your answer in the space below)

Total Respondents	**0**
(skipped this question)	**0**

35. Please rate the answer that best describes your opinion on how influencial or how important is each of the following criterion on the technology licensing decision ?

	Low Influence or not important <1>	Average Influence<2>	Moderately Influencial <3>	Highly Influential <4>	Critically Influential or highly important <5>	Response Average
The current or immediate market needs	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The existing competition	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The size of the potential market	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The market growth rate	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The expected demand trend	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The expected time to reach target market penetration	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The market accessibility (no dominant technology exist)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The competitive pricing	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The probability of market success	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Being first to market (early mover)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The R&D necessary to reach product development stage	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The expected payoff period	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The positive return on investment within a specified period	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Inventor Involvement & cooperation as a team player	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Inventor being technology leader	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Inventor's credibility in the field	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Inventor's realistic expectations	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Inventor as a stakeholder	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**

The nature and sophistication of technology	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The scope of technology (Future uses)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology uniqueness and superiority	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology has significant and identifiable benefits	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology perceived to have quantifiable benefits	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology sustainable competitive advantages	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology development time to market	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology's stage of development	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Barriers to entry	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology is new and non obvious	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The availability of a functioning Prototype	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology's technical feasibility	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology's degree of dependability on other technologies	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology's risks and weaknesses	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology's patent search completed, clear and clean	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology's confidentiality (no oral or written disclosures	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The strength of the technology's intellectual Property	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The exclusivity of the technology's intellectual Property	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	**0**

9. Thank you

36. To receive a final copy of the results of this survey, please enter your email address

Total Respondents	**0**
(skipped this question)	**0**

APPENDIX B: TESTING & VALIDATION DATA COLLECTION SURVEY

SURVEY

2. Demographics

1. What is your company's main business application focus?

	Response Percent	Response Total
Health related	0%	0
Biotech related	0%	0
Chemical related	0%	0
Computer related	0%	0
Agricultural related	0%	0
Manufacturing related	0%	0
Service related	0%	0
Consulting related	0%	0
University related	0%	0
Government related	0%	0
Food related	0%	0
Financial Related	0%	0
Other (please specify)	0%	0
	Total Respondents	**0**
	(skipped this question)	0

2. How many employees does your company employ?

	Response Percent	Response Total
Less than 100	0%	0
100-500	0%	0
500-1000	0%	0
1000-5000	0%	0
More than 5000	0%	0
	Total Respondents	**0**

3. Your position with your company is best described as?

	Response Percent	Response Total
Top corporate management	0%	0
Middle management	0%	0
Research division management	0%	0
Researcher	0%	0
Production Management	0%	0
Consultant	0%	0
Other (please specify)	0%	0
	Total Respondents	**0**
	(skipped this question)	0

4. What were your company's last year estimated revenues?

	Response Percent	Response Total
Less than $1 million	0%	0
$1-$5 million	0%	0
$5-$25 million	0%	0
$25-$100 million	0%	0
$100-$1 billion	0%	0
More than $1 billion	0%	0
	Total Respondents	**0**
	(skipped this question)	0

5. Does your company License-In technologies?

	Response Percent	Response Total
Yes	0%	0
NO	0%	0
	Total Respondents	**0**
	(skipped this question)	0

6. Using a 1 to 5 scale where "1 = Totally inferior to other technologies " and "5 =Unique and far superior to other technologies ", from a technological point of view, how do (did) each of th technologies under the two different scenarios compare to other available competitive technologies ?

	Totally inferior <1>	<2>	<3>	<4>	Unique and far superior <5>	Respon Averag
Technology assessment showed that the technology that was **licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology assessment showed that the technology that was **not licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	0

7. How much alteration is (was) needed on other required technologies for these technologies t work?

	Significantly altered <1>	Highly altered <2>	Moderately altered <3>	Slightly altered <4>	Alteration not needed <5>	Respon Averag
For the technology that was **licensed** to work, other technologies may have to be:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
For the technology that was **not licensed** to work, other technologies may have to be:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	0

8. The technology assessment showed that the technologies under the two different scenarios:

	Had prior claims to the technology <1>	Was weak <2>	Was strong but difficult to proof <3>	Strong & Acceptable <4>	Was strong and enforceable <5>	Respon Averag
Technology assessment showed that the technology that was **licensed** :	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology assessment showed that the technology that was **not licensed** :	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	0

9. Using a 1 to 5 scale where "1 = Very low or highly unacceptable" and "5 =Excellent", and thinking about the two scenarios, how do (did) you classify the "Odds of Market Success" for each scenario:

	unacceptable<1>	<2>	<3>	<4>	High/Excellent <5>	Average
Technology assessment showed that the "Odds of Market Success" for the technology that was **licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
Technology assessment showed that the "Odds of Market Success" for the technology that was **not licensed** :	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**

10. Using a 1 to 5 scale where "1 = Highly unacceptable" and "5 =Excellent", and thinking about the two scenarios, how do (did) you classify the "The technology development time to market " for each scenario:

	Highly unacceptable<1>	<2>	<3>	<4>	Excellent <5>	Response Average
The technology development time to market for the technology that was **licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The technology development time to market for the technology that was **not licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	0

11. Using a 1 to 5 scale where "1 = Highly unacceptable" and "5 =Excellent", and thinking about the two scenarios, how do (did) you classify the "The strength of the Intellectual Property" for each scenario:

	Highly unacceptable<1>	<2>	<3>	<4>	Excellent <5>	Response Average
The strength of the Itellectual Property for the technology that was **licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
The strength of the Itellectual Property for the technology that was **not licensed** was:	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	**0.00**
					Total Respondents	**0**
					(skipped this question)	0

12. For the technology that your company assessed and decided to license, the technology assessment showed that:

	Agree	Disagree	Response Average
No dominant technology existed yet in the field	0% (0)	0% (0)	**0.00**
The inventor was involved and willing to cooperate	0% (0)	0% (0)	**0.00**
Technology was perceived to have quantifiable benefits	0% (0)	0% (0)	**0.00**
The technology was still confidential (no past or future disclosures)	0% (0)	0% (0)	**0.00**
The technology has a functioning prototype	0% (0)	0% (0)	**0.00**
		Total Respondents	**0**

13. For the technology that your company assessed and decided to not to license, the technology assessment showed that:

	Agree	Disagree	Response Average
No dominant technology existed yet in the field	0% (0)	0% (0)	**0.00**
The inventor was involved and willing to cooperate	0% (0)	0% (0)	**0.00**
Technology was perceived to have quantifiable benefits	0% (0)	0% (0)	**0.00**
The technology was still confidential (no past or future disclosures)	0% (0)	0% (0)	**0.00**
The technology has a functioning prototype	0% (0)	0% (0)	**0.00**
		Total Respondents	**0**

4. Thank you

14. To receive a final copy of the results of this survey, please enter your email address

APPENDIX C: THE FRAMEWORK

Technology Assessment Framework

The purpose of this framework, is to provide an assessment tool for the evaluation
and prioritization of university technologies for licensing and commercialization

To determine the licensing probability of your technology, you will need to answer a total of 10 questions. Please keep in mind that the output is as reliable as your input.
So please do your homework.

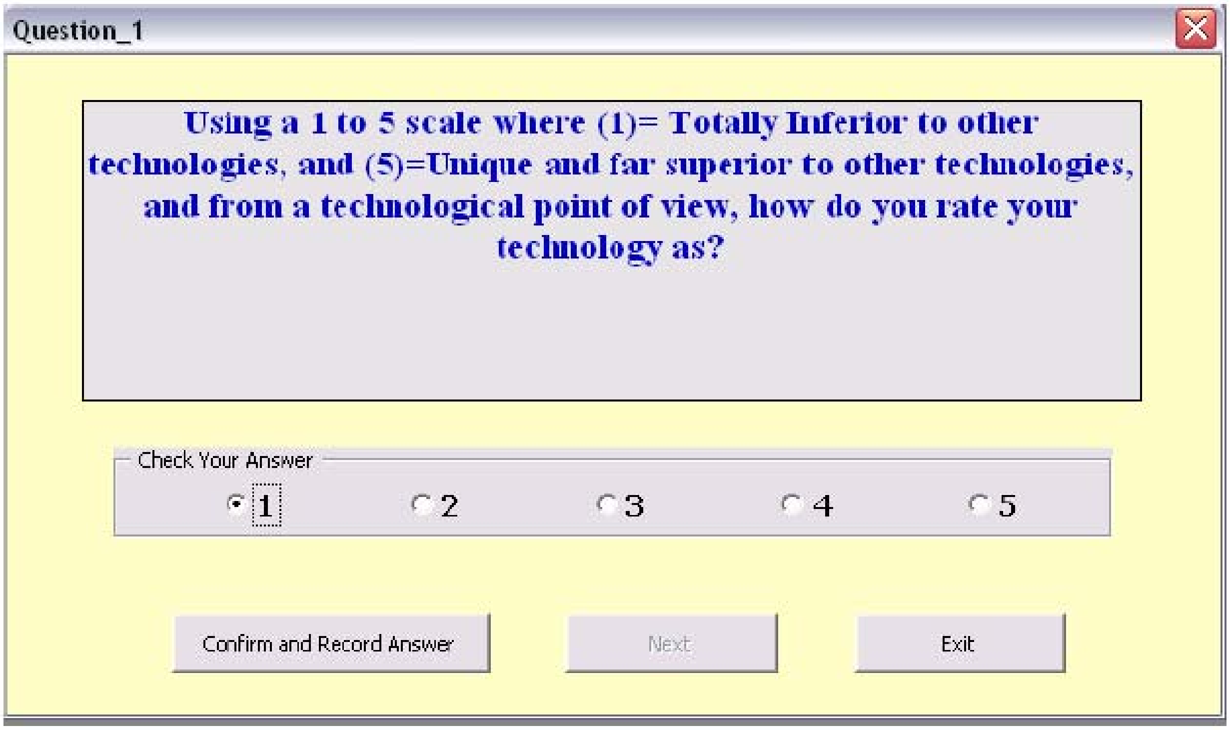
The outcome of this framework, is based on the most comprehensive national survey of the best technology licensing experts from major fortune 500 companies

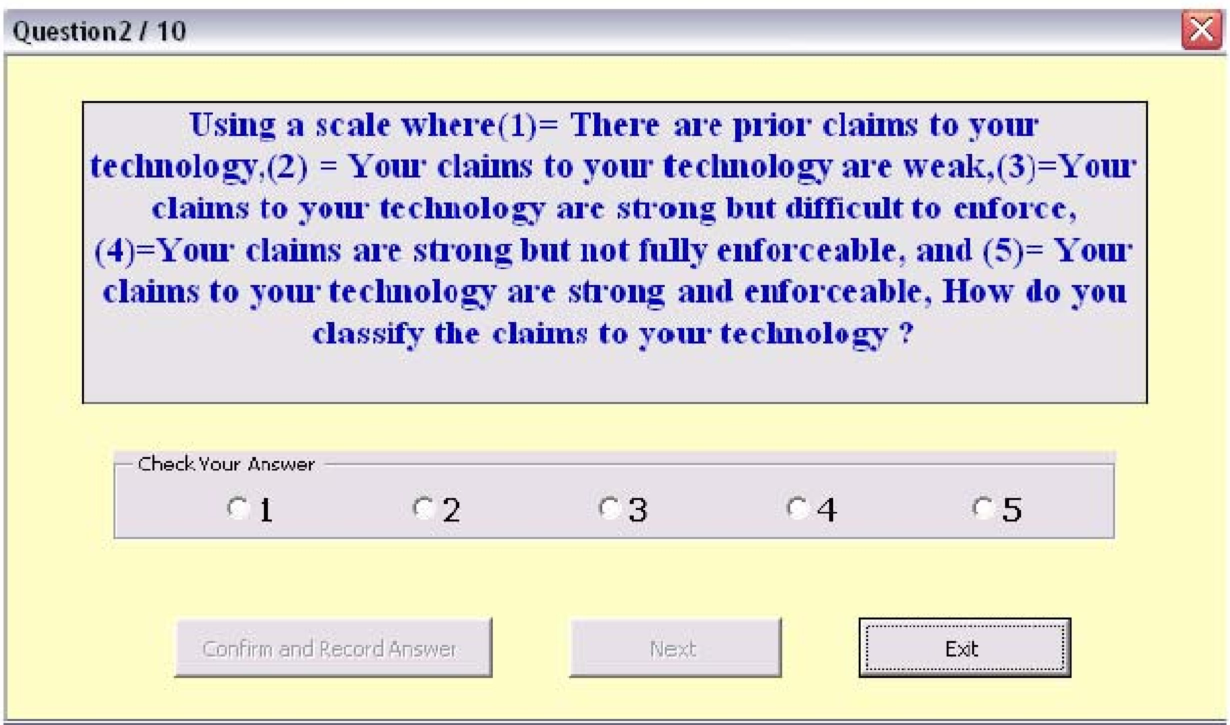
Start Evaluation

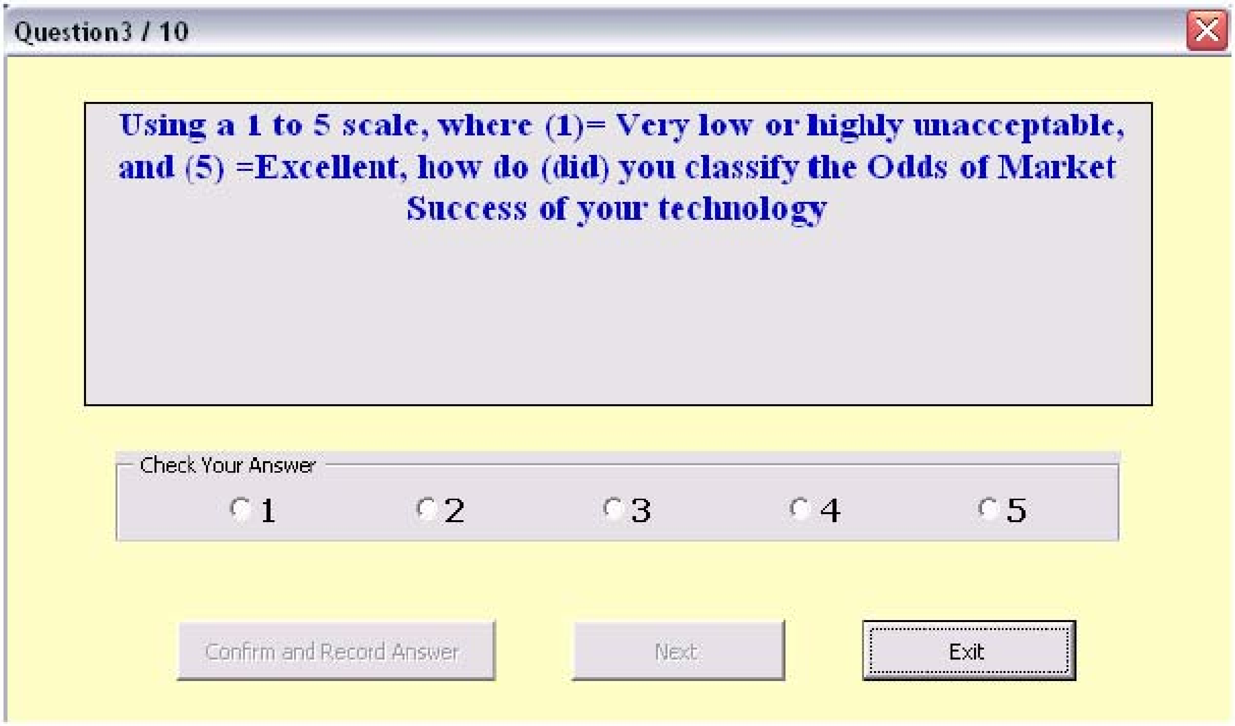
Question_1

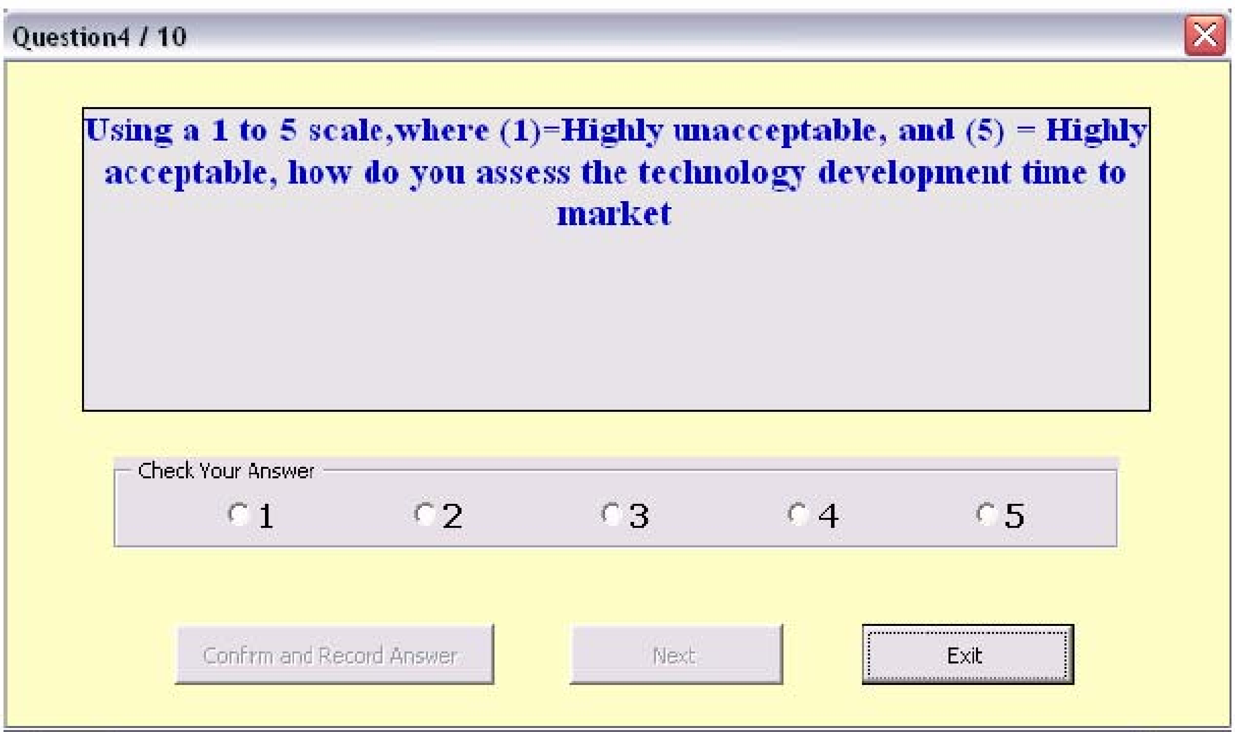
This technology assessment framework provides a tool to evaluate the licensing probabilities of university technologies for licensing and commercialization. Please note that the output of this tool is as good as your input. We suggest that you do your homework by evaluating your answers. Best wishes and Good Luck

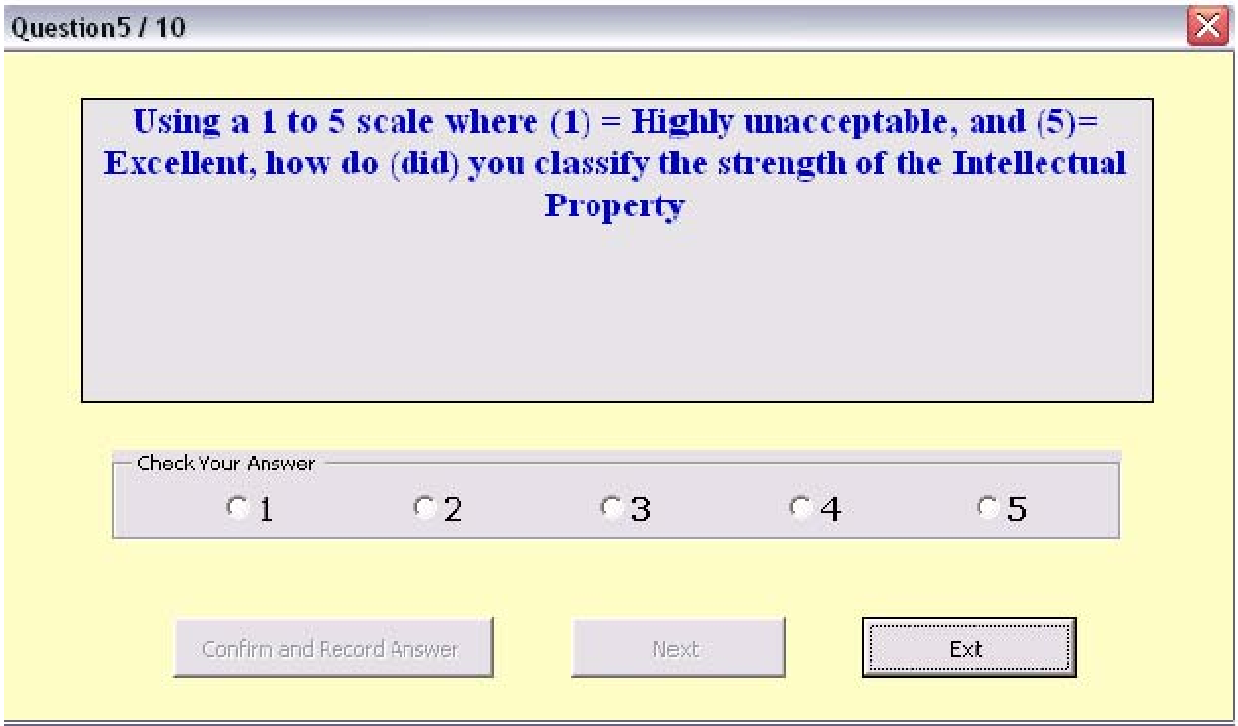
Start Assessment

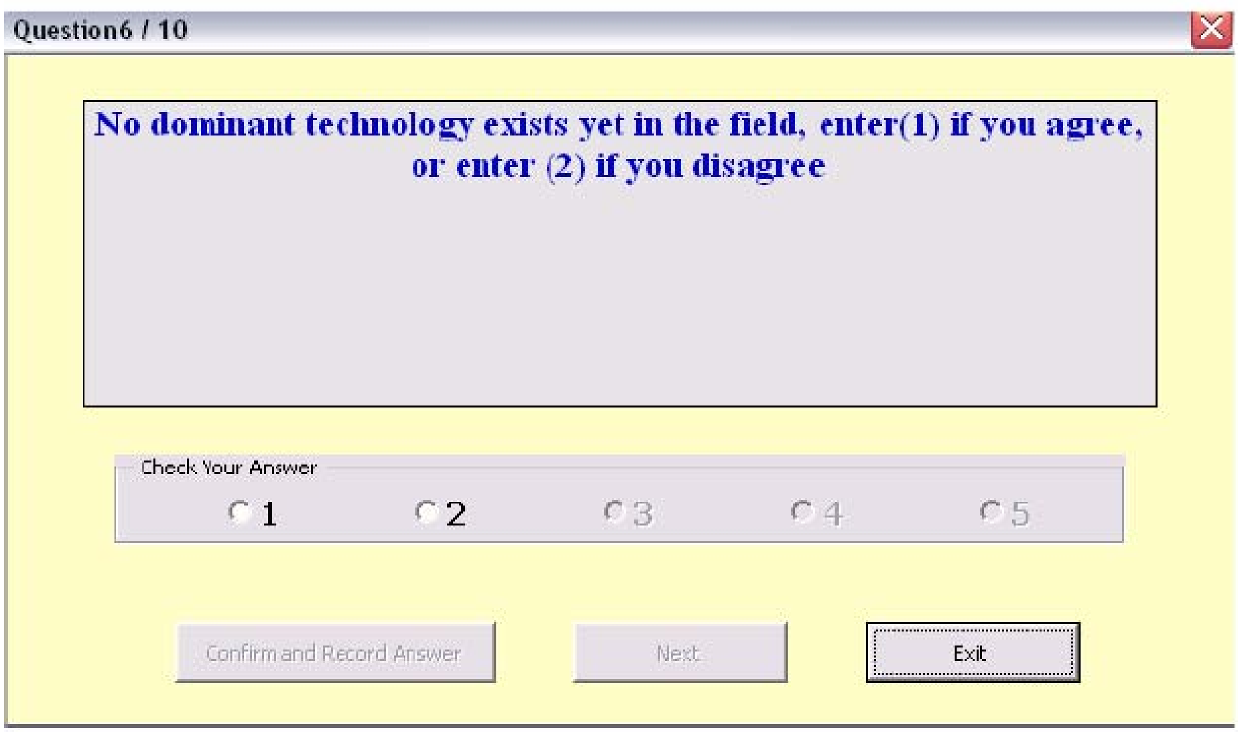

Question_1
Using a 1 to 5 scale where (1)= Totally Inferior to other technologies, and (5)=Unique and far superior to other technologies, and from a technological point of view, how do you rate your technology as?
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Next
Exit

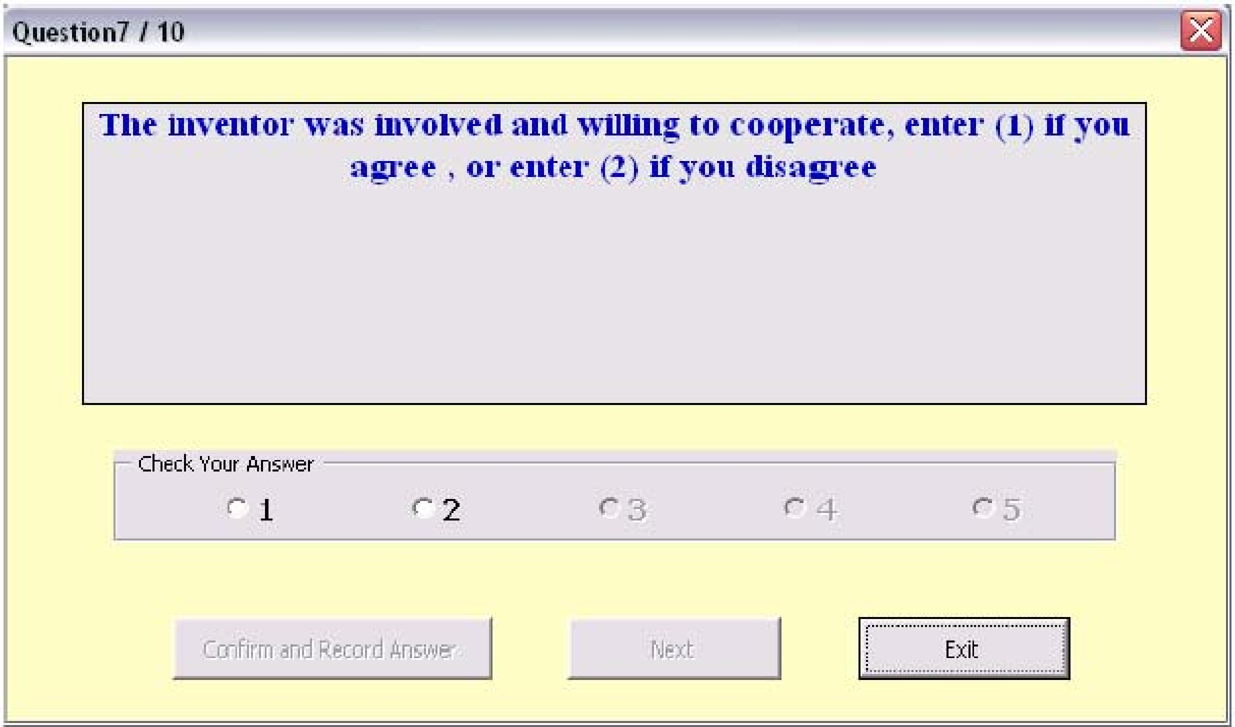

Question2 / 10
Using a scale where(1)= There are prior claims to your technology,(2) = Your claims to your technology are weak,(3)=Your claims to your technology are strong but difficult to enforce, (4)=Your claims are strong but not fully enforceable, and (5)= Your claims to your technology are strong and enforceable, How do you classify the claims to your technology ?
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Next
Exit

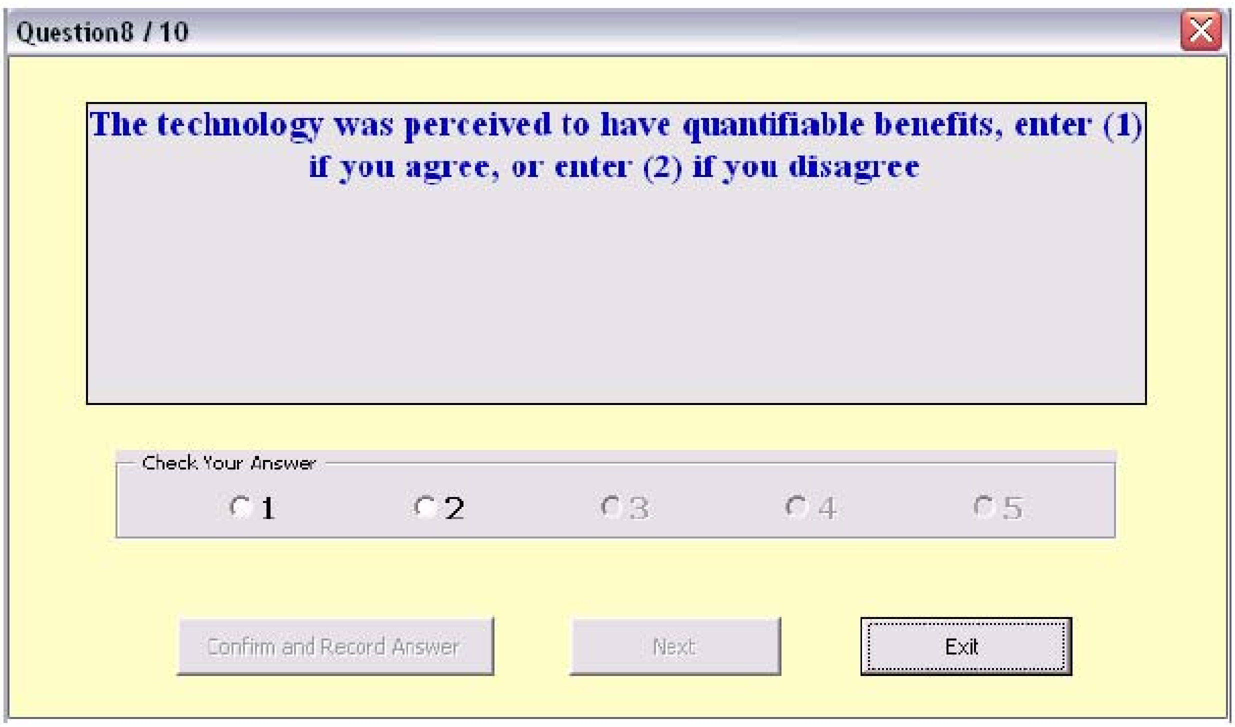

Question3 / 10
Using a 1 to 5 scale, where (1)= Very low or highly unacceptable, and (5) =Excellent, how do (did) you classify the Odds of Market Success of your technology
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Next
Exit

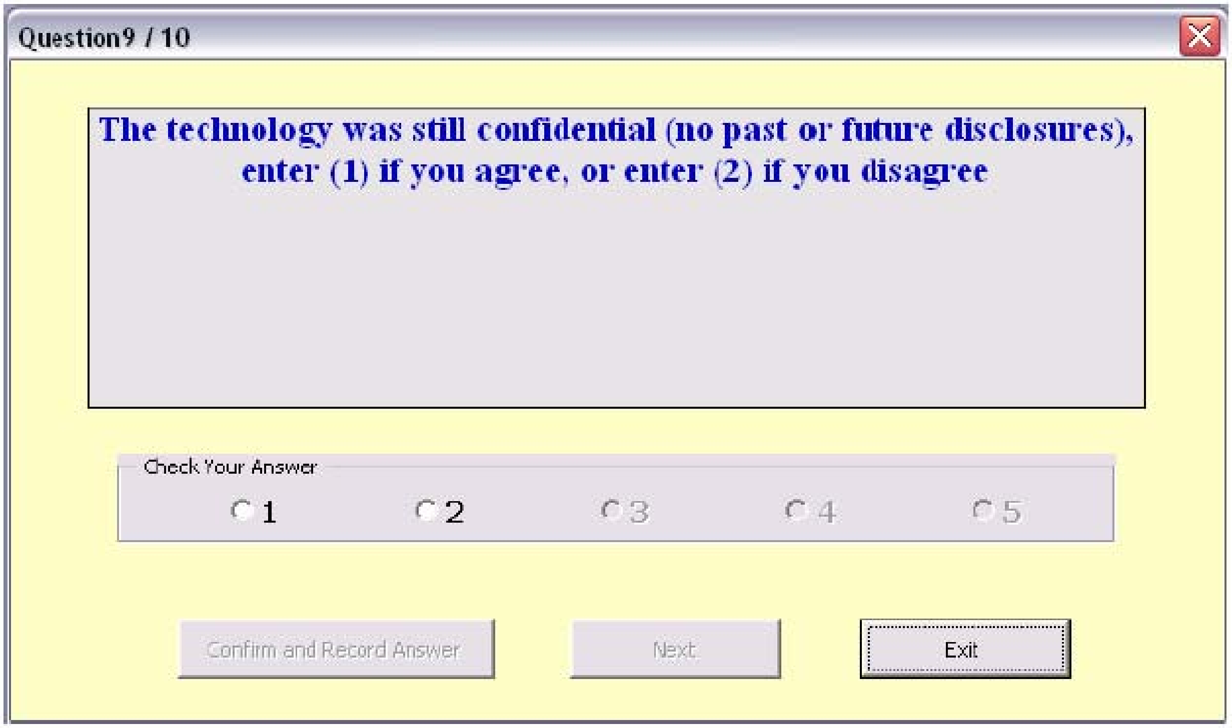

Question4 / 10
Using a 1 to 5 scale,where (1)=Highly unacceptable, and (5) = Highly acceptable, how do you assess the technology development time to market
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Next
Exit

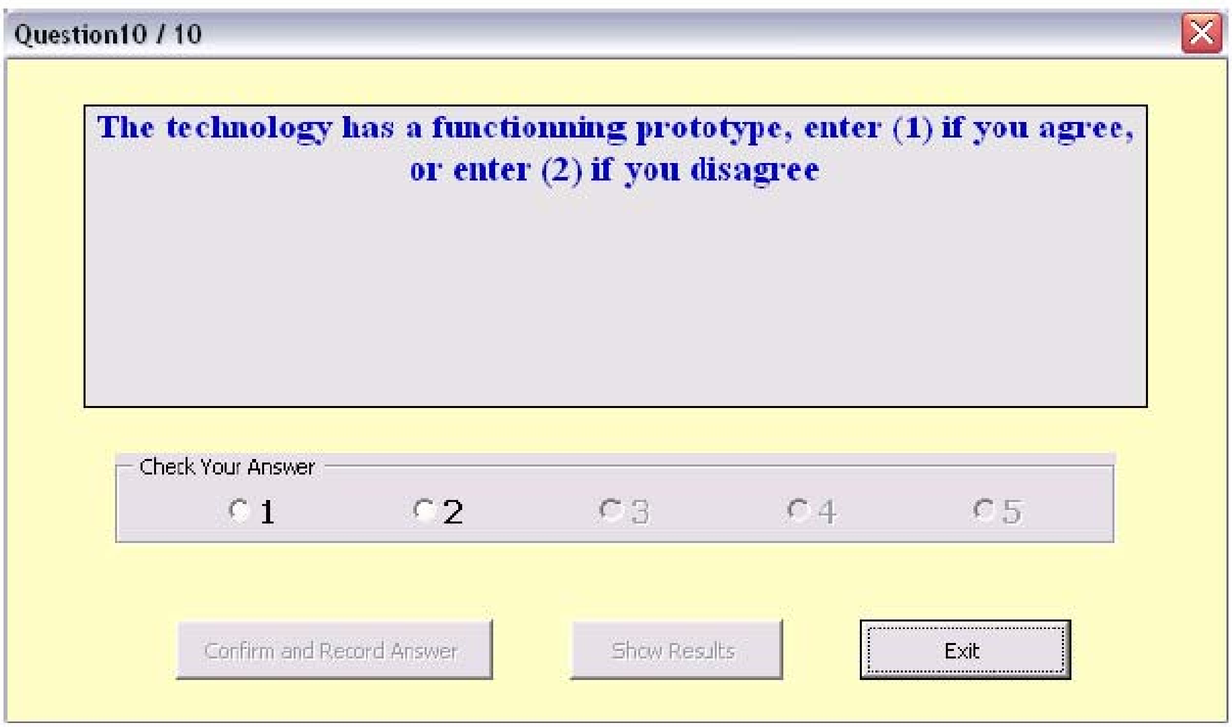

Question5 / 10
Using a 1 to 5 scale where (1) = Highly unacceptable, and (5)= Excellent, how do (did) you classify the strength of the Intellectual Property
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Next
Exit

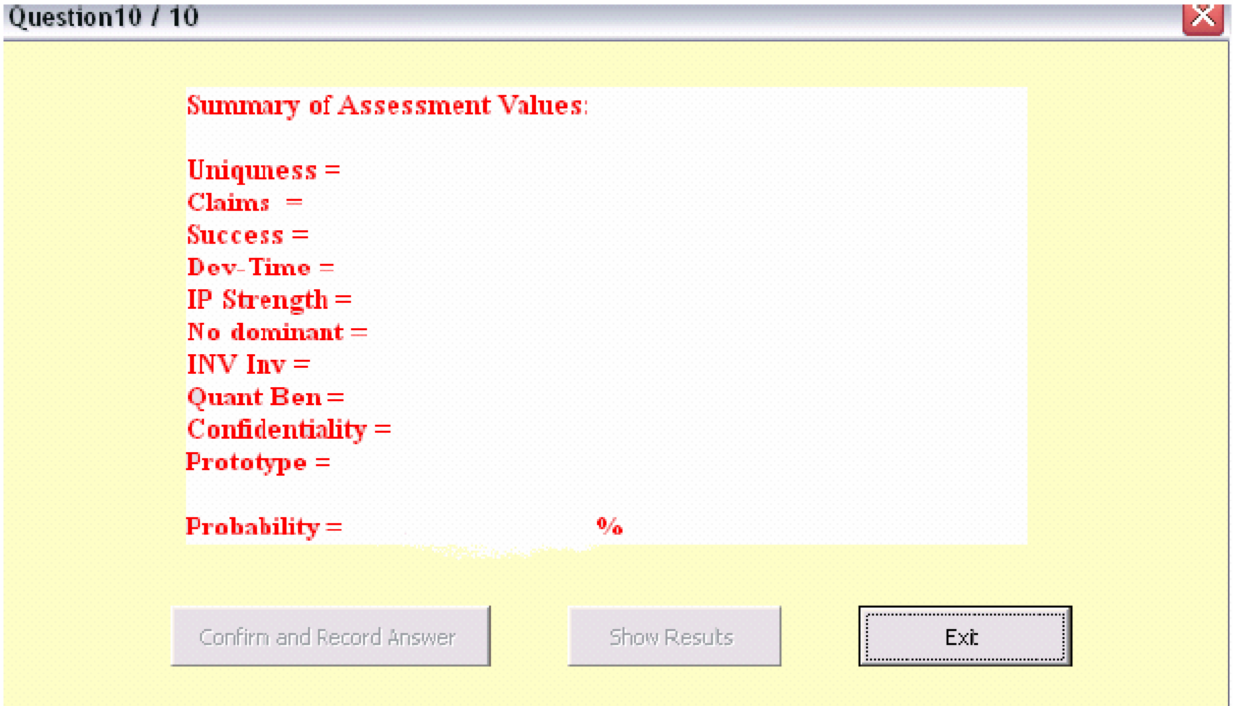

Question6 / 10
No dominant technology exists yet in the field, enter(1) if you agree, or enter (2) if you disagree
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Next
Exit


Question7 / 10
The inventor was involved and willing to cooperate, enter (1) if you agree , or enter (2) if you disagree
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Next
Exit


Question8 / 10
The technology was perceived to have quantifiable benefits, enter (1) if you agree, or enter (2) if you disagree
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Next
Exit


Question9 / 10
The technology was still confidential (no past or future disclosures), enter (1) if you agree, or enter (2) if you disagree
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Next
Exit


Question10 / 10
The technology has a functionning prototype, enter (1) if you agree, or enter (2) if you disagree
Check Your Answer
1
2
3
4
5
Confirm and Record Answer
Show Results
Exit


Question10 / 10
Summary of Assessment Values:
Uniquness =
Claims =
Success =
Dev-Time =
IP Strength =
No dominant =
INV Inv =
Quant Ben =
Confidentiality =
Prototype =
Probability = %
Confirm and Record Answer
Show Results
Exit

APPENDIX D: SURVEY RESPONDENTS’ EMPLOYERS

	Ranking Fortune 500		Ranking Fortune 500
AAI Pharma		Glaxo SmithKline	
Abbott Labs	100	Headwaters Technology Innovation	
Aclara Biosciences		Hitachi Global Star Technologies	
Agilent Technologies	290	HP	11
Air Products Corporation	281	Intel	50
Altus Pharmaceuticals		International Aids Vaccine Initiatives	
AOL/ Time Warner	32	Invitrogen	
Astra Zeneca		Johnson & Johnson	
AT&T	56	Medtronics	246
Baxter	237	Merck	84
Bayer		Monsanto	357
Bechtel		Motorola	49
Biomarin Pharmaceutical		Mylan Laboratories	
Boeing	25	Nexus Tech Ventures	
Bristol Myers Squibb	93	Ono Pharma USA	
Brtish Petroleum		Parker Technologies	
BTG Oncology		Pfizer	24
Cargill		Pioneer	
Chembridge Research Laboratories		PLX Pharma	
Comcast	102	Proctor & Gamble	26
Conoco Phillips	7	Roche	
Delphi	63	SAIC Engineering	
DOLBY		SAS	
Dupont	66	Seagate Technologies	
Earthlink		Solvay International	
Eastman Chemical	316	Storage Technologies	
Fifth Generation Computer Corporation		Texas Healthcare and BioSciences	
Fluor	241	The BOC Group	
GEN PROBE		Xerox	
General Electric	3	Yahoo	
Genzyme			

APPENDIX E: INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

University of Central Florida

Office of Research & Commercialization

March 15, 2005

Ahmad D. Rahal
975 Carriage Hill Rd.
Melbourne, FL 32940

Dear Mr. Rahal:

With reference to your protocol #05-2460 entitled, "Assessment Framework for the Evaluation and Prioritization of University Inventions and Innovations for Licensing and Commercialization" I am enclosing for your records the approved, expedited document of the UCFIRB Form you had submitted to our office. **The expiration date for this study will be 3/10/06.** Should there be a need to extend this study, a Continuing Review form must be submitted to the IRB Office for review by the Chairman or full IRB at least one month prior to the expiration date. This is the responsibility of the investigator.

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board through use of the Addendum/Modification Request form. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur.

Should you have any questions, please do not hesitate to call me at 407-823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

Barbara Ward

Barbara Ward, CIM
IRB Coordinator

Copy: IRB file

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