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1. The Future of Technology Transfer at a Major Land Grant University:
Report of the Cornell University Land Grant Panel on Technology Transfer

2. The Search for the Holy Grail?
Maximizing Social Welfare under Canadian Biotechnology Patent Policy

1. WR Coffman, JE Alexander, DJ BenDaniel, PL Carey, HG Craighead, CR Fay, PA Gould, JS Gross, JE Hunter, WH Lesser, S Loker, JN MacLeod, JJ Mingle, NR Scott & AF Krattiger
Cornell University, USA

2. DA Dierker & PWB Phillips
University of Saskatchewan, Candada

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Author's Addresses:

1. W Ronnie Coffman, Department of Plant Breeding, College of Agriculture and Life Sciences Cornell University, Ithaca NY 14853. wrc2@cornell.edu
2. Daniel A Dierker & Peter WB Phillips, Department of Agricultural Economics, University of Saskatchewan, 51 Campus Drive, Sasktatoon S7N 5A8, Canada. dad128@usask.ca and phillips@duke.usask.ca

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Editorial Policy: The purpose of *IP Strategy Today* is to provide a forum to share creative, innovative and pragmatic analysis and ideas in intellectual property strategies and management issues, particularly as they affect the transfer of proprietary technologies to developing countries, developing countries access to proprietary technologies in agriculture, the environment and health, and the international exchange of genetic resources. Emphasis on the implications of biotechnology are specifically encouraged. Papers must have a problem solving orientation and demonstrate originality and innovation in thinking, analysis, methods or application. Issues related to research investments and management, bilateral and multilateral donor policies, extension, teaching, public-private partnerships are equally encouraged, as is interdisciplinary research with a significant IP and international development component. Manuscripts, review articles and working papers that offer a comprehensive and insightful survey of a relevant subject, consistent with the scope of *IP Strategy Today*, are welcome. All articles published, regardless of their nature, will be reviewed anonymously by members of the editorial board.

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College of Agriculture & Life Sciences
Cornell University
Ithaca NY 14853, USA

Foreword

The responsibility of land grant universities to advance the common good is nowhere more complex than in technology transfer. The complexity comes from the need to transfer "knowledge across disciplines, professions, sectors, regions, communities and societies," as described by the panel members in this report.

The urgent need for economic development in New York State partly explains technology transfer's current importance at Cornell University. This report stresses the unalterable imperative of scientific and scholarly excellence, an imperative that is fundamental to technology transfer, for the benefit of industry and, thereby, the citizenry of New York. Cornell's reach extends far beyond New York State, however, and so technology transfer issues, including conflict of interest and commitment, university policies and surveillance, intellectual property protection, and securing venture capital are broadly viewed.

This report is one of five reports that address the land grant mission of Cornell for this century. Most closely related is the report on "Engineering Outreach: Economic Development"; other reports include "Outreach/Extension: Colleges of Agriculture and Life Sciences", "Human Ecology, and Veterinary Medicine", "Outreach/Extension: Industrial and Labor Relations", and "K-12 Education". All reports are posted on the website (http://www.provost.cornell.edu/land_grant/mission_review/).

The land grant mission review was envisioned by President Hunter R. Rawlings, III. His leadership and the interest and commitment of Provost Carolyn "Biddy" Martin were central to the panel's accomplishments.

Francille M. Firebaugh
Vice Provost for Land Grant Affairs, Cornell University.

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[1] *WR Coffman, JE Alexander, DJ BenDaniel, PL Carey, HG Craighead, CR Fay, PA Gould, JS Gross, JE Hunter, WH Lesser, S Loker, JN MacLeod, JJ Mingle, NR Scott & AF Krattiger*. 2003. The Future of Technology Transfer at a Major Land Grant University: Report of the Cornell University Land Grant Panel on Technology Transfer. *IP Strategy Today* No. 6-2003. Pp. 1-44.

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Executive Summary and Recommendations

Social problems seldom have technical solutions. Although technology development and technology transfer are important prerequisites for Cornell University ("Cornell") as it continues to fulfilling its land-grant mission of improving livelihoods for the citizens of our community, our state, the nation, and the world, it must be considered within the context of society's larger needs. A comprehensive, ecological perspective is needed. Unless we improve schools in New York State, the capacity of communities to govern well, health care, and the environmental and aesthetic quality of our landscapes, then technology development and transfer will not have much impact in our state. Cornell plays an important role in all of these areas, and so technology transfer must be placed in the proper perspective.

Cornell became a land-grant university when most of the people in New York State were living in rural areas. Many people were trapped in poverty with limited opportunities to improve their livelihoods. Accordingly, Cornell focused on improving the land's productivity through the development and transfer of relevant technology. Although still a constraint in many parts of the world, agricultural production is no longer at the heart of the land-grant mission in New York State. What remains central to the land-grant mission, however, is the underlying principle of knowledge for the benefit of the public good: knowledge that contributes to social and economic welfare. We hope this report will contribute to the rediscovery and redefinition of our land-grant mission for contemporary times. This Panel's vision is that Cornell must continue to excel in science and world-class scholarship and directly benefit people through technology transfer and public scholarship.

1. Definition and Evolution of Technology Transfer at Cornell

Cornell as New York State's land-grant university has had a major impact on the state, the nation, and the world in the discovery and transfer of knowledge. If Cornell is to continue to play a leadership role in addressing the problems and needs of society in the 21st century, it must continue to enhance its existing mechanisms for knowledge transfer. Because technology transfer is an *organizational* and not a *technical* process, it requires the transfer of knowledge across disciplines, professions, sectors, regions, communities, and societies. Presently, we do not have the coordinated and strategically effective program in industrial extension required to fulfill our land-grant mission in the modern context.

2. Conflict of Interest and Commitment

Conflict of interest and conflict of commitment have been clearly defined for faculty in a university policy statement and an agreement that they sign each year. For the university as a whole, these are defined by Bayh-Dole with regard to government-sponsored research. These policies have been developed to uphold the requirements of federal funding agencies and foundations, but the discussion about the university's role in patents, licensing, and business startups goes beyond these policies. At the foundation of the debate is the original land-grant mission, which has viewed research and its transfer as a philanthropic responsibility of the institution and its faculty. Our current challenge is to interpret conflict of interest and commitment in order to enhance the technology transfer opportunities of the faculty, the institution, and industry while maintaining the public trust. This is a core issue in considering how we fulfill our land-grant responsibilities.

3. Venture Capital

Major venture capital firms are not investing in Cornell technology. Our remoteness may be a factor, but a more likely possibility is that we have structural and cultural problems that do not facilitate the attraction of venture capital.

Cornell should organize alumni contacts to venture capital firms and work jointly toward a coordinated program in which we reach out to our alumni in venture capital and their networks. Both the Johnson

Graduate School of Management and Alumni Affairs and Development are already doing this. The idea is to inform firms that Cornell is trying to develop a free-flowing system where professors can initiate businesses. Specifically, we need the cooperation of alumni in such venture capital firms as Greylock, Charles River, APAX, OVP, and other firms that have not invested in a Cornell startup.

4. University Policies

Data suggest that the Cornell Research Foundation (CRF) has operated broadly within the country's top 30 research universities in the country in terms of patenting and licensing success and revenues. While CRF has been relatively aggressive and successful at patenting, it has been less so in terms of obtaining royalty income or equity income from big "winners." Patenting and licensing policies are similar across all U.S. universities. Implementation is the variable. Accordingly, we probably need a dialogue among the faculty and staff concerning our institutional attitude toward faculty entrepreneurship. Most faculty members do not know the CRF business model, not much less how to go about it for themselves. From the land-grant point of view we need to move inventions from Cornell to the public faster, streamlining the process of access to discoveries and using our knowledge for the public good.

5. Surveillance and Intellectual Property Protection

The dimensions of the problems related to intellectual property (IP) protection are difficult to assess. Internally, it is unclear whether or to what extent individuals may be circumventing the patent policy requiring disclosure and assignment of inventions to the University. Here, the University/CRF presume good faith compliance with the policy—signing the patent agreement upon appointment—and rely on faculty (and current and former graduate students) to report instances of unauthorized use of Cornell technology.

Externally, it is similarly unclear whether or to what extent companies are using Cornell-owned IP without entering into a license. CRF relies on faculty inventors and their network of research colleagues and associates (including former students) to alert us to any suspected infringement of university-owned technology.

6. The Special Case of New York State

New York State has lagged seriously behind other states such as Georgia, Illinois, Michigan, and North Carolina in funding technology transfer. The land-grant institution in every state has a special obligation to the state; and the state has a special obligation to the institution. Jointly they are expected to transfer technology to benefit the citizenry. In New York State we need to reexamine that partnership as we attempt to restructure our approach to technology transfer.

To enhance Cornell's ability to act in a positive economic fashion in its technology transfer program as the land-grant institution of New York State, Cornell might consider the following propositions (these are possibilities, not necessarily recommendations).

- Centralize its Industrial Outreach Program like the University of Wisconsin and the Massachusetts Institute of Technology (M.I.T.) in order to have industrial outreach that is team oriented and non-competitive internally, committed to maximizing university/industry relationships and sponsored research, and to standardizing the training of industrial outreach professionals in all respects. Not only have centralized industrial outreach groups shown that they can keep abreast of research developments in their assigned center(s), these central groups develop an *esprit de corps* not possible if they are spread across campus in isolated units.
- Move CRF back to the center of campus to assist in fostering entrepreneurship, in particular by facilitating and increasing faculty interactions with CRF.
- Create a five-year strategic plan and include the development of 50-75 acres of corporate buildings in the Cornell Business and Technology Park designating at least 50,000 square feet for Cornell in-

cubator space. Once there is a critical mass of growing companies, Cornell may develop the Business and Technology Park to the point of employing several thousand people, as has the University of Wisconsin at Madison.

- Prioritize the identification of a corporate partner to joint venture with Cornell concerning the Cornell Business and Technology Park, with the goal of making this corporate space more financially competitive with neighboring counties.
- View itself as a catalyst for economic growth in the region by developing a critical mass of quality company starts in the Cornell Business and Technology Park so as to attract venture firms, law firms, and other service industries to Ithaca.

7. The Future of Technology Transfer at Cornell

Cornell does not have an effective industrial outreach program. Both private companies and New York State are complaining about the difficulties of working with us. In matters of conflict of interest and commitment, faculty are considered guilty until proven innocent, thus curtailing faculty entrepreneurship, interaction with the private sector, and technology transfer. Major venture capital firms are not investing in Cornell technology, limiting our ability to fulfill our land-grant mission in the modern (highly industrialized, capitalist) environment. Cornell policies are not very different from like institutions, whether land-grant or ivy league, but we implement the policies differently from some (non land-grant urban institutions in particular) who appear more successful in technology transfer. Our emphasis on patents and the defense of patents may place us in a competitive posture with industry that possibly conflicts with our land-grant mission.

Option I. The first option, as always, is to maintain the *status quo*. This seems unwise given the concerns expressed by Cornell constituencies and this Panel's interpretation of the modern land-grant mission, which sees effective technology transfer as the key to linking research and scholarship to public benefit. Our panel was a diverse group, coming from the four corners of Cornell, and most of us believe that a change is needed.

Option II. The second option is to tweak the current system. We need an effective, coordinated industrial outreach system. Only with great difficulty and net loss of current effectiveness could we convert Cornell Cooperative Extension into such a system. Some of the elements needed are contained in the Office of the Vice Provost for Research, including the Office of Sponsored Programs (OSP) and the Office of Economic Development (OED). OSP also oversees CRF, a separate 501(c)2 organization with responsibility for patents and licenses. A minimum response would be to add an associate vice provost for outreach who would coordinate and hopefully improve the effectiveness of our outreach efforts. This position would: 1) coordinate outreach university-wide and utilize more effectively the human resources already in place; 2) work with CRF to liberalize the university's licensing arrangements; and 3) work with OED to increase the availability of venture capital to develop Cornell technologies.

Option III. The third option is a major overhaul. We could create a new, high profile Office of University Outreach led by a vice provost. It would be on equal footing with the Office for Research. The general division of labor would be that the Office for Research would have responsibility for the funding of programs, particularly research, and the Office of University Outreach would handle outreach including OED and CRF. The latter might need a name change, as it is not really a research foundation. Indeed, CRF is instrumental to industrial outreach. One alternative would be to relocate CRF to the main campus and to employ a geographically distributed model (the CRF staff who work in engineering would be located in that college; the staff who work with agricultural biotechnology would sit in CALS, etc.). Also, CRF could reorganize as an office within the university rather than as a separate entity as it presently exists, to emphasize the integration of outreach and technology transfer.

8. Recommendations

Recommendation #1. Because Cornell is one of the few institutions in the world with the leadership capacity to address the issues that are so vital to the future of society, the Panel **recommends** that the university should undertake a continuing reexamination and rediscovery of its land-grant mission with a vision toward excellence in science and world-class scholarship while directly benefiting people through technology transfer and public scholarship.

Recommendation #2. Because changes in socioeconomic conditions require a new approach in order to transfer technology from the university for the benefit of society, the Panel **recommends** that the land-grant mission of Cornell be implemented with more emphasis on promotion of technology development and transfer through collaborative industry relationships and faculty entrepreneurship.

Recommendation #3. Because New York State has lagged seriously behind other states such as Georgia, Illinois, Michigan, and North Carolina in funding technology transfer, the Panel **recommends** that Cornell work with New York State to examine and strengthen our partnership in regards to this crucial activity for developing the state's economy.

Recommendation #4. Because the university places a major emphasis (in compliance with federal requirements) on disclosure of conflict of interest and commitment and because this may inhibit entrepreneurship and linkages with industry, the Panel **recommends** that Cornell develop strategies to clarify specific conflict of interest and commitment policies to all campus members, making the discussion points more visible and understood, emphasizing the *management* of conflict of interest and commitment in a more standard manner among the colleges and encouraging faculty entrepreneurship by adding a proactive, entrepreneurial preamble to the ethical constraints placed on faculty and staff.[2]

Recommendation #5. Because faculty members lack incentive and expertise for pursuing the development of inventions the Panel **recommends** that Cornell recognize the issue of a patent on an invention as an academic contribution similar to the publication of a refereed journal article for promotion and tenure purposes and that the university utilize its considerable strength in entrepreneurial education to foster expanded entrepreneurial activity by the faculty, taking steps at the departmental level to inform faculty about the CRF business model and to promote a better understanding of the issues related to technology transfer and its role in a contemporary land-grant university.

Recommendation #6. Because a future benefit of patenting and licensing may be future research funding and philanthropy to the university and because these potential benefits may be jeopardized through aggressive negotiation of license agreements, the Panel **recommends** that Cornell balance its approach to technology transfer by lowering the barriers to obtaining licenses, through timely responses to and enhanced relationships with industry and by recognizing that CRF should not have as its first priority its own financial sustainability.

Recommendation #7. Because industry has indicated some degree of frustration in working with Cornell due, we believe, to the distributed nature of the institution, the Panel **recommends** that the university establish an office or organization that is charged with coordinating and increasing relationships with industry to: 1) offer easy entry to industry interested in collaboration with Cornell faculty; 2) provide resources to faculty interested in starting a business based on research; and 3) encourage venture capital investment in startups, in particular by organizing alumni contacts to venture capital firms and working with them to attract appropriate investments.

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[2] Yale University presently has such a statement that could be considered as a model: *"Yale University believes that a great university should reach out to the world. Accordingly, the University encourages its faculty to seek and to participate in sponsored research, to consult widely, and to engage in many other activities that may benefit not only the participants, but also the University itself, and the larger public. --- However, while Yale recognizes the benefit of such activities, it is also committed to ensuring that they are conducted properly and consistently with the principles of openness, trust, and free inquiry that are fundamental to the autonomy and well-being of a university, and with the responsible management of the university's business. ---The fundamental premise of this policy is that each member of the University must not let outside activities or outside financial interests interfere with that obligation."*

Recommendation #8. Because Cornell relies entirely on faculty for both the disclosure and enforcement of patents, the Panel **recommends** that Cornell ensure that all newly hired faculty and staff are informed of the disclosure and assignment obligations set forth in the university's Patent Policy, and that Cornell reinforce among faculty the importance of being especially vigilant about—and promptly reporting to CRF—any suspected infringement of university-patented technology.

Recommendation #9. Because of clear evidence that some companies will take advantage of universities and infringe on patent holdings, the Panel **recommends** that Cornell continue to pursue its current assertive policy stance on seeking legal recourse against suspected infringers when reasonable licensing efforts fail.

Recommendation #10. Because it is consistent with our land-grant mission; because it is important to provide jobs in Tompkins County that will attract two-career couples; because a strong money-multiplier effect in the local economy results from IP-based businesses that do not require manufacturing elsewhere (for example software); and because it is important to Cornell in its modern land-grant role to be situated in a strong and vibrant community of scientific entrepreneurs, the Panel **recommends** that Cornell should place increased emphasis on technology transfer activities that will support local business growth.

Recommendation #11. Because intellectual property rights (IPR) are here to stay and globalizing; because most key inventions will continue to occur in the public sector at research universities such as Cornell; because public funding should maximize public benefits and food security is an important public benefit; because international agricultural research centers and national agricultural research systems throughout the world need help with access to IPR; because the private sector will not serve poor farmers; because private companies have IPR that they are willing to donate, and IPR also creates added value; because Cornell scientists would like to see their work benefit needy people; and because a portfolio of public IPR supplemented by case-by-case licensing can provide freedom to operate and sharing that will benefit humanity, the Panel **recommends** that Cornell University participate in an effort by the Rockefeller Foundation and other leading research universities to establish an IPR clearinghouse and an IPR pool that will facilitate collective licensing of our technology for humanitarian use throughout the developing world.

The Panel recognizes that there are a number of issues and follow-up activities requiring additional discussion and consideration. These are summarized in the table below.

Major Areas for Further Consideration/Follow-up

Area	Issue
Policy and Strategy	There has never been a public debate about where on the entrepreneurial spectrum of entrepreneurial activity Cornell wishes to be. Such a dialogue is overdue.
	What are the "standards of excellence" by which Cornell's IP and technology transfer policies should be measured?
	Questions regarding the impacts of developing or expanding or diminishing an entrepreneurial spirit at Cornell need to be considered.
	What potential benefits could be accrued by increasing investment in IP protection and licensing as a means of being more supportive of technology transfer?
	What role, if any, should Cornell assume in the international arena for making technologies available to the poor on concessionary terms?
	Should the protection and licensing strategies (and perhaps the IP policy) be different for different schools at Cornell (e.g. medical, agriculture)?
Research	Research on the impact of policy on a university's technology transfer efficiency should be encouraged.
Teaching and Training	How can the protection of inventions be encouraged? How can it enable and enable Cornell to better capitalize on the technology transfer of its IP?

1. Definition and Evolution of Technology Transfer at Cornell

"The physicist, who having completed a research no matter how attenuated, on reaching the street can not explain his findings and its usefulness to the first man he meets, should return to the laboratory; his research is not complete." (Lord Kelvin, 1824-1907)

The nation's major research universities and Cornell University ("Cornell") in particular make unique contributions to society by education of young persons and by transfer of knowledge to business, government, and industry for the development of new products and activities that shape our global economy. In her book, *Knowledge Without Boundaries*, Walshok (1995) argues that research universities must create ways to make their resources more up-to-date and accessible to our publics.

One of the popular terms to express the transfer of knowledge is technology transfer. However, technology transfer is a complex issue. Vannevar Bush in 1945 set forth the relationship between research and society in his report, *Science: the Endless Frontier*, which embraces the social contract between science and society in the following theses:

- New scientific knowledge is intrinsically useful;
- Science provides a reservoir of knowledge that can be applied to national needs; and
- Scientific progress is essential to the national welfare and… results from the free interplay of free intellects, working on subjects of their own choice, in a manner directed by their curiosity.

Cornell's 1994 Task Force on the Generation and Application of Knowledge linked the importance of integrating knowledge discovery and knowledge transfer to the public via four guiding principles:

- The scholarship involved in discovery, integration, application, and teaching serves to shape modern society;
- Research and outreach programs, across the entire university, are integral components of Cornell's land-grant mission;
- Effective integration of research, teaching, and outreach is central to Cornell's mission; and
- Cornell's research and outreach efforts must address global opportunities and challenges.

Moving from knowledge transfer in a broad sense to technology transfer in a more specific sense, technology transfer means the transfer of results of basic and applied research from the university to industry for the development and commercialization of new products and processes (Walshok 1995). Thus, the goal of Cornell's technology transfer function has two components: 1) to insure that society benefits from the transfer of Cornell technology; and 2) to garner reasonable financial returns to Cornell through the licensing of intellectual property (IP). A mix of mechanisms, both formal and informal, has evolved to facilitate technology transfer. These mechanisms include:

Students: Undergraduate and Graduate. Students receive an education and take their new knowledge and capabilities to the workplace environment.

Faculty Exchanges. Faculty members take sabbatical leaves and also enter into consulting agreements.

Cooperative Extension. Since 1917, agricultural extension at land-grant universities has provided a model for engineering extension and technology extension services. Although Cornell has not established a formal engineering extension service, it did create an Innovative Industrial Extension Program to meet knowledge needs of small businesses from the mid 1980s to mid 1990s. Also, a Cornell University Outreach Council served to provide administrative leadership and support for facilitating, nurturing, positioning, and communicating university-wide outreach efforts from 1994- 1998.

University/Industrial Liaisons. Three relatively unique industry-sponsored research agreements were developed during the 1990s. One was a XEROX Corporation-supported Design Research Institute.

Another, the Electronic Packaging Alliance, involved support from IBM, Digital Equipment Corporation, AMP and 3-M Corporation. The Biotechnology Institute was initially supported for six years by Eastman Kodak, General Foods and Union Carbide. In addition to industry support, these liaisons leveraged support from both federal and state governments. Companies not only contributed financially but also individual companies deployed some of their employees to work on campus to enhance significant interactions between faculty, students, and the corporate employees. These alliances created a direct conduit for technology transfer. It should be noted, however, that based on Cornell's experiences, they have a limited life because corporations operate on short product cycles.

Conferences, Workshops, Seminars. These events vary from single-purpose events, including the many educational programs offered by Cooperative Extension, to sessions organized on a regular basis in partnership with corporations such as the annual meetings of the Polymer Outreach Program.

Incubator and Business Park. Cornell has managed the Langmuir Building at the airport since the 1960s as a virtual incubator. More recently, with the increased focus on small business development and startup companies in Langmuir and new buildings at the airport, a dynamic Business and Technology Park has emerged. The brochure *Cornell's Research Serves the Region: Small Business Development* documents that 38 companies were founded by Cornell faculty, staff, students, or alumni with a transfer of university technology or knowledge. Seventeen companies indicate that their proximity to Cornell's intellectual resources is essential to their business and 21 companies were founded to commercialize specific Cornell technologies. These companies employ approximately 7000 persons, about 3200 of whom are in the Ithaca area.

Entrepreneurship. The spirit of entrepreneurship has advanced, if not flourished, during the past decade. An increasing emphasis on entrepreneurship has developed within the Johnson Graduate School of Management (JGSM) and the Entrepreneurship and Personal Enterprise (EPE) program. In addition, courses have been developed within JGSM, the College of Agriculture and Life Sciences, and the College of Engineering, that attract large numbers of students who will later enter post-graduate life better prepared to operate in the corporate sector or to develop startup companies.

Patenting and Licensing. Over the years patenting and licensing have been perceived as traditional mechanisms for technology transfer, particularly in getting research results into the commercial sector. At Cornell University, as well as at our peer universities, there has been a significant trend in the 1990s to increase patents and licenses encouraged by the federal government and the desire to develop a new revenue stream. With few exceptions, patenting and licensing activities have not created funding on the scale of the research budget of the university.

These mechanisms are all in play at Cornell and have been important in promoting the transfer of knowledge and technology to our publics. The remainder of this chapter will address knowledge/technology transfer through the Cornell Research Foundation (CRF), which is perceived to be a key player in the commercialization of Cornell's IP portfolio. The mission of CRF is based on the principles of outreach to foster creativity and inventiveness, to protect and enhance the IP interests of faculty and staff, and to manage those interests for the benefit of Cornell's research and educational enterprise and its inventors. In carrying out this mission, CRF enhances the local, regional, and national economies and strives to transfer Cornell's IP for the public good.

Several parameters—financial, opportunities for "real" world contacts, and impact on business development and economic climate—can measure the success of technology transfer. The technology transfer process provides:

- ***Financial rewards to inventors, industrial partners, university research programs, and the university.*** From 1990 to 2001, CRF has distributed by formula a total of $37,714,896 to its constituencies: inventors $11,893,383; colleges/units $9,329,553; departments $2,317,841; and the university $2,383,914. CRF has utilized $10,795,726 of the total for operations and administration of patents and licenses.

- ***Business development opportunities based on new technologies.*** Faculty and staff have participated in forming startup companies and have developed relationships with local businesses. CRF has taken equity positions in over 20 companies; and several of these have gone public and provided significant financial benefits to the inventor, the university, CRF, and the local community. The most readily recognized financial successes are: Biolistics, Inc., which developed the "gene gun" for eventual sale to DuPont and the creation of Sanford Scientific, Inc.; the whole area of microelectromechanical systems (MEMS), which lead to TMS Technologies, Inc, then Kionix, Inc. and now Calient Networks; and Harpin technology for developing plant disease resistance, which lead to Eden Bioscience.
- ***Employment opportunities for spouses, students, and staff.*** Silicon Valley, Route 128 around Boston, and North Carolina's Research Triangle are highly touted examples of the benefits of technology transfer leading to local job opportunities for university-related spouses, staff, and students. The Cornell Business and Technology Park, which houses 25 companies plus another 42 Ithaca-based companies (all related to Cornell research) employs approximately 3200 persons, providing increasing opportunities for jobs and local economic development.
- ***Opportunities for faculty consulting and local interactions with industry.*** As a campus that is relatively isolated from centers of corporate activity, the opportunity to participate in "real" results from research and meaningful interaction with industry is increasingly advanced by the growth in local businesses based on their connection to Cornell's research enterprise.
- ***Educational and research opportunities.*** Participation in the technology transfer process creates opportunities to acquire research funding and project sponsorship through formal and informal interactions. There is also an increased opportunity for students to participate in internships and a natural opportunity to enrich the undergraduate and graduate curriculum via the introduction of examples and case studies from the industrial world.

Barriers to technology transfer are perceived to exist at Cornell, ranging from academic perceptions that "real" academics should not be engaged in patents and licenses to negative attitudes about CRF not being helpful, timely or aggressive enough in prosecuting patents and licenses. A reasonable approach to the former barrier is to promote discussions in the respective departmental faculties to address the value of patenting to the academic mission. Because faculty promotions and tenure decisions originate at the level of the department, it is important that the value of technology transfer be developed among the department faculty. Our perception is that the most critical link in the technology transfer process is at this level, not at the administrative levels. Significant changes in 1996 to the university's patent and licensing policy, which increases inventor incentives by increasing the inventor's distribution of royalty and equity streams, removed one barrier in the minds of those who felt Cornell's patent and licensing policy lacked adequate incentives.

Since 1998 CRF has also benefited from new leadership and management restructuring, including increased staffing. Changes include: the implementation of a data management system, CRF's on-site presence at the Weill Medical College in New York City, increased staffing in licensing and marketing, a new policy on equity position management, a new policy on outside counsel selection and improved interactions with the university's Office for Economic Development, Cornell Center for Advanced Technology in Biotechnology, Alliance for Nanomedical Technologies, Cornell Business and Technology Park and with local entrepreneurial groups. Thus, CRF is increasingly effective in the specific area of patenting and licensing of IP generated by Cornell faculty and staff.

As Walshok (1995) suggests, it is increasingly clear that technology transfer is an *organizational* not a *technical* process. It requires the transfer of knowledge across disciplines, professions, sectors, regions, communities, and societies. As New York's land-grant university, Cornell has had a major impact in the state and nation in the discovery and transfer of knowledge, and it is essential that the university continue to enhance its mechanisms for knowledge transfer.

2. Conflict of Interest and Commitment

"The success of the extension program in agriculture has been built on a simple formula: knowledge gained, knowledge integrated, knowledge shared, knowledge multiplied, knowledge applied, knowledge trusted. It is time to apply the same formula to our manufacturing industry" (Frank Rhodes, Cornell University President Emeritus, 2001).

"there need to be clearly defined policies for ownership, conflict of interest, and conflict of commitment… universities must have in place policies requiring full disclosure of financial interests and potential conflicts of interest. Anything less will lead to an erosion of public trust." (D. Leahey, Monsanto and former head of Washington University Technology Transfer Office, 1998.)

2.1 Introduction

Conflict of interest and conflict of commitment have been clearly defined for the university and faculty in a policy statement and agreement that they sign each year concerning government sponsored research with the Bayh-Dole Act ("Bayh-Dole"). These policies have been developed to uphold the requirements of federal funding agencies and foundations. But the discussion about the university's role in patents, licensing, and business startups goes beyond these policies. At the foundation of the debate is the original land-grant mission that viewed research and its transfer as a philanthropic responsibility of the institution and its faculty. How should this mission be interpreted in the 21st century so that the technology transfer opportunities of the faculty, the institution, and industry can be enhanced while maintaining the public trust?

In this chapter, we outline some of the issues surrounding conflict of interest for the faculty and the institution and propose some recommendations to guide technology transfer.

2.2 Conflict of Interest and Commitment for Individuals (Faculty Responsibilities vs. Entrepreneurship)

Faculty responsibilities include teaching, discovering new ideas, disseminating ideas, and practicing ethical behavior. They are generally rewarded for entrepreneurial activities as they carry out these responsibilities with salary increases, prestige, royalties, and new opportunities on and off campus. In research, entrepreneurial activities can include:

- Proposing and funding research grants;
- Filing patents;
- Consulting through contracts for research and facility use;
- Consulting through contracts for time and effort;
- Starting businesses; and
- Seeking and accepting venture capital.

However, conflicts of interest and commitment may occur between faculty responsibilities and their entrepreneurial endeavors. In addition to our formal policies, a continuing campus dialogue and other strategies are necessary to keep the conflict of interest and commitment policies visible to and understood by all campus members. The management of these conflicts requires diligence and consistency so that the rewards of technology transfer can be gained and the public trust kept.

Conflicts of faculty commitment that need to be considered include:

- Cooperative Extension faculty responsibilities to New York State organizations;

- Neglect of teaching, research, and service responsibilities;
- Discontinuation of an appropriate level of scholarly work;
- Using university-owned facilities for work not part of university responsibilities; and
- Spending too much time and energy on consulting or startup business.

Conflicts of faculty interests include:

- Conducting contract work that belongs to others, (e.g., contractor reviews manuscripts prior to being sent for publication review or sets restrictions on what research results can be used for);
- Ethical considerations about who funds research; and
- Time limits or other restrictions that influence research imposed by a business or venture capital firm funding the research.

Entrepreneurial endeavors are valued in the university for creativity, prestige, future research funding, and potential licensing and startup businesses as well as for discoveries that save lives, advance technology, or otherwise help society. Every effort should be made to guide these activities to prevent faculty conflict of interest and commitment.

2.3 Conflicts for the Institution

2.3.1 Philanthropic vs. Proprietary

Strong arguments can be made for the broadening of the land-grant mission in the 21st century as it relates to technology transfer. According to Crow (1998), the research model has changed from a linear one progressing from the basic-applied-commercialization model to a parallel process model where technology is being developed at the same time. Universities and industry work together in research and development, sharing ideas and resources, and commercializing technology. How can institutions encourage these collaborations for profit and still serve the public good?

Several possible approaches that combine philanthropic and proprietary interests of the university are listed below:

- Adopt specific requirements for industry-sponsored research. A simple guideline proposed by D. Leahey (1998) of Monsanto and former head of Washington University Technology Transfer Office included the following: 1) F*aculty salary to buy faculty commitment; 2) Graduate student stipends to train future professionals; 3) Travel to inform research and industry community; 4) Page charges to set expectation for publication; and 5) Facilities and administration charges to recognize university costs.*

  The University of California, Berkeley, among others, has a formal set of guidelines for collaborative agreements with industry that could be used as a model.
- Follow the guidelines of Bayh-Dole in industry-sponsored research as well as in government-sponsored research.
- Develop some incentive for New York State businesses to collaborate with faculty and the university in technology transfer. Possible approaches could be a lesser royalty rate as part of the negotiated package, a small percentage of every license to fund an organization that serves New York State, or work with the state to make it more feasible for business startups to remain in New York State.
- Develop a policy for private donors to clarify their expectations about research outputs from research and buildings they fund (i.e., "first looks").
- Agreements must not violate academic freedom.

2.3.2 Venture Capital Conflict Issues

To increase access to the university's technology, procedures and materials to guide and encourage venture capital investments should be developed. These could include a portfolio of venture capitalist firms with potential for funding and a list of CEOs able to run the business startup.

2.4 Recommendations

1. Implement Cornell's land-grant mission statement in a manner that places more emphasis on promoting technology development and technology transfer through collaborative industry relationships and faculty entrepreneurship.

2. Develop strategies to clarify specific conflict of interest and commitment policies to all campus members, making the discussion points more visible and understood. These should emphasize the *management* of conflict of interest and commitment and should encourage faculty entrepreneurial activities. All colleges should have the same policies.

3. Change the university culture toward technology transfer. Recognize that the profit from patents and licensing is in future research funding and philanthropy to the university. Therefore, maximize the number of licenses by lowering the barriers to get those licenses through enhanced relationships with industry. This may mean that CRF should not have to be financially self-sustaining.

4. An office or organization that is charged with coordinating and increasing relationships with industry should be established to encourage venture capital investment in startups. The office should be responsible for:

- Offering an easy-entry to industry interested in collaboration with Cornell faculty;
- Developing a list of potential CEOs to run Cornell business startups based on Cornell-generated research; and
- Providing resources to faculty interested in starting a business based on research.

3. Venture Capital

3.1 Lack of Venture Capital Investments at Cornell

The overriding question is why are there no major institutional venture capital investments in Cornell University technology? Of the 700 venture capital firms in the country, the top 50 have 70-80 percent of the money. These firms are well known: Kleiner-Perkins, Greylock, Brentwood, Summit, APAX, etc. They typically have multiple funds of several hundred million dollars, with a total in the order of .5 billion to 1 billion dollars. Overall, there are around 80 billion dollars presently available in these top-tier institutional venture capital firms. Their investors are major insurance companies, endowments (e.g., Cornell), pension funds, etc. They also have historically by far the best track record in internal rates of return to the limited partners. There are 650 other venture capital firms of decreasing size and prestige, and in general with significantly poorer performance. Since most of those have performed poorly, a shakeout is now taking place. The important point is that the top 50 firms are the primary growth engines of businesses in the country and it is important to have them as investors in Cornell University startups.

To the best of our knowledge, there is no startup from Cornell that has any of these major institutional venture capital firms as investors. They have not come into our deals. On the other hand, Harvard, the

Massachusetts Institute of Technology (M.I.T.), Stanford, and others of our peer schools have numerous investments from these firms. Why are none of these firms investing in Cornell startups?

3.2 Possible Explanations

Cornell's remoteness from major venture capital locations is one explanation that has been offered. But there are other non-urban universities that have had better success, the best example of which is the University of Texas (UT). UT made Texas into the second-largest venture capital region in the country. Its success has been attributed to the aggressiveness of the business school, starting 30 years ago. Before that Texas was a new business development desert. Pennsylvania State University (PSU) is another example, although not of the magnitude of UT. Nonetheless, PSU is non-urban and still has substantive involvement with venture capital. The University of Illinois, Urbana, also has venture capital in their deals. So remoteness is not the full answer.

There seems to be a structural problem at Cornell. The emphasis is on "what does Cornell own?" This leads to protracted and contentious licensing negotiations rather than an emphasis on getting the business started and providing growth support.

Also, communication at Cornell is poor. The faculty need information about how to start a business. At present, faculty members are apprehensive with respect to what Cornell will or will not let them do. They certainly do not have a sense that they are a part of an organized process worth their faith. This same complaint was heard at the Advisory Council at the Engineering School and has been corroborated by the Land-Grant Panel on "Engineering Outreach: Economic Development."

Another explanation offered for the lack of major institutional venture capital investments is the culture at Cornell. Starting a venture is a very unfamiliar process. At Cornell, we are below nucleation. Faculty cannot go down the hall and ask their colleagues what it's like to start a business. At other schools collegial support is a common means of getting a venture going.

It is also not clear that the CRF process works for determining whether or how to license venture startups. On the contrary, the present approach leads to delays and arbitrariness.

3.3 Possible Solutions

We can solve the above problems. First, the decision for providing patents to professors starting ventures should not rest entirely with CRF, which has had a record of protracted and contentious negotiations. Instead, this should be carried out jointly with the dean and/or the department heads of each school. The school, moreover, should have a budget item to cover patenting in the case of dispute. Generally, in research organizations it is not the patent operation that decides why an invention ought to be patented, it is the head of the line department. In the case of university-spawned ventures, the decision as to whether or not a professor or graduate student should proceed in starting a business affects the rest of the department and the relationship of the professor with colleagues.

There are many academic and administrative issues related to whether or not a venture should get started. The deans and faculty, including the business school, are actually best equipped to consider all the factors that influence the venture's viability. Of course, the advice of experts in patent protection and patent law has to be an important part of the decision. But they do not have the expertise to assess adequately the venture's viability. The real expertise resides in the department with people immersed in the technology, particularly in the case of discontinuous innovations that could lead to venture "home-runs" and when dealing with very early-stage university technology deals.

This recommendation is only intended for ventures started by professors and researchers at Cornell based on work that they do at the university. In all other situations, the existing process remains unchanged; CRF negotiates case by case with other businesses. Thus, the function of CRF stays the same as it has been for over six decades. During that time period, centralization in American organizations has been replaced by decentralization. Cornell's new desire to transfer technology to venture startups is better handled through a decentralized approach.

As with any venture investor, Cornell's interest should be in venture "home-runs." If the university wants to assure that it gets a piece of every home-run that comes from Cornell, how can it do this? Obviously, it should get a flat percentage of the initial stock of every business started by Cornell researchers based on technology in any way related to their work. Instead, what exists now is a lot of haggling. Picking winners and losers is difficult. The key is to get businesses started. This means helping faculty get the business up and running, without the frustration of negotiating back and forth and taking a long period of unproductive time with each and every venture. The university is better served by taking a reasonable and fair percentage, possibly as high as 5 percent of initial stock, and getting the business started rather than worrying about a couple of percentage points. Presently, arguing between professors and CRF takes a lot of time and creates alienation between the faculty and Cornell. There should be instead an understanding that Cornell will be given a small percentage of the original stock of every venture startup, without probing whether the work was done while faculty were sitting in their office using university equipment or at home. If everyone were to buy into this, we would be partners and not antagonists, and a big barrier to venture startups would be removed.

Furthermore, Cornell (e.g., JGSM, CRF, Alumni Affairs and Development) should organize alumni contacts to venture capital and work jointly so that there is a coordinated program in which the university reaches out to its alumni in venture capital and their networks. JGSM and Alumni Affairs and Development are already doing this. The idea is to bring them in and tell them that Cornell is trying to develop a free-flowing system where professors can form businesses and that it is doing what it can to support them. The university needs the cooperation of alumni in firms like Greylock, Charles River, APAX, OVP, all of whom who have not invested in a Cornell startup.

Finally, Cornell should make startups part of the educational and research process. There are several incubators forming in the biological sciences arena. If we are not careful, however, these are going to come to cross-purposes; we will be fighting over who controls what. The idea is to develop a highly cooperative environment for forming businesses using the great strengths of the university. We should involve professors and students in all departments to help form businesses, making the startups part of the educational process by helping them in the early development and the implementation of their business model. A highly cooperative environment for the formation of businesses using the great strengths of the university is what is desired.

4. University Policies

4.1 Introduction

4.1.1 Background

Passage of the Bayh-Dole Act in 1980 was a watershed for the licensing of innovative results that were created from federally sponsored research projects in the United States. Through Bayh-Dole the federal government remedied a problem recognized by governmental, industry, and academic leaders: few of the discoveries made possible by federally sponsored research projects were benefiting U.S. taxpayers. The nation's support of public research was not paying off for the public. There was also pressure at both the federal level and within many individual states to reduce public budgets, including the public support provided to higher education and its related research activities. Enabling research institutions to license the results of their researchers' work seemed a positive way to cushion the shock of reduced governmental research support, and such policies also respected the then emerging "privatizing" atmosphere.

The key provisions of the Bayh-Dole Act[3] are:

- established a uniform patent policy for federally funded research;
- encouraged university-industry collaboration;
- universities and/or for-profit grantees/contractors[4] may elect to retain title to inventions developed through government funding; and
- the government retained a non-exclusive license to practice the invention throughout the world (an option that could only be exercised if statutory protection was sought in foreign jurisdictions).

Bayh-Dole and subsequent guidelines have led to a dramatic increase in university-industry IP transfers. In that regard it has been considered highly successful, owing to three key factors:

- Bayh-Dole gave certainty of title to inventions;
- Bayh-Dole delegated leadership to the inventors (individuals and/or institutions) and only provided minimum requirements; and
- Bayh-Dole provided a uniform IP standard for all research conducted with government funds and a predictable patent and licensing procedure.

Because Bayh-Dole permitted research institutions to claim ownership of federally funded research results, this law provided a mechanism for research institutions to commercialize those research results. and in this way, it was argued, the public would benefit. The terms of Bayh-Dole provided the incentive for many U.S. universities (and similar U.S. research institutions) to establish or expand their technology licensing activities. As a result of the new legislation, changing public perceptions, and more stringent fiscal philosophies, most U.S. universities began to establish technology transfer offices during the 1980s and early 1990s.

Based on the membership of the Association of University Technology Managers (AUTM), there are presently more than 300 technology managing offices representing U.S. universities, hospitals, research institutions, and other public sector organizations in the U.S.

4.1.2 Cornell Research Foundation (CRF)

Technology licensing activities at Cornell are managed by CRF, which was established in 1931. CRF has the mandate to manage the IP that is created by Cornell's faculty and staff. It involves obtaining and defending Cornell's IP rights while concurrently seeking to license such IP to appropriate commercial partners. In some cases CRF is involved establishing startup businesses to develop and market Cornell research discoveries.

The objectives of CRF (www.crf.cornell.edu) are to:

1. foster creativity and inventiveness at Cornell;
2. support Cornell's educational and research mission;
3. enhance and protect the IP interests of Cornell and its employees; and,
4. manage IP for the benefit of Cornell's research and educational enterprise and its inventors.

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3 P.L. 96-517 of 12 December 1980 and subsequent modifications (P.L. 98-620 of 8 November 1984).

4 The for-profit grantee clause was part of an amendment in the form of a Presidential Memorandum on *Government Patent Policy* of 18 February 1983.

The <u>technology management activities</u> of CRF include steps to:

1. work with Cornell faculty and staff to identify works and discoveries that might expand Cornell's portfolio of patents, trademarks, and copyrights;
2. evaluate the commercial potential of such IP;
3. determine whether IP protection should be sought;
4. seek and protect appropriate IP rights protection;
5. identify suitable commercial development partners or research and development collaborators and facilitate the partnership development;
6. market Cornell's IP to these technology development entities; and
7. negotiate and manage Cornell's IP licenses.

These activities of CRF are undertaken "recognizing that inventions and discoveries of commercial importance may be the natural outgrowth of research" and that IP protection "can often enhance the reduction to a public usefulness of inventions which result from [Cornell] University Research ..." (www.crf.cornell.edu, Patent Policy). In accordance with Bayh-Dole, Cornell's Board of Trustees has authorized CRF to establish a formula to distribute a portion of the each technology's royalties and/or license fees to the Cornell faculty or staff who are the named discoverers/inventors/creators.

CRF's FY 1999–2000 budget was $3.5 million ($1.9 million for patent expenses and $1.6 million for salaries, supplies, and travel). It has a staff of six professionals who are located in offices in at the Cornell Business and Technology Park in Ithaca and at Cornell's Weill Medical College in New York City.

4.1.3 Objectives of the Chapter

This chapter's three objectives are to:

1. identify the impact, in selected categories, of the technology transfer activities at selected U.S. research universities;
2. compare Cornell's technology transfer policies to those of peer universities; and
3. identify technology transfer-related issues for possible subsequent consideration by Cornell.

Overall, the chapter focus is on Cornell's patenting and licensing policy, and not on CRF's specific strategies or management practices of those policies. Indeed, given the lags between changes in practice and results, the information presented here is more reflective of the past than present CRF leadership.

4.2 Aggregate Effects of Public Sector Technology Transfer

Based on a recent survey by AUTM for FY 1999 (www.autm.org, Survey Summary; the most recent available data on the Web), in which 190 member institution from U.S. public-sector research institutions responded, the following data were collected and effects noted (Table 1; page 20).

Seemingly, public-sector economic activity has made a significant contribution to technology availability and to income/job development for FY 1999 and beyond. Moreover, in all categories, there has been a steady annual increase since 1980. One can speculate that much of this economic growth would not have occurred without the impact of publicly developed technologies and their distribution to the public through technology transfer offices at public research institutions. Although it is difficult to quantify, there is a broad general belief that a significant amount of technology startup activity is attributable to technology transfer activities from public institutions. There is little evidence, however, to corroborate that general belief (Mowery *et al*. 2001).

Table 1:	Aggregate Effects of Public-Sector Technology Transfer (1999)		
Total patent applications filed:		**8,802**	
US patents issued:		3,661	
Licenses and options executed:		3,738	
Proportion to	startups:	12	%
	small companies	50	%
Adjusted gross licensing income		**$ 862**	**million**
Legal fees expended		$ 121	million
Number of startups formed		*188*	
Estimated economic impact generated		$ 41	billion
Estimated jobs created		270,900	

According to available data, the direct financial benefits to universities are less clear. There is a substantial margin of licensing income over legal costs ("Net Royalty"), but expenses for the technology transfer offices and for patent enforcement and litigation-related legal charges expenses are not included in the reported data, nor are enforcement and patent litigation-related legal expenses. Moreover, while the AUTM data are indicative (as with much survey data), it is not possible to determine whether information was aggregated or reported separately.

The above data are also difficult to interpret for a variety of reasons. For example, experience indicates that in general, net returns grow over time, with sales and royalties typically lagging behind the initial letting of licenses by five to eight years. So, a direct annualized relationship of "research income" to "number of patents applied for" or "number of patents granted" is a stretch. The type of research, moreover, for which an institution is noted (emphasis on the arts, humanities, or social sciences compared with medical, veterinarian, or biotechnology research) is likely to be more of a determinant than the total amount of research support when considering the amount of licensing or royalty income generated. At Cornell, for example, the greater part of the royalty income is generated by from veterinary vaccines.

Similarly, the entrepreneurial spirit of a research organization's faculty, staff, and administration is also a determining factor in the amount of technology that will be transferred. Finally, licensors often take an equity stake in startup firms (143 in FY 1999) as part of compensation, so any payout under such circumstances would be accrued in the future.

In summary, there are many factors that will influence the results of such data as that included here, and so care must be taken when using it for policymaking purposes or strategy formulation.

4.3 Cornell Patenting and Licensing Policies vs. Peer Institutions

4.3.1 Protection of Inventions, Licensing Incomes and Startup Companies

In this section, CRF's patenting and licensing activities are compared with those of comparable major research universities in the U.S. Table 2 presents data from an AUTM licensing surveys for the years 1998, 1999 and 2000. The table presents 30 leading institutions in alphabetical order.

It has already been stated that licensing revenues will always lag research expenditure and patent activity. Therefore, the only data treatment has been to present licensing revenue as a percentage of sponsored research funding and then to use patent activity and company startups as a function of sponsored research to consider the relative activity of the universities sampled. These universities represent the top 30 schools that responded to the AUTM *Licensing Survey FY2000* in terms of Sponsored Research Expenditure, all of which reporting more than $200 million each year for the three years (1998, 1999, and 2000).

Table 2: Research Expenditures & Technology Transfer Data for Selected U.S. Universities (Average for 1998 to 2000)

Name of Institution	**Total Sponsored Research** ($ million)	**Adjusted Gross Licensing Income** ($ million)	**Adjusted Licensing Income as % of Sponsored Research Expendi-ture** (%)	**Research Expenditure per U.S. Patent Application Filed** ($ million)	**Research Expen-diture per U.S. Patent Granted** ($ million)	**Research Expenditure per Startup Company Created** ($ million)
Baylor College of Medicine	245	9.6	3.9	5.3	12	147
California Institute of Technology	226	12	5.3	0.9	3	21
Columbia University	284	96	34.0	2.8	4	50
Cornell University (CRF)	**372**	**5.4**	**1.5**	**2.4**	**6**	**102**
Duke University	319	2.4	0.8	3.1	9	159
Georgia Institute of Technology	240	2.6	1.1	1.7	10	40
Harvard University.	402	10.3	2.6	2.5	7	402
Johns Hopkins University	1,010	10.1	1.0	3.7	10	138
M.I.T.	738	21.4	2.9	2.2	5	33
North Carolina State University	403	4.9	1.2	5.7	12	64
Ohio State University	252	1.7	0.7	5.9	11	379
Pennsylvania State University	403	2.0	0.5	1.7	11	101
Purdue Research Foundation	244	1.5	0.6	3.5	12	56
Stanford University	421	35.2	8.4	1.8	5	35
SUNY Research Foundation	411	14.0	3.4	3.4	7	88
Texas A&M University System	398	5.2	1.3	4.9	19	199
University of Arizona	323	0.4	0.1	12.1	26	121
University of California System	1,886	136.3	7.2	2.8	7	98
University of Florida	272	22.3	8.2	2.2	5	68
University of Georgia	238	3.4	1.4	4.2	12	38
University of Illinois*	569	5.3	0.9	6.0	18	114
University of Michigan	497	4.7	1.0	3.7	8	99
University of Minnesota	421	10.5	2.5	3.7	8	53
University of Pennsylvania	474	12.2	2.6	2.9	8	88
University of Pittsburgh	316	2.1	0.7	4.2	11	86
University of Southern California	263	1.1	0.4	2.4	17	56
University of Texas	266	1.6	0.6	4.1	13	80
University of Wisconsin-WARF	446	19.0	4.3	3.1	5	103
Washington State University**	521	26.5	5.1	4.2	11	112
Washington University	321	6.6	2.1	4.5	7	160

Source: Association of University Technology Managers Licensing Surveys, 1998, 1999, 2000.

* Chicago and Urbana
** Washington Research Foundation

Note: The data are the means of the three years 1998, 1999, 2000 and represent the top 30 Universities (in terms of Total Sponsored Research Expenditure) responding to the AUTM 2000 Licensing Survey.

Total Sponsored Research: annual expenditure including industrial support provided for clinical trial studies.

Adjusted Gross Licensing Income: gross licensing income adjusted for license income paid to other institutions.

US Patent Applications Filed: includes any filing during the year, including provisional applications, provisional applications that are converted to regular applications, new filings, continuations-in-part (CIPs), continuations, divisionals, reissues, and plant patents. Applications for certificates of plant variety protection may also be included.

US Patents Granted: includes the number of U.S. patents issued or reissued in the year requested. A certificate of plant variety protection issued by the USDA. may also be included.

Startup Companies Created: companies that were dependent on licensing the institution's technology for initiation.

When analyzing the data in Table 2, note should also be taken that a single year of results can be misleading if the year included a major license agreement. As noted previously, research results that produced licensing/royalty income are not uniformly distributed across all university disciplines.

With those cautions in mind, it is nonetheless useful to see how Cornell's performance compares with other leading research universities. There are many other ways to analyze this data, but one significant measurement is to assess the number of patents granted as a function of research expenditure, which more accurately measures research output (and patenting office activity). At $2.4 million and $6.0 million, Cornell ranks 8th and 7th respectively in research expenditures per number of patent applications (column 4) and patents issued (column 5). The California Institute of Technology, at $0.9 million and $3.0 million respectively, of sponsored research per patent filed and per patent issued tops the list. Granted patents are slightly more wide-ranging, and there is also a range in success from two to five applications per granted patent, although again the lag between application and granting makes this figure somewhat suspect.

Among the 30 institutions, Cornell ranks 16th in terms of total sponsored research at $372 million, and, significantly, 16th in terms of adjusted gross licensing income ($5.4 million)[5]. In relative terms, when gross licensing income is expressed as a percentage of research expenditures (column 3), Cornell ranks 15th at 1.5 percent. The range of the institutions listed is from 34 percent (Columbia University) to 0.1 percent (University of Arizona). Only four universities have a return over 7 percent (University of California System, Columbia, Stanford and Florida), but over 10 generate 1 percent or less. Most universities are in the 1 to 2 percent range but this figure can fluctuate widely as a year-on-year figure with a few major licensing deals having a relatively large effect. For example, in FY2000, the University of California System received over $260 million in gross licensing income, whereas in the previous two years this was less than $75 million (and below 5 percent of research expenditure). Cornell's own gross licensing income over these three years was relatively stable at $4.8-$6.0 million and nearly constant at around 1.5 percent of research expenditures.

In general, those institutions with a high cost per patent have a low return in licensing income. This may be expected since fewer patents mean less opportunity to license and less chance to hit the jackpot. However, although there is some connection in that those institutes with a higher licensing income also file and obtain more patents (effectively those with a lower figure for research expenditure per pat ent), many other institutes with similar rates of filing/granted patents do not have high rates of licensing income. Thus, while low number of patents do seem to suggest low licensing, high numbers of patents do not guarantee high licensing incomes and this reinforces the inference that large returns are made on relatively few patents. Whether getting such a "winner" is fortuitous or the result of sound decisions and management cannot be determined.

In sum, Cornell scores well in terms of both numbers of patents granted (one for every $2.4 million of research expenditure) and success with better than one in three applications resulting in granted patents. The relatively low level of licensing income may be due to any of a number of factors, for example lower activity in high-value medical areas or a greater emphasis on non-exclusive licenses to broaden availability. Or it may simply be a function of not having any one single blockbuster invention with large money-making potential.

Based on this admittedly limited information, it would appear that CRF is relatively aggressive in filing patents and protecting Cornell inventions, but somewhat less successful in its gross income. Whether that is due to the timing of royalty flows, the nature of research at Cornell, overly ambitious or misdi-

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5 Unfortunately, data pertaining to legal fees are available only for the year 2000 and are not included in Table 2 nor in the calculations. The difficulty in using such data is due to the irregular occurrences of major expenditures (e.g. litigation). For the year 2000, the legal fees as a percent of total research expenditures varies across the sample from 3 percent to 57 percent.

rected patenting efforts, or other reasons, cannot be determined from the available comparative data. Overall, however, CRF is operating well within the bounds of major universities.

4.3.2 Cornell/CRF Intellectual Property Policy[6]

Copyright: Based on "long-standing academic tradition", copyright ownership is vested with the author(s) except in cases where:

- ownership of the work is controlled by terms of a research agreement;
- the work produced is expressly a "work for hire" (a relatively rare event that requires special authorization from Cornell),
- the work is encoded ("software") and its creation required "substantial use" of Cornell Resources which are not generally available to members of the faculty.

"As a matter of principal and practice, the University encourages all members of the Cornell community to publish without restriction..." (CRF 1995).

Patents: Patentable inventions are university property if they are created "in the course of an inventor's employment with the University" or using "University Resources." University Resources are defined in the negative as not including the use only of university office space or library facilities. Waivers to these practices can be sought on a case-by-case basis, including in response to the requirements of research project sponsors.

"It is the general policy of the University to encourage the development and marketing of inventions resulting from University research so as to reach a public usefulness and benefit." That is, inventions are generally patented if a viable commercial market exists under the perception that patenting and licensing (including exclusive licensing when considered necessary) is a more effective means of assuring that inventions are made available for public use. License agreements typically include due diligence clauses, which set a minimum utilization of the patented technology over a period of time, in order to require that licensees effectively utilize the technology.

Cornell policy provides that a portion of licensing and royalty revenue be shared with the technology's inventor/producer. The formula is:

50 percent of the first $100,000 of Net Royalties[7]; and

25 percent above those Net Royalties exceeding $100,000.

The balance of Net Royalties, per technology, are shared with the inventors' department and college and with CRF to cover its expenses.

Material Transfer Agreements: Many materials used in research, including biological materials, are made conditionally available under a Material Transfer Agreement (MTA). At Cornell, the Office of Sponsored Programs is responsible for reviewing and approving incoming MTAs; while CRF controls outgoing MTAs. The MTAs used by CRF are written in response to the National Institutes of Health guidelines for making research materials available for ***research purposes only***. Commercializing technologies that result from the use of such materials requires the negotiation of a commercial license.

Conflict of Interest: The Conflicts Policy (for the Ithaca campus) recognizes that all regular Cornell faculty and staff have a full-time commitment and clear obligation to conduct the affairs of the university

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6 Policies have been taken from www.crf.cornell.edu except where noted.

7 Net Royalties are equal to gross licensing and royalty income less unreimbursed legal fees.

"solely on the basis of a desire to promote the best interests of the institution." Specific conflicts of interest occur when an employee:

a. has an existing or potential financial or other material interest which impairs or might appear to impair the individual's independence and objectivity;

b. may have received a financial or other material benefit from knowledge or information confidential to the university; or,

c. engages in other employment, except as specifically allowed by university policies, which divert from full time efforts.

So long as these guidelines are not violated, it is recognized that the quality of an employees contribution to the university "may be enhanced when members participate in external activities..." (www.univco.cornell.edu/policy/conflicts). The policy is implemented through an annual reporting responsibility and conflict resolution process.

4.3.3 Comparison with Peer Institutions

The IP policies (patenting/copyright and licensing) of Cornell and a dozen peer institutions listed in Table 2 including Cornell's were surveyed. Each of the institutions surveyed stated that its mission included the dissemination of research results as widely as possible. Although not stated in the respective mission statements, it is presumed that knowledge dissemination is the principal objective, temporizing, where a possible conflict exists, each university's push to expand its IP portfolio and generate licensing/royalty income to offset research costs. Moreover, no U.S. university is conducting research primarily to generate income-producing IP.

There are no significant variances in university technology-transfer policies across major research universities. All have patent and copyright policies applying to faculty and staff.

With only one known exception in the U.S., all universities require that faculty, staff, and graduate students assign their potential IP rights to the university, as a condition of employment. The single exception is the University of Wisconsin System, which grants technology discoveries to its faculty or staff inventors unless there were federal funds used in conducting the research, in which case Bayh-Dole fully applies. In selected cases, undergraduate students are also required to assign their potential IP rights to the university in which they are enrolled. However, to date, undergraduate students have produced few patentable research discoveries.

Other universities do distribute royalties differently than Cornell. However, the shares are either very similar (say 20 vs. 25 percent) or expenses are levied differently so the net effect shows no notable differences across the selected peer institutions. This similarity of policies is due in large measure to competition for faculty and the stipulations of Bayh-Dole.

It has not been possible to systematically survey related policies, particularly those affecting faculty and staff opportunities to engage in entrepreneurial activities while remaining in university employment. Cornell's conflict of interest policies are restrictive in that regard, while other universities are reported to accommodate more outside income earning activities that are closely associated with university responsibilities. It has not been possible, however, to verify the extent or even existence of those policies.

It has been reported anecdotally, for example, that Yale University, while actively encouraging staff to participate in external activities and consulting, has a policy that faculty may spend no more than one day in a work week on such activities and that faculty ownership or management of private enterprises is subject to review and to limitations. Furthermore, undertaking research in a university laboratory on behalf of a company in which the faculty member has a financial interest would be subject to strict scrutiny. The University of California system differentiates between accepting a managerial or executive position with a business (profit or non-profit), which is ordinarily not allowed, and accepting a consulting or a board position, which is allowed subject to limitations on the number of days a year served.

4.4 Assessment and Recommendations

4.4.1 Assessment

Comparisons of Cornell's technology transfer policies with those of peer institutions reveals that the institutions differ little at the policy level. The more important issue is to determine the criteria for such comparisons between institutions. For example, what are to be the "standards of excellence"?

In addition to a university's IP policy, many factors are believed to play significant roles in regards to the number of patents (either issued or granted), startup companies created per million of research dollars spent, or other metrics of technology transfer impact. Among these are the:

- types of research for which the university is noted (hard sciences, soft sciences, and the arts);
- entrepreneurial spirit of faculty and university administration;
- resources, strategy, skills, and aggressiveness of the tech licensing entity; and
- good fortune of hitting a "home-run" invention (e.g., Stanford University's Cohen-Boyer patent).

Within these constraints of analysis, CRF appears to be operating broadly comparably to similar technology transfer offices in peer research universities. Moreover, the relative financial success of CRF is but one dimension of its contribution to Cornell, New York State and the larger community. Finally, the current CRF leadership is recent, with current policies not yet reflected in the statistics of patent applications, royalties, etc. The remainder of the comments here, therefore, applies to Cornell policy and not to the performance of CRF in executing those policies.

The imperfect and limited data available to study the policy impacts do not allow for any meaningful conclusions, where economic impact is taken to mean income generation for the university as well as the creation of economic wealth through the exploitation of university inventions. Specifically, to our knowledge, there has never been a systematic assessment of the effects of differences in policies on technology generation and transfer. Likely, the small differences which exist have limited effects on motivating faculty and staff, or on the selection of employment among universities.

The exception may be the effect of conflict of interest policies on faculty and staff opportunities to operate businesses associated with their research focus. That issue warrants further investigation, in terms of both as regards business generation and potential conflicts of interest. As regards the dual roles of faculty, Cornell's policies appear to be relatively conservative but it is not clear whether this is overall beneficial or not.

Bayh-Dole undoubtedly had a significant impact in the U.S. on the protection and transfer of university inventions. By extension, the impact of federally funded research on Cornell's IP policy and management/licensing of inventions strategies was considerable. At present, the U.S. Government is one of a very few major research funders with an explicit IP policy. However, current discussions under several fora are shifting rapidly in the direction of establishing policies. That is, philanthropic foundations and other sponsor agencies are increasingly coordinating their policies to create a unified, level playing field. The objectives of these institutions mainly relate to their missions of ensuring access to research inventions by developing countries for social and humanitarian benefits.

This debate and ensuing policy shifts are expected to lead to new challenges for universities, especially one like Cornell with a long history and interest in collaboration with organizations in the developing world. These challenges are related to the difficulty of reconciling different IP policies of research sponsors, and of harmonizing Cornell's IP policy with any possible new restrictions imposed.

A complementary development in the international debate relates to reducing the barriers impeding access specifically to agricultural biotechnology for subsistence and minor crops. Among others, what has been proposed is the creation of a clearinghouse to advise researchers, administrators, and technology managers about practical IP management strategies that will result in quicker decisions, lower transaction costs, and ultimately, the development and dissemination of plant varieties using biotechnology that address hunger (subsistence crops) or contribute to more vibrant state economies (minor commercial crops). In addition, endeavors are proceeding towards the creation of a mechanism such as a technology pool derived from many public sector institutions to grant researchers broader access to complementary collections of agricultural biotechnologies and materials for specific purposes.

The question of allowing faculty to start a company (or take employment with a company) that licenses their own inventions from the university is one that raises issues of conflict of interest. These issues are dealt with in the policy statements of many universities, including Cornell's, and thus it is implicitly assumed that faculty have the right to such activity, but clear statements to this effect have not been found in Cornell's policies. There have been discussions about these matters in email newsgroups, some dealing with the aspect of allowing faculty an "entrepreneurial leave of absence" to start their own companies, and it seems that the practice of faculty members being involved in some way with the commercial development of their own inventions is an important aspect. The conflict of interest (and conflict of commitment) issues need to be considered, but with a system in place to monitor this aspect, most universities at least allow and often encourage faculty to take such external roles.

Some believe that Cornell's policies are largely external to the research process. That is, the policies are seen to be top down in the sense of having been subject to little debate across the Cornell community. That approach to policy setting may have contributed to the alien feeling some researchers express to CRF. Another element, and perhaps the most important factor, might be the lack of understanding among many faculty of how CRF operates, how IP is protected and licensed, and the options available to CRF on how to manage its IP portfolio.

Moreover, existing policies evidence apparent internal conflicts that lead to questions about their overall roles and effectiveness. Possible examples include:

- CRF has a fiduciary responsibility, which may best be resolved with exclusive licenses, but exclusive licenses can (and appear may to have, as in the case of the "gene gun" among others), sometimes provide a lower public benefit than non-exclusive licenses. How is that conflict to be resolved?
- Sometimes access to a technology is possible only by cross licensing, but when doing that, CRF must make decisions about the use of technology that may have been discovered by another inventor(s). How should those conflicts be resolved?
- Is it possible and appropriate to identify critical technologies (like the gene gun) and forgo exclusive licensing for greater public benefit? Does exclusive licensing actually provide for greater public benefit by providing adequate corporate incentive to expand the technology's use? These matters need to be studied in more detail and discussed openly so that policy outlines may be established for assisting CRF in some very difficult choices.

Perhaps most significant to the research process is the possible reduction in the exchange of information caused by property rights and financial benefit issues. Certainly there are adequate anecdotal examples of the chilling effects of property rights on information exchange and publication speed. But anecdotes are not a proper basis for policies. A few surveys have been conducted, particularly in the medicine/human genomics fields which suggest some modest effects on information exchange and speed of publication which can be attributed to property rights practices. Those results may or may not apply to Cornell so that it is important to conduct a Cornell-specific survey/research, and, should the results indicate a depressing effect of Cornell/CRF technology transfer policies on scientific exchange, the benefits and costs of the current policies need to be carefully considered.

More broadly from a policy point of view, the ongoing debate on policy shifts by other research sponsors, including the possibility for the creation of clearinghouses and patent pools (primarily based on U.S. university IP), is expected to have an impact on the way researchers at Cornell, and CRF, will do business in the future. At a minimum, it is important to anticipate some of these developments and internally formulate a response. At best, due to Cornell's longstanding interest in the international agricultural arena and medical research field, Cornell might want to consider taking a proactive role in those debates.

4.4.2 Recommendations

The Panel, on considering the available information, has determined that Cornell could better serve its internal and external responsibilities by placing a greater emphasis on the development and commercialization of university inventions. While such a change in emphasis would eventually involve many aspects of the university, a starting place is an increase in incentives for activities leading to and promoting commercialization. Hence, the Panel recommends the following changes be made in university policy:

1. Recognize the issue of a patent on an invention as an academic contribution similar to the publication of a refereed journal article for promotion and tenure purposes.
2. Provide additional and, particularly, more rapid financial (including for research) support for inventors. The present system with a lag of five to eight years between invention and realization of any financial returns provides limited incentives for inventors to develop an invention further, particularly for younger professionals.
3. Modify the university's Conflict of Interest policies to allow more joint activity as a university faculty or staff member and officer in a startup firm directed to commercializing the invention.
4. Because IPRs are here to stay and globalizing, most key inventions will continue to occur in the public sector at research universities such as Cornell. Public funding should maximize public benefits—food security being an important public benefit—and international agricultural research centers and national agricultural research systems throughout the world need help with access to IPR. In particular, the private sector will not serve poor farmers, although private companies have IPR that they are willing to donate, and pooling IPR also creates added value. Cornell scientists would like to see their work benefit needy people, and because a portfolio of public IPR supplemented by case-by-case licensing can provide freedom to operate and sharing that will benefit humanity, the Panel **recommends** that Cornell University participate in an effort by the Rockefeller Foundation and other leading research universities to establish an IPR clearinghouse and an IPR pool that will facilitate collective licensing of our technology for humanitarian use throughout the developing world.

At the same time, the Panel recognizes that there are a number of issues and follow-up activities requiring additional discussion and consideration. These are summarized in Table 3.

Table 3: Major Areas for Further Consideration/Follow-up

Area	Issue	Questions/Note
Policy and Strategy	There has never been a public debate about where on the entrepreneurial spectrum of entrepreneurial Cornell wishes to be. Such a dialogue is overdue.	Where does Cornell have the greatest comparative advantage in terms of technology transfer and economic development? What are the main interests of faculty? Do different schools at Cornell have different views? If yes, what would be the implications for a CRF? Are different approaches manageable? What are the effects at Cornell of IP policies on the dissemination of information?
	What are the "standards of excellence" by which Cornell's IP and technology transfer policies should be measured?	Clear definitions must be determined before meaningful policies can be put forth.
	Questions regarding the impacts of developing or expanding or diminishing an entrepreneurial spirit at Cornell need to be considered.	How entrepreneurial does Cornell want to be? What are the implications to a series of facets of Cornell?
	What potential benefits could be accrued by increasing investment in IP protection and licensing as a means of being more supportive of technology transfer?	Considering that Cornell's investment in patenting and licensing activities is comparatively small (or very small when compared to relative expenditures by the corporate sector), is the university using its "IP potential" optimally or not?
	What role, if any, should Cornell assume in the international arena for making technologies available to the poor on concessionary terms?	
	Should the protection and licensing strategies (and perhaps the IP policy) be different for different schools at Cornell (e.g. medical, agriculture)?	Should policies, strategies and management approaches be targeted to particular technology areas, colleges, etc.?
Research	Research on the impact of policy on a university's technology transfer efficiency should be encouraged.	There are no comprehensive studies in this area. Cornell internal and peer-specific data available regarding the relationships between university IP and technology transfer are missing.
Teaching and Training	How can the protection of inventions be encouraged? How can it enable and enable Cornell to better capitalize on the technology transfer of its IP?	Is there a need to strengthen Cornell's faculty support infrastructure? Is there a need to develop specific faculty training programs? Considering the increasing importance of IP management across disciplines, is there a need for the development of specific graduate courses in this area?

5. Surveillance and Intellectual Property (IP) Protection

This chapter discusses how to approach the issue of protecting IP that is developed by faculty and owned by the university.

5.1 Key Assumptions

There are two key assumptions. First, IP produced by Cornell faculty for the university's benefit is varied and vast. It represents a critically important and valuable asset of the university. Second, (and this is more an "aspiration" than an "assumption"), the university should resolve to protect this asset against unauthorized use or infringement and commit the necessary resources to protect this asset against unauthorized use or infringement.

5.2 Invention Disclosure and Assignment Process

Under longstanding policy, both at Cornell and elsewhere, inventions and discoveries developed by university agents (faculty and staff) in the scope of university research (i.e., in the course of the inventor's employment or with use of university resources) are owned by the university. Accordingly, such inventions are required to be "disclosed" to CRF, which is the entity the Board of Trustees entrusted with the responsibility to protect and commercialize university technology.

In consultation with the faculty inventor (and colleagues), CRF makes a threshold assessment of the commercial viability of the discovery described on the disclosure form. If there appears to be licensing potential, an assessment is then made of the patentability (via a patent search) of the invention. If the invention is deemed commercially viable and potentially patentable, the faculty member "assigns" the invention to CRF, which then proceeds with the patent protection and licensing process. If the invention or discovery lacks commercial promise, CRF disclaims any proprietary interest on behalf of the university and the faculty member is free to develop and market the invention on his/her own.

5.3 Salient Facts and Figures

CRF received 190 disclosures last year. That represents about one disclosure for every $2 million sponsored research funding that the university receives, a disclosure rate that is in line with the benchmark for most research institutions. CRF would like to see about 250 disclosures per year. The last couple of years it has been 170 to 190. After evaluating the commercial viability and the potential patentability of the discovery, CRF declines about 60 percent of disclosures. Faculty members are then free to pursue those on their own. There is no precise time limit on how long CRF can take to make the decision about whether to patent an invention, and at times this has been a source of complaint among some faculty members. The current patent portfolio is about 450-500 patents, with another 350-400 in the pipeline. That is a sizable and valuable asset for the university and for faculty inventors.

5.4 Challenges

There are also two challenges that need to be considered. One is internal: ensuring that all discoveries and inventions developed by faculty and research staff are brought forth in a timely fashion to CRF under the university's patent policy. The other challenge is external: determining what monitoring system should be in place—and what policy stance should be adopted to detect and pursue the suspected infringement of Cornell technology patents.

The dimensions of these problems are difficult to assess. Internally, it is unclear whether or to what extent individuals may be circumventing the patent policy that requires disclosure and assignment of inventions to the university. Here, the university presumes good faith compliance with the patent policy. Where there are instances of discoveries or inventions not being disclosed to CRF, we rely on faculty colleagues to bring it to the university's attention.

5.5 Patent Agreement

A related issue that requires examination is the "Patent Agreement." Bayh-Dole relinquished federal government proprietary rights to universities conducting funded research. Soon after enactment of this federal statute in 1980, many research universities (including Cornell) instituted patent waiver agreements, to be signed upon appointment, that acknowledge on the part of the inventors that the university would own technology that is developed in the scope of their research responsibilities using university resources. The requirement for signing the Patent Agreement is clearly stated in the university's patent policy and in the faculty handbook.

The Office of Sponsored Programs, Human Resources, and CRF recently examined the Cornell patent agreement collection process and discovered that compliance with this requirement has not been achieved. The guiding document for the process is a 1984 memorandum issued by the Vice President for Research, which underscores the importance of signing the Patent Agreement, but then sets out a long list of departments (humanities, etc.) that are excluded from the requirement. It appears now that many of the previously excluded departments clearly need to be included. It was also discovered that some departments are modifying the Patent Agreement, an inadvisable practice that also needs to be corrected.

5.6 Dealing with Suspected Patent Infringement

Turning to the external issue, it is similarly difficult to determine whether or to what extent companies are using Cornell-owned IP without entering into a license. CRF relies on faculty inventors and their network of research colleagues and associates (including former students) to alert us to any suspected infringement of university-owned technology. Then, when alerted, CRF contacts the company to attempt to negotiate a suitable license. What happened in connection with Intel and Hewlett-Packard (H-P) concerning licensing efforts is particularly illuminating:

Patent involved: 1989 patent for a high-performance computer instruction processing technique, invented by Professor Emeritus H.C. Torng of the School of Electrical and Computer Engineering.

Suspected infringers: Intel and Hewlett-Packard. Reluctantly, Intel entered into license in 1997. H-P recently demurred, repeatedly rebuffing CRF licensing demands and a pre-litigation settlement offer.

During the internal review of the suspected infringements, varying viewpoints emerged about how aggressively Cornell/CRF's stance should be. Apprehensions were voiced, for example, regarding the impact of patent infringement litigation on fund-raising and gifts from the companies, continuing research relationships, and the hiring of Cornell graduates, in the event of patent infringement litigation. These factors were weighed against the importance of protecting university and faculty IP interests, the need to send a strong signal to potential infringers regarding the university's resolve, and the possibility of securing a sizable financial settlement or judgment. The expense of such highly specialized and protracted patent infringement litigation was also taken into account. The judgment was ultimately made to settle with Intel in 1997, and to file suit against H-P in January 2002.

These issues and episodes raise several questions about how to curtail circumstances of companies from taking our technology without paying for it. Are there ways to monitor and conduct surveillance to ensure that the technology that the university owns—, developed by faculty who will be receiving royalties as a result of that technology—, is not being infringed? Should the university deal with suspected infringement on a pliable, ad-hoc basis, or should it adopt a more aggressive stance?

To aid in detecting potential infringement, CRF could hire additional staff who would undertake "surveillance" responsibilities, by checking patent filings, and comparing them with CRF's patent portfolio. But such an approach would be time intensive and expensive. Furthermore, electronic surveillance systems are not sufficiently advanced at this time. An alternative is to contract with firms to conduct surveillance checks on specifically suspected infringements.

It appears that a particularly effective surveillance or monitoring mechanism is to sue for infringement. That sends a clear message to those who are resisting licensing. In the few months since the lawsuit against Hewlett-Packard was initiated, CRF has already seen a more conciliatory response from some companies that have been resisting entering into license agreements involving other patented technologies.

5.7 Recommendations for Fortifying Intellectual Property (IP) Protection

1. All "newly hired" faculty and research staff should be clearly informed of the disclosure and assignment obligations set forth in the Patent Policy. The current requirement for all faculty to sign a Patent Agreement should be re-vitalized and made uniform for everyone without exclusion.
2. The university should also reinforce among faculty the importance of being especially vigilant of—and to promptly report to CRF—any suspected infringement of university patented technology.
3. The university should take a more aggressive stance toward pursuing patent infringement so that external entities know the university is serious about protecting university and faculty proprietary interests. Cornell/CRF should seek legal recourse against suspected infringers when reasonable licensing efforts fail.

6. The Special Case of New York State

6.1 Introduction

"Provided, that the moneys so invested or loaned shall constitute a perpetual fund… the endowment, support, and maintenance of at least one college where the leading object shall be, without excluding other scientific and classical studies and military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts,… in order to provide the liberal and practical education of the industrial classes in the several pursuits and professions of life." (Morrill Act, 1862, sec 4)

The leading object of the corporation hereby created shall be to teach such branches of learning as are related to agriculture and the mechanic arts, including military tactics; in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life. But such other branches of science and knowledge may be embraced in the plan of instruction and investigation pertaining to the university, as the trustees may deem useful and proper. (From the Cornell University Charter)

Until the nineteenth century, higher education was considered the province of the leisure and professional classes, and the traditional university curriculum was centered on classical studies. The first Morrill Act in 1862, which established the land-grant college system, was enacted as a reform measure for the purpose of opening access to higher education to the larger industrial class. The land-grant college curriculum was designed to provide a more practical agricultural and technical education in addition to classical studies. This education would be of more direct benefit to the working lives of the citizenry and thereby the economies of the land-grant states.

The special emphasis placed on instruction in "agriculture and the mechanic arts" lay at the heart of the land-grant mission, and this language was explicitly carried over to Cornell's 1865 charter. The need for such instruction reflected the economic realities of the time. The economy of the United States in the mid-1800s was overwhelmingly based on agricultural output. Over 50 percent of the workforce was engaged in agriculture; and another 15 percent were employed in manufacturing (see Table 4 below.) The establishment of the land-grant colleges recognized that an educated industrial class was a necessary component of a strong and healthy economy.

As we re-examine Cornell's role as a land-grant university, we can look at the tenets of the Morrill Act as a guiding force in Cornell's relationship with New York State. Today, as in 1865, Cornell endeavors to provide its students with a practical education and to contribute to an educated workforce. Armed with critical thinking skills and practical training, Cornell students are the future leaders of the state's business and industry. New York State views higher education as a strategic component of a healthy economy. Cornell's capability to positively impact job creation and economic development is often a principal consideration in decisions regarding the allocation of state resources to the university. The New York State economy today, however, is markedly different than in 1850.

As revealed in the 1990 census (see Table 5 on page 33), agricultural jobs make up only 1.1 percent of the New York labor force. While in 1850 some 70 percent of the workforce was employed in "agriculture and the mechanic arts," only 15 percent of the New York labor force was employed in those sectors by 1990. Agriculture is still a major industry in New York, and Cornell's agricultural education is one of the very best in the nation. But clearly the state economy has shifted toward an emphasis on science and technology-based enterprises.

The growth in commercial sectors such as manufacturing, finance and business, and health services reveals that advances in science and technology have been a principal driver for the changes in the state economy from 1850 to the present. A strong and vital state economy is increasingly reliant on advances in science and technology. As one of the country's premier research institutions, Cornell faculty are exploring the frontiers of knowledge and leading new science and technology developments. The transfer of that knowledge for the practical benefit of the citizens of New York is central to the mission of the land-grant university. And Cornell has responded to this historical shift in the state economy with a corresponding expansion of its educational offerings and research program.

Table 4: Labor Force and Employment by Industry: 1850 Census, United States
(over the age of 10, free and slave)

	Labor Force	**Percent of Total**
Agriculture	4,520,000	54.9
Manufacturing	1,200,000	14.5
Trade	530,000	6.4
Construction	410,000	5.0
Domestics	350,000	4.2
Transportation (Ocean Vessels & Railway)	155,000	1.8
Mining	102,000	1.2
Teachers	80,000	1.0
Fishing	30,000	0.4
Unemployed	873,000	10.6
Total Labor Force	8,250,000	100.0

Table 5: New York Labor Force Status and Employment Characteristics: 1990 U.S. Census Bureau (Employed persons 16 years and over)

	Labor Force	Percent of Total
Commercial Sectors		**69.4**
Trade, retail & wholesale	1,599,592	17.8
Manufacturing, durable & non durable	1,227,170	13.8
Finance, Business, Insurance, Real Estate	1,212,394	13.4
Health services	847,035	9.4
Other professional, related services	684,827	7.6
Transportation	432,904	4.8
Communications, public utilities	227,729	2.5
Mining	7,946	0.1
Other Sectors		**23.7**
Educational Services	799,457	8.9
Construction	431,962	4.8
Public administration	424,136	4.7
Personal services	249,148	2.8
Entertainment, recreation services	128,814	1.4
Agriculture, forestry, fisheries	97,604	1.1
Unemployed	**618,903**	**6.9**
Total Labor Force	**8,989,621**	**100.0**

6.2 Technology Transfer Funding in New York State

The New York State Office of Science, Technology and Academic Research (NYSTAR) is New York State's principal technology transfer support mechanism. NYSTAR was created as part of the landmark Jobs 2000 legislation (J2K), enacted by the New York State Legislature and signed into law by Governor Pataki in 1999. NYSTAR was launched with a $120 million investment in research universities in New York State. The five goals of NYSTAR are:

1. Encourage and expand high-tech research and economic development;
2. Coordinate and organize science and technology information resources and provide access to them;
3. Reform and improve policies on royalties and licensing fees;
4. Increase federal research dollars in the state; and
5. Develop policies that will allow the state to take advantage of the economic power of its current research assets.

NYSTAR awards funding through several program areas:

- Capital Facility Program
- Faculty Development Program
- Technology Transfer Incentive Program
- Science and Technology Law Center Program
- Centers for Advanced Technology (CAT's)
- CAT Development Program
- Regional Technology Development Centers (RTDCs)

NYSTAR's Technology Transfer Incentive Program is specifically designed to help business rapidly transfer new ideas and technology from the research lab to the marketplace. This new program supports the efforts of New York's colleges and universities to commercialize high-tech innovations by providing awards to help them move leading-edge technologies from the research lab to the marketplace. It is intended to fund worthy projects at public and private research institutions and to provide an added resource for ensuring that New York State cultivates a thriving technology business base.

The Technology Transfer Incentive Program supports a wide array of activities associated with bringing new technologies to the marketplace, such as creation of business and marketing plans, obtaining venture capital, filing patent applications, and product evaluation and assistance. This program is structured so that awards may be made several times a year, giving potential applicants greater opportunity to quickly move a product from the research lab to the marketplace. Under the Technology Transfer Incentive Program, NYSTAR has awarded a total of $3.5 million to 15 projects (one to Cornell) since this program was established in 1999.

6.3 Technology Transfer Funding in Other States

As we probe the relationship between Cornell University's technology transfer activities and its land-grant mission, it is useful to look at how other states encourage and support university technology transfer activities. Following are some brief examples from other states with land-grant institutions.

Michigan

Using the $1 billion received from the tobacco industry litigation settlement, this state has established the Michigan Life Sciences Corridor. The state plans to award $50 million annually for 20 years to universities, research institutes, and biotechnology companies to promote life sciences research and business development. Last year the state launched LinkMichigan to create a high-speed telecommunications infrastructure in the state.

In early 2002, Governor John Engler announced NextEnergy, an Economic Development Strategy for the NextMichigan. Dollar amounts for this initiative are not spelled out and the proposal awaits passage of legislation in the Michigan House and Senate, but the goal is to offset a possible loss of 200,000 jobs (estimated value, $10 million) currently tied to the engineering and manufacture of engines and transmissions in Michigan. NextEnergy is a "plan to nurture innovation, strengthen collaboration and focus on long term growth and job creation in the alternative energy industry."

Illinois

Governor George Ryan has developed VentureTECH, a five-year, $1.9 billion strategy to invest state resources in education, advanced research and development, health sciences and biotechnology, and information technology. This money will support such projects as:

- Illinois Virtual Campus (giving access to undergrad, graduate study, and professional development);
- A Digital Library;
- Engineering equipment grants for universities;
- Information Technology grants for employees;
- Illinois Virtual High School;
- K-12 funding for connecting schools to the Internet;
- Fermi and Argonne funding to lure the next-generation accelerator;
- University of Illinois Tech Incubator (lab and office space at the Champaign-Urbana research park);

- Centers for Academic Excellence will fund teaching hospitals to conduct additional clinical care research;
- Higher Education Health Services Grants for training health professionals;
- Support for agriculture and veterinary research.

VentureTECH will also fund the construction of new facilities. These include: 1) a Post-Genomics Institute at UI-Urbana; 2) a new bio-medical research facility at the UI-Chicago Medical School; 3) a medical resonance imaging center; and 4) chemical, pharmaceutical and biomedical research facilities.

North Carolina

The North Carolina Technology Development Initiative was created to test a new model for partnerships between universities, venture capital, and incubators. Working with the state-supported economic development agency, in 1998 North Carolina State University used $10 million in venture capital seed money to invest in startup companies affiliated with NC State. The success of that partnership led to a new partnership with the Longleaf Venture Fund, which has $30 million in seed funding available.

Georgia

Georgia has committed $100 million to economic development in the state over the next five to seven years through a program called Yamacraw. Yamacraw is "an economic development initiative to make Georgia a world leader in the design of broadband communications systems, devices, and chips." The goal of the program is "to capture a disproportionate share of the telecommunications infrastructure market for Georgia." Yamacraw works closely with the University System of Georgia and graduated 700 students with "Yamacraw training" in 2001, the second year of the program. The Yamacraw Research Program includes 70 professions and 140 graduate students. Member companies in the Yamacraw Design Center have hired 1,000 professionals in the areas of infrastructure systems, devices, and chips. The Yamacraw Seed Capital Fund has $5 million in seed money for start up companies.

6.4 Models for Industrial Relations and Technology Transfer

The Centralized Industrial Relations Department, University Funded

This model is team-based. The university creates an Industrial Relations Department (IRD) comprised of university staff employees that are centrally located on campus. Industrial Relations employees occupy a common space or a separate building dedicated to this effort. M.I.T. is the most typical example of a successful, centralized IRD, but the centralized model is the most common mode of initiating university-industry relationships nationwide. Advantages of such a centralized department are:

- Centralized IRD groups tend to work primarily for the common good of the university, thus research departments do not "compete" for industrial funding.
- Centralized IRD groups are usually reviewed based on their overall industrial funding generated per year. There is incentive to work in teams and brainstorm to develop the most effective/efficient means of attracting corporate funding, etc.
- Centralized IRD is more flexible, it allows for cross-training between areas of science, coverage for employees on leave or vacation, and allows the IRD to focus as a cross-trained group on a particularly large funding program in a given year.
- Centralized IRD groups are highly compliant with university policies governing IP, conflicts of interest, proper allocation of overhead expenses, etc. As a group, IRD employees are employed by the university and are trained by technology transfer professionals and university counsel, thus standardizing their knowledge of university policies.

- Research investigators generally like centralized IRD since all investigators operate under the same sponsored research policies as administered by one central IRD group.
- Centralized IRD allows for a greater overall knowledge of university research due to cross-training and the centralized IRD's collective knowledge base. This is considered to be the greatest factor in explaining the high success rate of centralized IRD in proactively attracting multi-year industrial funding totaling $1 million or more for multidisciplinary research.

The Technology Transfer Office Acting as the Primary Industrial Liaison

The Technology Transfer Office (TTO) is often utilized as the central contact point for university-industry relationships. The university seldom recognizes, however, that industrial relations (with the primary goal of relationship building and research funding), and the TTO (with the general goals of licensing and company formation), are separate and often conflicting activities.

Because of the depth of its experience with corporations, the TTO is usually very skilled at making contacts and creating relationships with industry. Often, at larger research institutions such as Cornell, the TTO has little time to devote to relationship building due to an immense workload of patenting, licensing, and company starts, yet it is expected to act as the primary industrial relations liaison.

Licensing, company starts, and industrial relations are inherently in conflict as technology transfer activities. If the TTO has responsibility for at least the three functions above, the TTO professional will have a basic financial dilemma to resolve each time a license or new company deal is constructed. Where will the TTO professional place the financial emphasis for a deal that contains a license agreement or company start along with the opportunity for corporate sponsored research back to the university lab that created the subject technology?

In most cases, the TTO, either consciously or without malicious intent, will place the cash portion of such a deal into the deal component upon which the TTO is reviewed by the university. Thus, a TTO that is rewarded for licensing and company start revenue will often shift some or all of any available sponsored research funds into the cash portion of the corresponding license or new company transaction.

In the long run, it is normally wise to separate industrial relations from the TTO. Both the TTO and industrial relations will thus be given greater emphasis. Such a structure will have a greater chance to successfully increase corporate involvement/funding for labs, which will then serve to foster relationships and technology transfer to corporations.

Decentralized University Industrial Relations

Decentralized Industrial Relations (DIR) can take many forms. The thrust of a DIR is to place an industrial relations professional in each major research center of the university. The motivation for this structure is to give individualized attention to each center and to promote an intimate knowledge of each center's research by an industrial relations "expert" in each area of science. This comprehensive knowledge of a center's research, its people and culture, and the industries that a center normally collaborates with aims at a more effective and efficient development of industry relationships, sponsored research, and ultimately, technology transfer.

While the motivation for this model is on track, several aspects of a DIR structure render it less effective. As mentioned, in this model competition between research centers for corporate sponsored research funds often develops in this model. Each industrial relations professional is rated on the amount of sponsored research funding generated per year. Therefore, it is somewhat understandable for these professionals to attempt to discover or manufacture a competitive edge in attracting corporate funds relative to other centers. This is the antithesis to the centralized IRD model where teamwork, group strategy development, and a focus on maximizing university-wide sponsored research funding are rewarded.

The DIR model is also inherently isolating, making any group strategy development or collaboration difficult or impossible. DIR professionals are also difficult to train in university policy since training by OSP, technology transfer, or University Counsel is done individually or through the difficult process of coordinating schedules across all research centers. It is easy to see why the DIR model produces professionals of varying skill level who do business with corporations in a highly varied fashion. Corporations are confused about how a university desires to foster a relationship. If this dynamic dominates university-industry relationships, industrial partners ultimately are lost and the entire technology transfer process suffers, including sponsored research.

6.5 Technology Transfer Models at Other Land-Grant Universities

University of Wisconsin, Madison (UW-Madison)

The University of Wisconsin at Madison (UW-Madison) contains a multifaceted technology transfer effort that is currently one of the most successful in the nation. As a land-grant institution, it is similar to Cornell in the quality and amount of university research, strength in earning peer-reviewed grants, top-tier educational reputation, and its relatively remote location relative to urban centers.

UW-Madison entered into a technology transfer program early, well before federal law allowed academic centers to own their IP. The technology transfer program, the Wisconsin Alumni Research Foundation (WARF), has transferred UW-Madison technology to the private sector for the good of the State of Wisconsin and UW-Madison for over 75 years. Technology transfer at this land-grant university is composed of: 1) a revenue-producing industrial relations unit working with early-stage programs; and 2) an active, successful technology transfer effort transferring late-stage technology and educational programs to the public.

Centralized Industrial Outreach. To enhance its technology transfer success, UW-Madison formed a centralized industrial outreach program, University-Industry Relations (UIR) 40 years ago. The UIR is now populated with PhD-level staff specializing in one or a select few research area(s) with the goal of forming strong relationships between companies and research investigators, deans, and faculty. The UIR is very successful in funding research, academic programs, and in creating technology transfer opportunities for WARF. This is probably the first "M.I.T." style of centralized industrial relations collaborating with a centralized university technology transfer effort in the U.S.

University-Funded Incubator. UW-Madison company starts have the benefit of a 65,000 square foot dedicated incubator facility which houses 50 early-stage companies at full capacity. The incubator facility is a 50-50 joint venture of the Madison Gas & Electric utility company and the nonprofit University Research Park. The Madison Gas & Electric investment was a significant local economic development initiative aimed entirely at UW-Madison company starts. UW-Madison provides seed grants to pre-incubator company starts and promising technology. These grants average $40,000/grant with a total of $1.3 million in grants awarded competitively each year.

University Research Park. Companies graduating from the incubator then move on to the 23-acre University Research Park (URP), which is a nonprofit entity that purchased barren UW-Madison farmland 55 years ago. Financing for local startup companies is available through five venture capital firms. The URP returns all profits to UW-Madison for education and research programs. This includes education and training at UW-Madison's Small Business Development Center and its Center for Entrepreneurship. Madison also offers free business management advice through its Service Corp of Retired Executives. There are now 34 buildings in the University Research Park and the park itself employs 3,500 people. The park has 255 acres of unused land for further expansion. Companies in this corporate park include "clean" industries such as biotech, IT, and financial services as well as petroleum, energy, and chemical companies. All tenants of the park are held to high environmental standards.

State Assistance for Technology Transfer. No state or federal money is needed to assist the 80 corporate tenants of the University Research Park; instead, these startup companies pay taxes to the City of Madison and the State of Wisconsin. The state has not been utilized as a financier or source of real estate for the university incubators or startup companies. In this case, Madison, Wisconsin has reaped the benefits of a broader tax base due to university startup companies.

Like Ithaca, Madison is a beautiful area dominated by lakes and home to world-class winter recreation and outdoors activities. The citizens of Madison are environmentally conscious and conscientious. UW-Madison judiciously selected a site for its University Research Park and incubator facilities three miles off campus. This land-grant university did not target its state for research or company financing. UW-Madison aggressively targeted the private sector as a source of revenue through technology transfer and industrial relations in a manner acceptable to university leaders, researchers, faculty, students, and its local community. In the process, it converted 23 acres of unproductive farmland into a clean commercial site valued at $110 million, employing 3,500 people, and housing over 80 companies that collectively pay $2.2 million in taxes to Madison, Wisconsin annually. The Wisconsin Alumni Research Foundation patent and technology licensing program has consistently been in the top five of all U.S. universities in the annual amount of technology transferred and in technology transfer revenue.

Pennsylvania State University (PSU)

Centralized Industrial Relations Outreach. Like UW-Madison and M.I.T, this group actively matches university research programs with company strengths and needs. Conversely, the group provides data on corporations to researchers and departments that are proactive in identifying corporate partners. This group provides services to corporations such as student recruitment, coops, and professional development using PSU faculty and researchers. These activities are also effective in building lasting corporate relationships.

Technology Transfer Office. This office acts similarly to most technology transfer offices (TTO) at universities nationwide. The TTO evaluates PSU inventions for patent ability and commercial potential. This office is responsible for marketing and licensing PSU IP, but is not responsible for initiating company starts. The TTO has the monumental task of tracking all PSU IP and all agreements pertaining to such PSU property. This includes monitoring payments on agreements and determining when unlicensed IP needs to be abandoned for financial and commercial reasons.

Research Commercialization Office. PSU has concentrated personnel with talent in the area of business starts. The Research Commercialization Office (RCO) performs the following functions: 1) in collaboration with the TTO, the RCO assesses those PSU technologies broad enough to become companies; 2) again, with TTO or industrial relations, the RCO manages the contacting of the appropriate seed investment for new companies; and 3) identifies and mentors initial company management. As *an example of local assistance:* the local county, Centre County, has a Chamber of Business and Industry that is currently supporting four biotech companies in a joint venture with PSU. These four companies are in one of PSU's two incubator facilities.

PSU Incubation. As mentioned, PSU has two incubator facilities in separate buildings. One incubator is set aside for science-based company starts and houses significant wet lab space. As *an example of local and national assistance:* The Small Business Development Center located near the PSU campus lends free consultation to small companies in PSU's incubators and in its Company Park. This office is part of 1000 such similar small-business development centers nationwide and thus has a national component. Basic mentoring to entrepreneurs and advanced management techniques are part of the services offered.

PSU Company Park. PSU has allocated 120 acres of university land to its state-of-the-art new company park. The park contains both multi-company buildings, and independent corporate sites. In addition to standard company park business services, the PSU Company Park provides a hotel and conference center and independent conference centers throughout the park. The park offers access to PSU faculty by being located across the street from one portion of PSU. Built as a permanent real estate development, the facility offers employees of the park and tenant companies childcare and other services.

State Assistance for Technology Transfer.

- *Pennsylvania Technical Assistance Program (PENNTAP).* PENNTAP specialists aim to improve the competitiveness of PSU company starts and Pennsylvania small businesses statewide. These specialists provide technical assistance, business information, short-term management consulting, referrals to business contacts, and a business librarian as a resource to state companies.
- *The Ben Franklin Center of Central Pennsylvania.* Again, this center offers technical and entrepreneurial consulting to PSU company starts as well as other small businesses in the region. The center also offers competitive funding to small and medium-size companies. It seeks to link public, private, and academic resources to help businesses grow. The Ben Franklin Center also focuses on workforce training for small technical companies.

University of Massachusetts at Amherst

Centralized, University-wide Commercial Outreach. In 1995, the University of Massachusetts at Amherst (UMass) formed an Office of Economic Development with a staff of three. This OED acts university-wide and has a state and national mission. It perceives its role is to link campus research programs and research resources with Massachusetts companies and companies nationwide. These company links consist of collaborative research support and links to the potential transfer of technology. The OED maintains a list of research areas university-wide with a new group called Strategic Alliances. UMass takes the strong view that while the university would prefer to see regional companies prosper, UMass believes in open competition between U.S. companies for research transferred to the public sector in adherence with federal law. The OED also encourages entrepreneurship among faculty.

Technology Transfer Office. UMass technology transfer is negotiated into legal agreements by its Office of Commercial Ventures and Intellectual Property (CVIP). This office has technology transfer authority over all commercial ventures involving IP and works in collaboration with the Office of the General Counsel, which provides legal review for all such agreements. Like many technology transfer units, the CVIP has authority over hiring patent counsel and making patent decisions. It also carries all patent expenses on its budget. Two things stand out in this technology transfer model: 1) the CVIP rather than OED is responsible for maintaining a list of commercializable UMass technology/research and for marketing this list to companies; and 2) services such as business consultation, venture capital financing, assistance with space acquisition, and other business assistance are made available to UMass company starts by a group called Mass Ventures. Mass Ventures was formed in 1995 by a joint venture of UMass, the Western Massachusetts Community, and the Commonwealth of Massachusetts.

Financial and Consulting Assistance. Mass Ventures Corporation is a for-profit corporation contracted by UMass to utilize Mass Ventures' expertise in almost every phase of the company startup process. Mass Ventures helps to "package" and market UMass new companies so that they have the best possible chances for adequate financing through Mass Ventures' network of investment capital sources. Mass Ventures has a high commitment to help growth companies in Western Massachusetts succeed, some of which are UMass company starts. Mass Ventures charges UMass a fee for its services. Depending on a company's stage of development these services include: Capital/Financing Acquisition, New Venture Development, Company Infrastructure Development, Strategic Planning, Business Plan Analysis, Market Analysis, Team Building and Management Recruiting, Financial Forecasting, a limited ability to incubate IT and eCommerce new ventures, and UMass technology commercialization assistance.

Company Park. UMass is a five-campus academic organization. The main campus in Amherst, Massachusetts has no incubator or company park. The Commonwealth of Massachusetts and an investment firm, the Massachusetts Biotechnology Resource Institute (MBRI), have invested in the Massachusetts Biotechnology Park adjacent to the UMass Medical Center in Worcester, Massachusetts. MBRI both invests in companies and in biomedical research in Massachusetts universities, primarily at UMass. The Biotechnology Park is an independent entity.

The level of investment by the state and MBRI is confidential, as are any tax-relief programs to new companies borne out of UMass Medical Center technology. Large companies such as Knoll Pharmaceuticals are long-term tenants of the Biotechnology Park. The park has invested time and effort to attract large pharmaceutical and biotechnology firms to create an environment where young companies can collaborate, acquire investment, and gain long term strategic partners. This has had only marginal success, although several successful UMass biotechnology companies, such as the Alpha-Beta Corporation, started in the Park.

6.6 Conclusions and Recommendations

Develop Incentives for Young New York-Based Companies

Discoveries can be patented and licenses issued to young companies headquartered or producing significant product volumes in New York with incentives as part of their license agreements. Such agreement incentives could include:

- Reduction of up-front, milestone, and other cash payments in a license agreement with a young New York company in return for: 1) producing free research reagents for Cornell researchers; 2) allowing Cornell research staff to use industrial equipment not available at Cornell; or 3) have the young company sponsor a small/medium Cornell research program and provide free research labor to Cornell Investigators; or
- Structuring royalty arrangements to maximize the young company's chance for success. Royalty payments could adhere to sales milestones to help a startup company control initial product commercialization costs. In this model, a company would pay a lower royalty at low product sales levels, and higher royalties as sales reach higher sales milestones. Royalties may begin at 3 percent, increase to 4 percent at $5 million in sales, and reach 5 percent for sales of $8 million or more. In this way, the startup company would be able to retain more of its sales revenue when its costs are high and sales are low. Cornell would sacrifice royalty income only at the lowest sales levels and receive full royalty payments at high or expected sales levels. This royalty structure can be incorporated into a market rate license agreement and not unfairly favor New York companies or be anti-competitive.

Cornell could do a great deal more to provide support to new company starts. In conjunction with state and local officials, Cornell could help young companies in New York by working with a company to find a suitable corporate site, offer creative financing (such as an initial lease of five years at below market rate followed by a market rate lease), low interest rate loans for corporate site purchase, tax incentives, etc. Beyond these initial steps, support could include assistance with writing business plans, locating venture capital, and staffing new companies with executives. This last service might be carried out through the hiring of a recruitment firm.

Assistance with developing formal business plans is a key ingredient for a successful young company. A business plan is a professional document soliciting investment in competition with hundreds of similar business plans. To model PSU, a group of seasoned (20+ years experience) New York business executives (including Cornell alumni) who donate their time or charge a minimal fee could produce an effective, professional business plan document for a startup company. Such a service might also provide a fertile training ground for Cornell MBA students.

Expand NYSTAR's Technology Development Program

Universities typically need financial help at a very early stage of technology development, i.e., "seed money." Currently, the majority of New York State support comes only after proof of concept has been established at the "2nd round" of financing. The exception to this pattern is NYSTAR's Technology Transfer Incentive Program. But this program is very modest and incapable of maximizing the potential for technology development across the state. Expanding this program is necessary to advance New York State and Cornell interests in technology transfer. Following the UMass MBRI example, New York State could be encouraged to partner with private venture capital and "proof-of-concept" funding firms to form a state-sponsored Venture Capital Fund to invest in early stage university technologies.

Investigate Alternative Technology Transfer Models for Use at Cornell

Like Cornell, the UMass, Amherst is fairly young in its technology transfer program and has made a relatively small investment in technology transfer relative to its peers in total research expenditures. Technology transfer requires consistent investment and consistent effort on the part of technology transfer and related staff.

Over long periods, the University of Wisconsin, M.I.T, Stanford, and others now have diverse, extensive, and profitable technology transfer programs. Cornell's growth in technology transfer requires an analysis of not only its research, but also its research culture, its commitment to technology transfer growth, and an analysis of the type of technology transfer program that will be most effective.

To enhance Cornell's ability to grow its technology transfer program as the land-grant institution of New York State, Cornell might consider the following propositions:

- Centralize its Industrial Outreach Program like Wisconsin and M.I.T. in order to have industrial outreach that is team oriented and non-competitive, committed to maximizing university-industry relationships and sponsored research, and to standardize the training of industrial outreach professionals in all respects. Not only have centralized industrial outreach groups shown that they can keep abreast of research developments in their assigned center(s), these central groups develop an esprit de corps not possible if they are spread across campus and thus isolated.
- Move CRF back to the center of campus to assist in fostering entrepreneurship.
- Create a five-year Strategic Plan with the development of 50-75 acres of corporate buildings in the Cornell Business and Technology Park, including at least 50,000 square feet for Cornell Incubator space. Once a critical mass of growing companies is formed, Cornell might develop the Business and Technology Park to the point of employing several thousand people, as has the University of Wisconsin, Madison.
- Prioritize the identification of a corporate partner to joint venture with Cornell concerning the Cornell Business and Technology Park with the goal of making this corporate space more financially competitive with neighboring counties.
- View itself as a catalyst for economic growth in the region by developing a critical mass of quality company starts in the Cornell Business and Technology Park that would attract venture firms, law firms, and other service industries to Ithaca.

7. The Future of Technology Transfer at Cornell

Social problems seldom have technical solutions. Although technology development and technology transfer are important prerequisites for Cornell to continue its land-grant mission of improving livelihoods for the citizens of our community, our state, the nation, and the world, technology transfer must be considered within the context of society's larger needs. A comprehensive, ecological perspective is needed. Unless New York improves schools, health care, the capacity of communities to govern well, and the environmental and aesthetic quality of our landscapes, then technology development and transfer will not have much impact in our state. Cornell plays an important role in all of these areas, and so technology transfer must be placed in the proper perspective.

Cornell became a land-grant university when most of the people in New York State were living in rural areas. Many people were trapped in poverty with limited opportunities to improve their livelihoods. Accordingly, Cornell focused on improving the land's productivity through the development and transfer of relevant technology. Although still a constraint in many parts of the world, agricultural production is no longer at the heart of the land-grant mission in New York State. What remains central to the land-grant mission, however, is the underlying principle of knowledge for the benefit of the public good: knowledge that contributes to social and economic welfare. We hope this report will contribute to the rediscovery and redefinition of our land-grant mission for contemporary times. This Panel's vision is that Cornell must continue to excel in science and world-class scholarship and directly benefit people through technology transfer and public scholarship.

In the preceding chapters we have defined and examined technology transfer at Cornell, in relation to its land-grant mission, and identified several major issues. This chapter will summarizes those issues and proposes options for addressing them.

7.1 Issues

American land-grant universities are no longer operating in an agrarian environment but in a highly industrialized, capitalist context. To fulfill its mission of contributing to the economic and social development of its constituencies, Cornell needs a more effective industrial outreach program. Both private companies and New York State are complaining about the difficulties of working with us. In addition, major venture capital firms are not investing in Cornell technology. In matters of conflict of interest and commitment, faculty are considered guilty until proven innocent, thus curtailing faculty entrepreneurship, interaction with the private sector, and technology transfer. Cornell policies are not very different from like institutions, whether land-grant or ivy league, but we implement the policies differently from some (non land-grant urban institutions in particular) who appear more successful in technology transfer. Our emphasis on patents and the defense of patents may place us in a competitive posture with industry, possibly in conflict with our land-grant mission.

7.2 Option I

The first option, as always, is to maintain the status quo. This seems unwise based on the concerns expressed by Cornell constituencies and on the interpretation by this Panel of the modern land-grant mission, which considers effective technology transfer as the key to utilizing our world-class scholarship and research to benefit society. Our panel was a diverse group, coming from the four corners of Cornell, and we all believe that a change is needed.

7.3 Option II

The second option is to tweak the current system. An effective, coordinated industrial outreach system is needed, but only with great difficulty and net loss of current effectiveness could we convert Cornell Cooperative Extension into such a system. Some of the elements needed are contained in the Office of the Vice Provost for Research, including the Office of Sponsored Programs (OSP) and the Office of Economic Development (OED). This office also oversees CRF, the separate 501(c)2 organization with responsibility for patents and licenses. A minimum response would be to add an associate vice provost for outreach who would coordinate and hopefully improve the effectiveness of our outreach efforts. This position would: 1) coordinate outreach university-wide and utilize more effectively the human resources already in place; 2) work with CRF to liberalize the university's licensing arrangements; and 3) work with OED to increase the availability of venture capital to develop Cornell technologies.

7.4 Option III

The third option is a major overhaul. We could create a new, high profile Office of University Outreach led by a vice provost. It would be on equal footing with the Office for Research. The general division of labor would be that the Office for Research would have responsibility for the funding of programs, particularly research, and the Office of University Outreach would handle outreach including OED and CRF. The latter might need a name change, as it is not really a research foundation. Indeed, CRF is instrumental to industrial outreach. One alternative would be to relocate CRF to the main campus and to employ a geographically distributed model (the CRF staff who work in engineering would be located in that college; the staff who work with agricultural biotechnology would sit in CALS, etc.). Also, CRF could reorganize as an office within the university rather than as a separate entity as it presently exists in order to emphasize the integration of outreach and technology transfer.

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Appendix: Statement of Mandate

CORNELL'S LAND-GRANT MISSION: Why consider the land grant mission now?

Cornell has been a national leader in land grant affairs for many years. Along with many land grant universities, Cornell seeks more contemporary interpretations of the land grant mission.

Cornell's leadership, the President and the Provost, and members of the Board of Trustees want to pursue the land grant concept for the 21st century.

The re-accreditation team also recommended "giving voice to the ongoing discussion within Cornell about what it means to be an Ivy-League, land-grant, fully engaged university."

Cornell's administration and some leading faculty are interested in engaging disciplines across the university in translating the outcomes of research and scholarly work for the public benefit.

Cornell is committed to the involvement of students, faculty, and staff in interaction with the public outside the classroom through research, community-based learning, and participation.

Background

1. The key ingredient in the traditional land grant university concept was and is the application of research-based knowledge to the practical problems confronting society. "It was the deepest article of faith that the university would not only generate new knowledge but would also apply that knowledge to real-life problems. This is what is distinctive in the land-grant concept." (Harold Enarson, 1989).
2. When the original land grant legislation was adopted, agriculture dominated the national economy, but manufacturing was very much on the rise. The full range of agricultural sciences, ranging from agronomy to veterinary medicine, was applied to the field of agriculture, while emerging programs in engineering and architecture responded to the needs of industry.
3. Federal legislation further defined the land grant university movement, namely the Hatch Act of 1887, which funded agricultural research, and the Smith-Lever Act of 1914. The latter established the Cooperative Extension Service, providing appropriations for "giving instruction and practical demonstrations in agriculture and home economics to persons not attending or resident in (the land grant) colleges." The unique character of the land grant institutions came to be more and more associated with agriculture.
4. Mechanic arts, now engineering, was named in the Morrill Act, but in later years its development followed a different pattern. In many land-grant universities, including Cornell, engineering became less associated with fulfilling the land grant missions.
5. Following World War II, increased funding for scientific research came with the formation of the National Science Foundation, resulting in a broadened base of research and land-grant university funding.

Public universities other than land grant institutions today play an important role in the national research enterprise, and community colleges offer highly specialized instruction geared to the needs of local businesses and industry. We should be clear on the role of Cornell University as the land grant university of New York State.

The big question

What are the unique contributions of Cornell to New York State as the land grant university? How should Cornell address the question and effect change?

<u>President's Oversight Commission</u>: President Hunter R. Rawlings, Chair

<u>Purpose</u>: The Commission will a) oversee the work of the panels to assure their effectiveness, intellectual rigor, and timeliness; b) address cross-cutting issues at Cornell; and c) define the implications of Cornell as a model of a private university with a public mission. Strategies for communication of the outcomes of the panels and the President's Oversight Commission will be developed as they evolve.

Panels

<u>General purposes</u>: The panels will consider existing programs and recommend future programs that may be a) new or b) expanded or contracted current programs related to the various topics that:

- address pressing state needs;
- generate and allocate resources effectively;
- increase the permeability of boundaries between applied and basic research;

- reduce the barriers between departments and specifically develop working relationships between endowed and contract college faculty members;
- consider the associated ethical issues;
- involve undergraduate and graduate students.

Members: Panel members will be directly associated with Cornell and each panel will be encouraged to seek wider input from appropriate constituents. The latter may be through focus groups or search conferences related to the panel topic.

Timing: All the panels will be asked to have a preliminary report by June 30, 2002, with a final report by October 15, 2002.

1. Outreach/Extension:
Colleges of Agriculture and Life Sciences, Human Ecology and Veterinary Medicine

Additional charge: The Panel should take a broad view of the current extension effort, but should also pursue a close examination of Cornell Cooperative Extension in an effort to find ways to renew programmatic vigor; to identify programs that need to change, to grow, or to become smaller; to review and strengthen current linkages between research, extension, and the undergraduate experience; to sharpen the resources generated and allocated; to further reduce the bureaucratic complexities and rules. The Panel will also highlight particularly successful programs and seek "best practices" among them. With the Industrial and Labor Relations Outreach/Extension panel, they will explore opportunities for work across colleges.

Members: Mal Nesheim, Chair, Ron Ehrenberg, Co-Chair
Trustee: Craig Yunker
Liaison: Michael Matier

2. Outreach/Extension: Industrial and Labor Relations

Additional charge: The Panel should take a broad view of the extension effort, but also pursue a close examination of extension in ILR in an effort to find ways: to renew programmatic vigor while dealing with funding exigencies; to identify programs that need to change, to grow, or to become smaller; to review and strengthen the current linkages between research, extension, and the undergraduate experience; to identify any barriers to change. The Panel will also highlight particularly successful programs and seek "best practices" among them. With the CALS/HUM EC Extension panel, they will explore opportunities for work across colleges.

Members: David Butler, Chair
Trustee: Paul Cole
Liaison: Mary Opperman

3. Engineering Outreach: Economic Development

Additional charge: The Panel will seek a) new and enhanced existing partnerships with manufacturing and service industries, and with local and state government; b) new funding mechanisms; c) new approaches to foster economic development across New York State; and d) opportunities for involvement in economic development across colleges.

Members: Chris Ober, Chair, Clifford Pollock, Co-Chair
Land Grant Committee Member: Edward Cupoli
Liaison: Richard Duell

4. K-12 Education

Additional charge: The purpose of this panel is to increase the visibility of the strong K-12 Science, Math, Engineering, and Technology programs at Cornell; to increase the number of such programs; to project how to sustain the best of the programs; and to coordinate Cornell's current support for the programs, including space. This group (supplemented by external constituents in K-12) will serve in an on-going capacity as advisory to the Provost.

Members: Biddy Martin, Chair
Trustee: Roy H. Park, Jr.
Liaison: Anna Bartel

5. Technology Transfer

Additional charge: This panel will focus on university-wide issues of technology transfer, including incentives and disincentives to Cornell faculty participation in technology transfer; and explore new mechanisms to increase access to technology as integral to the land grant mission.

Members: Chair **W. Ronnie Coffman**, Professor and Chair, Department of Plant Breeding; Director of International Programs, College of Agriculture and Life Sciences

Members **David BenDaniel**, Berens Professor of Entrepreneurship, Johnson Graduate School of Management

Harold Craighead, Interim Dean, College of Engineering; Professor, Applied and Engineering Physics

Charles Fay, Vice Provost for Research Administration

Jay Steven Gross, Professor, Pharmacology, Weill Medical Center; Member, Cornell Research Foundation Board

Jim Hunter, Associate Dean and Director, New York State Agricultural Experiment Station at Geneva; Professor, Plant Pathology, College of Agriculture and Life Sciences

William Lesser, Professor, Applied Economics and Management, College of Agriculture and Life Sciences

Suzanne Loker, Professor, Textiles and Apparel, College of Human Ecology

James Macleod, Associate Professor, Baker Institute, College of Veterinary Medicine

James Mingle, University Counsel

Norm Scott, Professor, Biological and Environmental Engineering, College of Agriculture and Life Sciences

Trustee Members **John E. Alexander**, CEO, The CBORD Group

Paul A. Gould, Managing Director and Executive Vice President, Allen & Co.

Other Contributors **Paul L. Carey**, Director, Office of Economic Development

Anatole F Krattiger, Adjunct Professor of Plant Breeding and Director, SWIFTT

The Search for the Holy Grail?

Maximizing Social Welfare Under Canadian Biotechnology Patent Policy [1]

Daniel A. Dierker and Peter W.B. Phillips
Department of Agricultural Economics
University of Saskatchewan
51 Campus Drive, Saskatoon S7N 5A8, Canada

Executive Summary

The presence or absence of freedom to operate under an intellectual property rights regime (i.e., the ability to use technologies in a research program different from the program that developed the technologies) is a key consideration in the design and development of intellectual property rights regimes, particularly in developing nations. The rationale for the existence of intellectual property protection is that such protection creates incentives to invest in research and development that would not otherwise exist. Alston and Pardey (1999) explain that one reason the return to agricultural research and development investment is high is because there is too little agricultural research and development. This may partly be due to an intellectual property rights regime that fails to optimize the use of innovations.

In the first section of this paper we use a simple two market model to show that the adoption of an intellectual property rights regime, although a second best instrument, can be *pareto* improving given a world of free and perfect information and no private transactions costs. We then show that allowing economic agents the freedom to operate with other's innovations will produce a *pareto* improvement over an intellectual property regime that does not allow freedom to operate.

In the next section we relax the information and transactions costs assumptions. Performing comparative statistics on the model reveals that under different institutional arrangements the potential *pareto* improvement observed under the original assumptions can be curtailed or eliminated. These comparative statistics suggest that different institutional structures produce a wide range of social welfare levels.

In the third section we use a survey-based description of the patenting strategies of the Canadian agricultural biotechnology research industry to show that the industry is not generating all the potential benefits of a system employing full freedom to operate. This suggests, of course, that freedom to operate in the industry is constrained. We then examine and recommend institutional changes suggested by comparative statistics as welfare enhancing. These changes include more stringent examinations of patent applications, an international agreement as to what constitutes prior art, the adoption of something

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1 Dierker, DA and PWB Phillips. 2003. The Search for the Holy Grail? Maximizing Social Welfare Under Canadian Biotechnology Patent Policy. *IP Strategy Today* No. 6-2003. Pp. 45-62.

like the European Patent Office opposition system to lower litigation costs, and potentially revising how public research is done.

In short, we show that the adoption of an intellectual property rights regime can be welfare enhancing, even though it is a second best policy. We further demonstrate that the welfare gains from an intellectual property rights regime can be increased if that regime has effective freedom to operate provisions. Additionally, there is good reason to believe that the current Canadian system is not generating all of the welfare gains possible.

We attribute the failure of the system to generate all of the potential welfare gains partly to the opportunistic behavior of some participants in the agricultural biotechnology industry. At this time, we cannot ascertain whether the failure of other participants in the industry to control opportunistic patenting strategies through existing mechanisms is a result of high transaction costs (particularly litigation costs) or an attempt on the part of industry incumbents to control entry. While we identify how the government might intervene to achieve greater freedom to operate (e.g., by changing how public research is done, more rigorously examining patents, or streamlining the patent challenge process) and hence greater welfare enhancement, until we know whether or not the industry's failure to regulate its patenting behavior with existing mechanisms is due to high transactions costs or seeking excess profits, achieving all potential welfare gains may prove problematic.

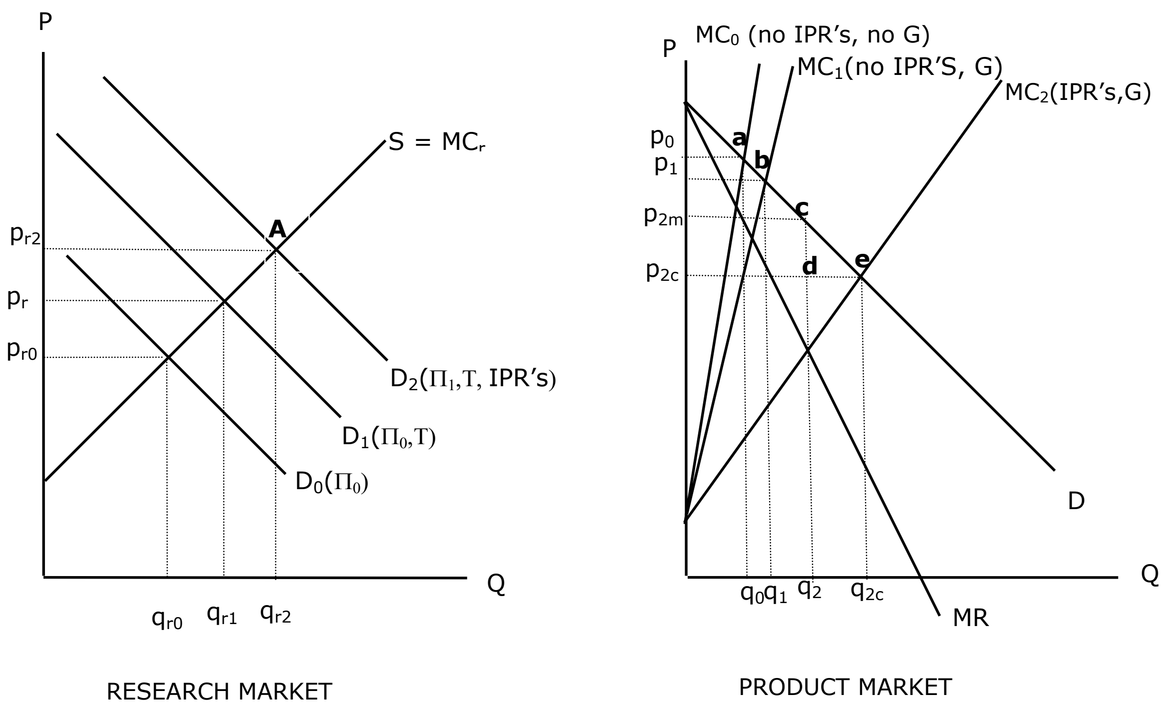
1. The Simple Models

The debate about the type of incentive that formal intellectual property institutions generate, in either the private or public sectors, may be largely spurious. After all, innovations have occurred throughout human history. Long before Great Britain adopted the Statute of Monopolies in 1624—not to mention the 1995 Agreement on Trade Related Aspects of Intellectual Property (TRIPS) requiring signatory nations to adopt legislative protection for trade secrets—humans invented new technologies. During the middle ages, for example, western European guilds were able to accomplish exclusion and hence the *de facto* protection of their arts. In contrast to the lengthy history of private innovation, government involvement in research and development is a relatively recent phenomenon. The wheel, the pulley, the inclined plane, maize, wheat, and the cross and long bow were all invented without government laboratories or funding. And so instead of considering what kinds of incentives intellectual property rights generate, it seems better to ask whether there is any reason at all to believe that formal intellectual property rights increase the overall rate of technological change and improvement in social welfare.

The following model (Figure 1) suggests that there is reason to believe that adopting patent and copyright protection enhances welfare. We assume that research services produce a process that can lower the costs of production in some final goods market. The goods available in the final goods market are assumed to be homogenous. The demand for research is modeled as downward sloping, while the marginal cost of research is assumed to be positive and upward sloping through out.

There is no freedom to operate. For simplicity, profits (Π) available to the innovator in the product market are assumed to equal zero in situations where no patent and copyright protection exists. Given D_0 and D_1 in the research market: D_0 being private demand for research, while D_1 is the sum of public and private research, with public research constrained by T. T is a tax constraint on government's demand for research and G is research that government has provided. Trade secrets can be abstracted,

Figure 1: A simple model for research with and without IPRs



since anything kept secret without legal authority can be kept secret with legal authority. Both firms and government supply research efforts to lower the marginal cost in the product market, thus shifting outward the marginal cost curves in that market.

In the absence of intellectual property rights, the private sector demands research along the demand curve D_0 in the research market, which results in q_{r0} research being done at the price p_{r0}. That is, at the equality of D_0 and the research supply curve S, which assumes that research is competitively supplied and thus equal to the marginal cost of research, MC_r. In the products market this transforms to marginal cost curve MC_0. Along MC_0, q_0 of the product is supplied at price p_0. Allowing government to demand research as well as firms will shift the demand for research out to D_1 with a corresponding increase in the amount of research q_{r1} at the price p_{r1}, which corresponds to marginal cost curve MC_1 in the product market. In equilibrium q_1 will be supplied at the price p_1 in the product market.

If society chooses to adopt patent and copyright protection, firms will recognize that by successfully innovating they can shift the product market supply curve to MC_2 and price as monopolists, thus earning profits equal to the area bounded by p_{2m}, c, d, and p_{2c}. Assuming that government research does not crowd out private research as Diamond (1999) finds regarding general science funding in the United States, or that government only partially crowds it out as Malla, Gray and Phillips (1999) imply with respect to canola research in Canada, this will prompt the rational firm to demand more research, shifting the research demand curve to D_2, along which the market will demand research quantity q_{r2} at price $p_{r2.}$This extra research will lower the marginal cost in the product market to MC_2, with the monopolist firm pricing at price p_{2m} and supplying quantity q_{2m}. Thus adopting intellectual property rights creates a *Pareto* improvement in the product market, since q_{2m} is greater than q_1 while p_{2m} is less than p_1.

But while the model shows that adopting intellectual property rights can be *Pareto* improving, there are several things to note. First, the adoption of intellectual property rights is a second-best solution since the results were generated by constraining government involvement in the research market. Second, if in fact there are increasing returns to scale in research as Romer (1990) suggests, then the average cost will lie above the marginal cost, insuring that monopoly rents will be necessary to induce firms to conduct any research. Third, the model reveals in a triangle cde the dead weight losses in the products market resulting from monopoly pricing. This is because private firms use the monopoly power granted by legislated institutions and leave unsatisfied demand at the marginal cost of production.

Finally, it is worth noting that if the demand curve in the products market is sufficiently elastic, the available monopoly profits will not be sufficient to induce the private sector to shift up the demand in the research sector. For example, only after property rights protection was granted to open pollinated crops in most of the developed world did private firms spend any significant amount of research on open pollinated crops. This is consistent with the argument that if research results are non-appropriable then private firms will not invest. An essentially freely available good or process must have by definition a nearly perfectly elastic demand curve in competitive markets. As Alston and Pardey (1999) observe: "One common and important argument is that the extent of market failure and the degree of private underinvestment will be greater in more-basic research, whose benefits are by definition less appropriable that those of more-applied or near-market research" (p. 14).

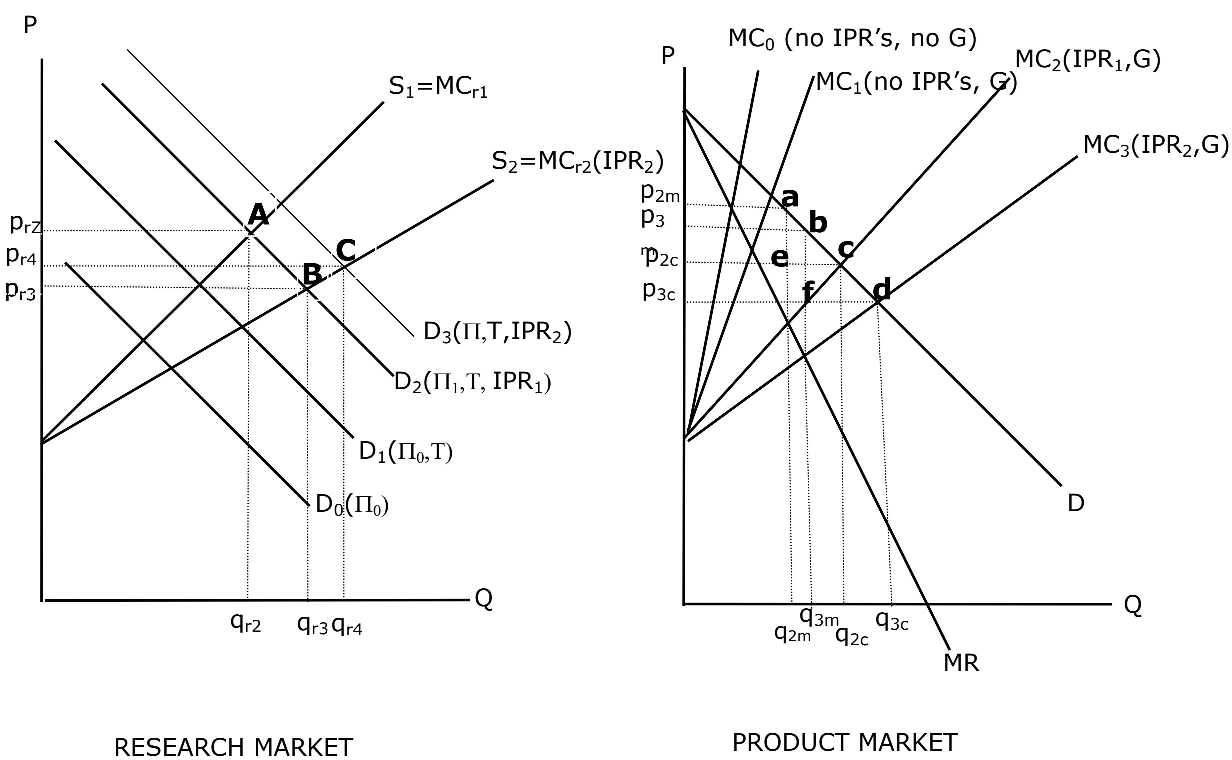
When intellectual property rights protection is combined with freedom to operate provisions then welfare benefits increase. Freedom to operate is the ability of one entity to use the intellectual property of another entity in order to improve on the original intellectual property or to invent something new. In this paper we consider freedom to operate as a research exemption to the patent: you can use anyone's patent in your own research coupled with some form of licensing arbitrator to prevent bad faith bargaining on the part of the original patent holder. Because freedom to operate lowers the marginal cost of doing research—a society does not need to continually reinvent the wheel—one would expect a larger increase in welfare under an intellectual property rights regime that incorporates freedom to operate (IPR_2 in Figure 2 below) than from one that does not (IPR_1 in Figure 2 or the situation modeled in Figure

1). The area bounded by p_{3m}, b, f, and p_{3c} is larger than the area bounded by p_{2m}, a, e, and p_{2c}. Thus as well as the shift to $S_2=MC_{r2}$, in the move from point A (which is the same as point A in Figure 1) to point B in the research market the anticipated extra profits will shift $D_2(\Pi_1,T)$ to $D_3(\Pi_2,T)$, point C. In Figure 2, the Π's, T's and G's have the same meaning as in Figure 1.

Given that adopting an effective intellectual property rights regime can enhance welfare, why are some governments, particularly in developing countries, leery of adopting them? One answer, prevalent in the popular press, is that these countries fear that through an over-broad patent claim of prior knowledge or of some local tradition, custom, germplasm, or something of such ilk—particularly if a first to register rather than first to invent policy is adopted—the patent holder will use monopoly pricing to place the patented good or process beyond the resources of the poor in the developing world. In other words, these countries fear being used opportunistically. Governments in the developing world are also concerned that if they use measures such as compulsory licensing to weaken the property rights holder's ability to extract rents, which is legal under Article 31 of TRIPS, then the governments of the developed world will tie them up in international trade disputes.

The obvious response to such concerns is to design the system in such a way as to eliminate, or at least minimize, the opportunities for opportunistic behavior. But this raises another issue, one that suggests a different answer to the question of why developing countries have been slow to adopt intellectual property rights systems. It is costly to design and operate an effective system. The costs—both fiscal and transactional—to establish an effective intellectual property rights system in a developing country, particularly if it has other institutional problems, may be prohibitive.

Figure 2: A simple model for research with IPRs and freedom to operate provisions



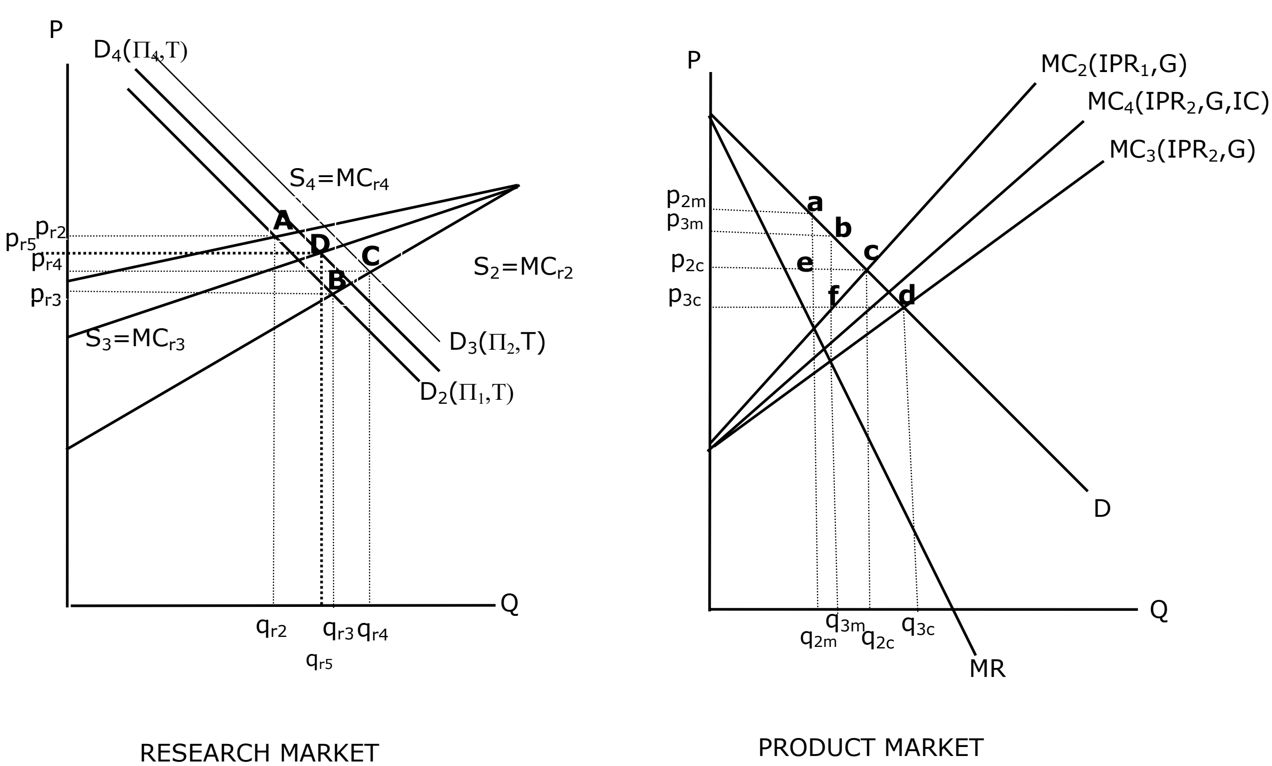
These issues are equally relevant, however, to developed countries. Just as nations may hesitate to enact intellectual property regimes for fear of opportunistic behavior or because of costs, it is possible that freedom to operate, even in the developed world, is curtailed by either opportunistic behavior or by transactions costs. Should this be the case, then even countries with effective intellectual property regimes will not be fully enjoying the potential gains of their systems. Consequently, to insure that a society is reaping the maximum gains possible it is necessary to analyze whether or not the potential gains, including those that can be obtained from freedom to operate, are being realized.

2. Some Comparative Statics

Using the model in Figure 2, we can examine the effect of the opportunistic behavior of over-broad patenting and that of the presence of high transactions costs on a intellectual property rights protection system that incorporates freedom to operate. We show that either effect can reduce gains.

In Figure 3 everything has the same meaning as it does in Figure 2, including the letters designating the equilibrium points in the markets, except for IC, which is costly and asymmetric information. Recall from Figure 2 that, under the assumption of full and costless information and freedom to operate provisions, the lowering of marginal cost of research from freedom to operate moved the equilibrium from A to B and then the increase in profits in the products market moved the equilibrium to C. By relaxing the assumption of full and costless information, thus allowing for costs in relation to acquiring and dealing with information, the $S=MC_{r2}$ curve rotates about the point where the quantity of research Q ap-

Figure 3: The simple freedom to operate model restrained by transactions costs



proaches infinity (the point were additional fixed costs have no effect on production at the margin) to some new curve, say $S=MC_{r3}$ or $S=MC_{r4}$. This implicitly assumes that information costs are fixed, including for example the costs of negotiating a license agreement or the costs of litigating to overturn an over-broad patent or a patent on prior art, or the costs of doing patent and literature searches to determine the prior art. As in Figure 2, the shift of the S=MC curve in the research market is going to cause a change in the products market, an inward shift of the MC curve in the products market from MC_3 to MC_4 or conceivably to MC_2, or further. For as the marginal cost of doing research rises, the marginal cost reductions obtained from the innovation in the products market will fall. If it costs more to get the innovation, then the research and development costs that the innovator will have to garner out of the products market will be greater, and thus the reduction in marginal cost due to the innovation will be smaller.

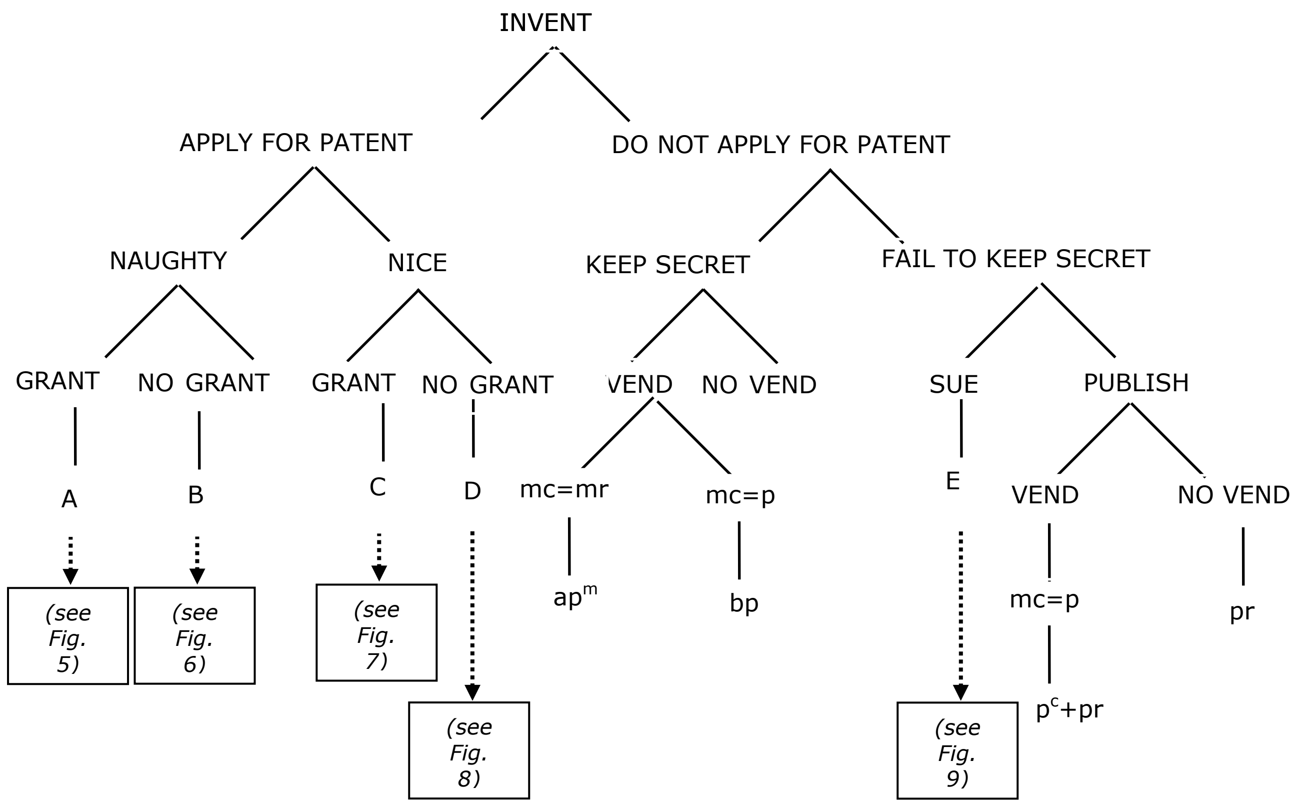
Several things bear notice. Depending upon the size of the cost increase, the lessening of the effects may be to some intermediate point such as D, which is obviously still a *Pareto* improvement over A, or all the way back to A, which is the situation modeled in Figure 1. The farthest that the society can be forced back, irrespective of the source of the cost increase, is point A, at least in a static world. For regardless of the cause of the supply for research curve shift, society still gains all of the *Pareto* improvement from the original innovation. This is the result of the assumptions that drive the model in Figure 1, which assumes that welfare increases are generated as a result of shifts in the demand for research curve. The shift in the supply curve for research only occurs in Figure 2 when freedom to operate is allowed. Thus, in terms of welfare generation, the worst that an intellectual property rights regime that incorporates freedom to operate can do is to be identical to an intellectual property rights regime that does not incorporate freedom to operate. This occurs if the shifts in the supply of research curve is modeled as a rotation about some fixed point, as they are here, or a horizontal shift. With a horizontal shift the only substantial difference is that the gap between the curves will be constant, rather than variable as modeled herein.

Given that the nature of the shift is not significant for welfare implications, it is apparent that regardless of whether a shift in the research supply curve from the freedom to operate position is caused by transactions costs inherent in the system or from opportunistic behaviour on the part of participants in the industry, the end result will be the same. Depending on the magnitude of the cost change, the new equilibrium in the research market will lie somewhere below C down to and potentially including A in Figure 3. The welfare effects of the innovation are going to be at least the *Pareto* improvement available at point A, but smaller than the *Pareto* improvement available at point C.

3. The Structure of the Freedom to Operate Game

In order to attain some insight into where between points A and C in Figure 3 above we actually are, we modeled the potential decisions as a game in extensive form (Figure 4). Once a research program has developed an invention it can choose whether to patent or not. If it patents, it can act in a naughty manner (i.e. practice an opportunistic patenting strategy) or follow a nice approach (fail to act opportunistically). The patent office then has a choice to either issue a patent (grant) or not issue a patent (no grant) on the claim. If the research program chooses not to patent it relies on its ability to keep its innovation secret if it wishes to maximize profits. Should it fail to do so it can choose to launch a suit for breach of a confidentiality agreement or for inducing the breach. The vend no vend dichotomy is the decision to commercialize the innovation. Payouts A, B, C, D, and E are additional segments of the game.

Figure 4: The top segment of an extensive form patenting strategy game



Where:

a = $p_{ts}p_m$
b = $p_{ts}(1-p_m)$
d = court ordered damages
p_m = probability the innovation is major
pr = publishing revenue
p_{ts} = probability of keeping a trade secret
p^m = net present value of monopoly pricing for as long as you can keep the innovation secret
p^c = net present value of marginal cost pricing when the innovation is not kept proprietorial.

As is clear from the definitions of a and b, the decision of whether or not to patent is going to be based on the probability of keeping the trade secret.

Segment A of the game (Figure 5) commences with the patent office choosing to grant a patent following naughty behavior on the part of the innovator. Other players can then choose to sue or not sue. Suing would involve attacking a granted patent on the grounds that it fails to meet the eligibility criterion for patenting. Not avoided and avoided reflect a competitor's ability to invent around a patented technology. If they can invent around the patented technology they are said to avoid the patent; if they cannot then that is not avoid. The node following sue, settle/litigate, allows the innovator to choose between fighting to maintain an opportunistic claim, or cutting a deal with the player attacking the opportunistic claim. Vend/no vend is again the choice to commercialize or not. The payouts are as follows:

$\alpha = p_{g1}(1-p_{s1})(1-p_{a1})p_m$

$\beta = p_{g1}(1-p_{s1})(1-p_{a1})(1-p_m)$

$\chi = p_{g1}(1-p_{s1})p_{a1}$

$\delta = p_{g1}p_{s1}p_{a1}$

$\varepsilon = p_{g1}p_{s1}(1-p_{a1})p_m$

$\phi = p_{g1}(1-p_{s1})(1-p_{a1})(1-p_m)$

$\gamma = p_{g1}p_{s1}p_{a1}p_{bl}$

$\eta = p_{g1}p_{s1}(1-p_{a1})p_m p_{bl}$

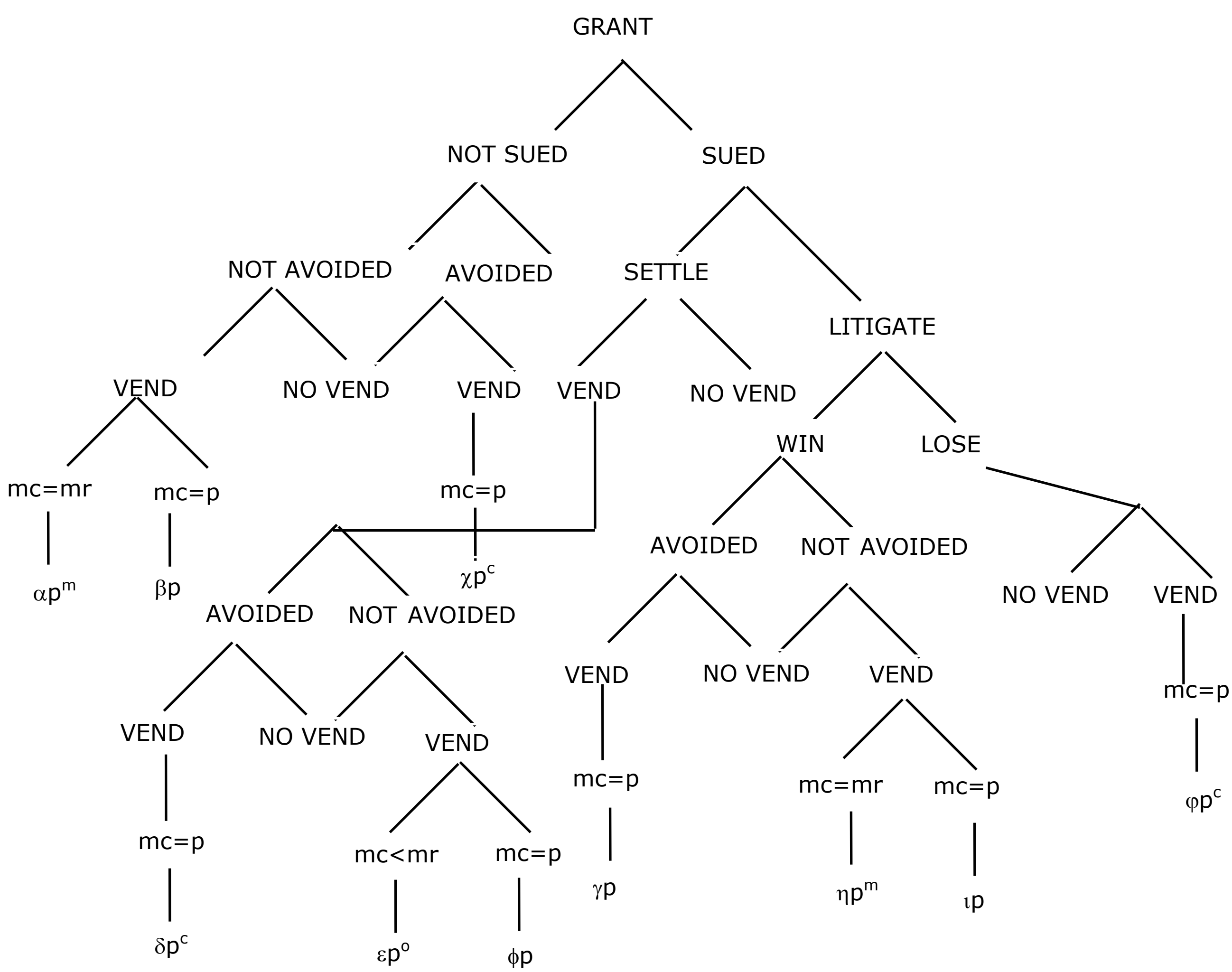
$\iota = p_{g1}p_{s1}(1-p_{a1})(1-p_m)p_{bl}$

$\varphi = p_{g1}p_{s1}(1-p_{bl})$

where:

- p_{g1} = probability of grant of opportunistic claim
- p_{a2} = probability of inventing around a non-opportunistic claim
- p_{s1} = probability of suit challenging opportunistic claim
- p_m = probability innovation is major
- p_{bl} = probability of a court decision being contrary social welfare enhancement, i.e. the allowing of an opportunistic claim or refusing a non-opportunistic claim
- p = net present value of pricing at the marginal cost associated with a minor innovation for the life of the patent (for a good discussion of major and minor innovations and the effect that the nature of the innovation has on pricing see Shy pages 222-224)
- p^m = net present value of monopoly pricing for the life of the patent.
- p^o = net present value of oligopoly pricing for the life of the patent.
- p^c = net present value of marginal cost pricing when the innovation is not kept proprietorial.

Figure 5: Segment A of an extensive form patenting strategy game following off of patent naughty grant



In **Segment B** of the game (Figure 6), the patent office commences by refusing the grant of letters patent to an opportunistic claim. The applicant then has the option of pursuing legal action to force the patent office to grant a patent or accepting the patent office's decision. If the applicant chooses to sue, they have the choice of litigating or settling. Settling is included for the sake of completeness. To choose settling in such a situation is akin to choosing not to sue in the first place; the patent office has no incentive, and no real statutory authority, to deal. The nodes vend/no vend, avoided/not avoided, the probabilities p_{g1}, p_{a1}, p_m, and p_{bl}, and the prices have the same meanings as they do in Figure 5. The payouts are as follows:

$\kappa = (1-p_{g1})p_{s2}p_{bl}(1-p_{a1})p_m$ where: p_{s2} = probability of challenging in court the refusal of an opportunistic claim

$\lambda = (1-p_{g1})p_{s2}p_{bl}(1-p_{a1})(1-p_m)$

$\mu = (1-p_{g1})p_{s2}p_{bl}p_{a1}$ $\nu = (1-p_{g1})p_{s2}(1-p_{bl})$

$\theta = (1-p_{g1})p_{s2}p_{a1}$ $\rho = (1-p_{g1})p_{s2}(1-p_{a1})p_m$

$\sigma = (1-p_{g1})p_{s2}(1-p_{a1})(1-p_m)$ $\tau = (1-p_{g1})(1-p_{s2})$

Figure 6: Segment B of an extensive form patenting strategy game following off of patent naughty no grant

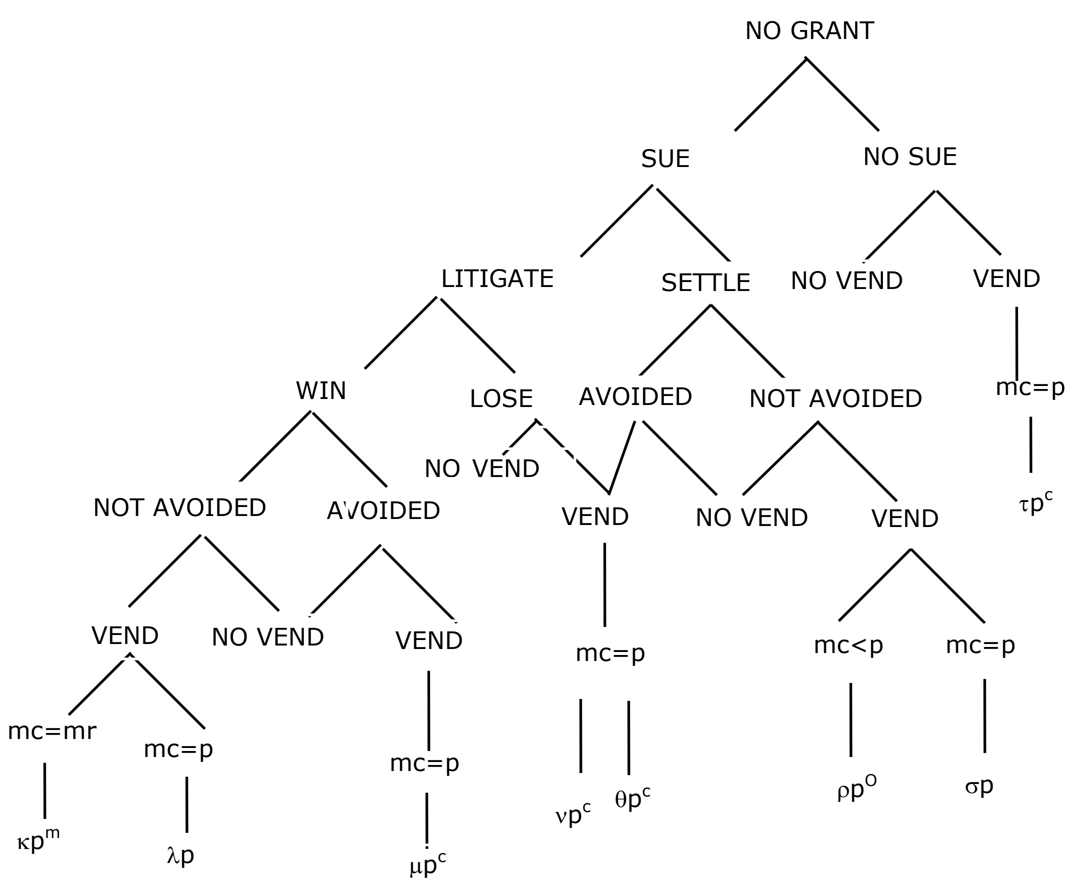


Figure 7 (**Segment C**) is the analog of Figure 5. In this segment of the game the patent office chooses to patent a non-opportunistic claim. Other players can then choose to challenge that grant or choose not to, the sued/not sued decision. Avoided/not avoided is, again, the risk that the patent will be invented around. Vend/no vend is also the same meaning as in the previous Figure, as do the prices and the probabilities p_m and p_{bl}. The payouts are as follows:

$\upsilon = p_{g2}(1-p_{s3})(1-p_{a2})p_m$

$\varpi = p_{g2}(1-p_{s3})(1-p_{a2})(1-p_m)$

$\omega = p_{g2}(1-p_{s3})p_{a2}$

$\xi = p_{g2}p_{s3}p_{a2}$

$\psi = p_{g2}p_{s3}(1-p_{a2})p_m$

$\zeta = p_{g2}p_{s3}(1-p_{a2})(1-p_m)$

$A = p_{g2}p_{s3}p_{a2}(1-p_{bl})$

$X = p_{g2}p_{s3}(1-p_{bl})(1-p_{a2})p_m$

$\Delta = p_{g2}p_{s3}(1-p_{bl})(1-p_{a2})(1-p_m)$

$E = p_{g2}p_{s3}p_{bl}$

where:

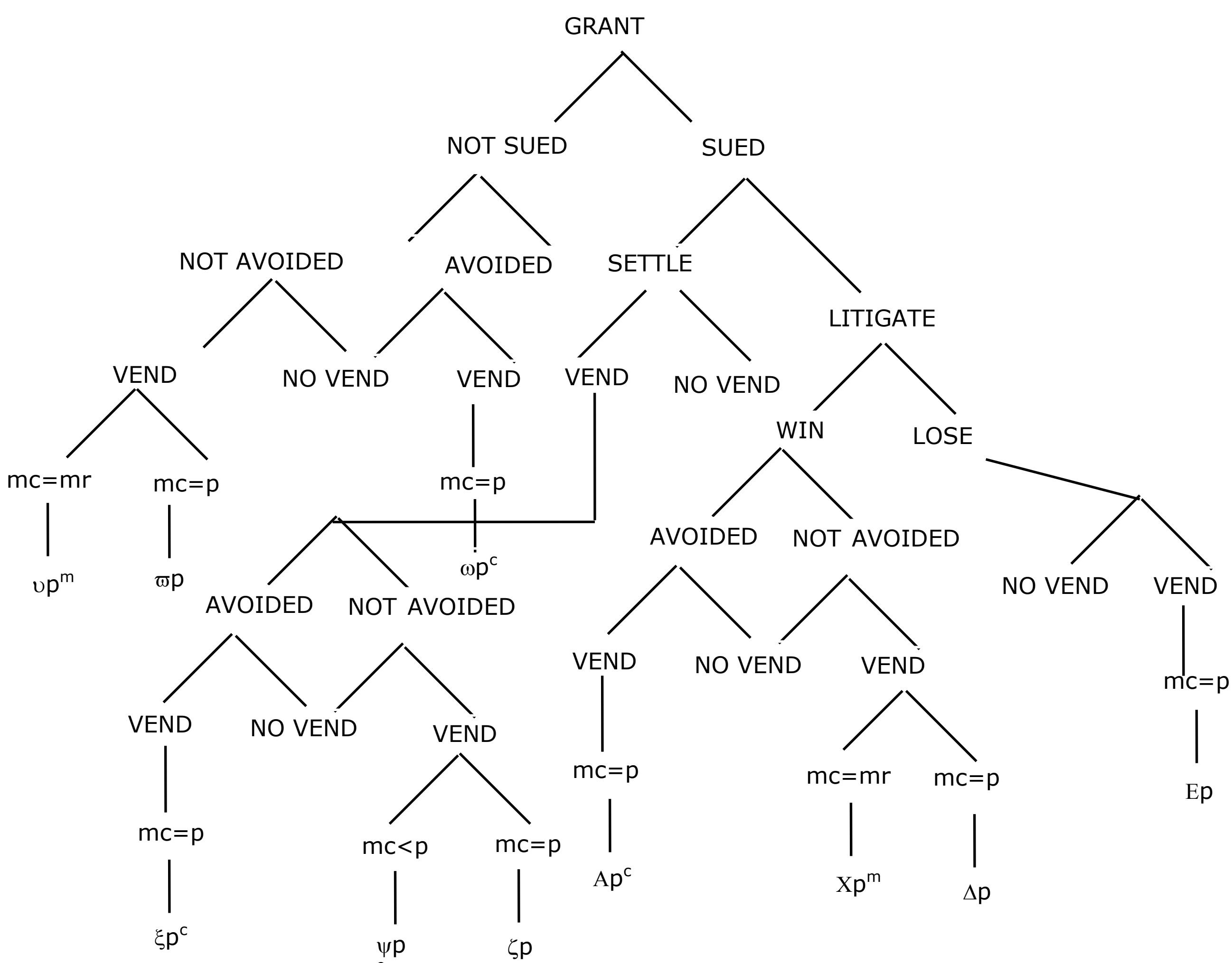
p_{s2} = probability of challenging in court the refusal of an opportunistic claim

p_{g2} = probability of grant for a non-opportunistic claim

p_{s3} = probability of a challenge to the granting of a non-opportunistic claim

p_{a2} = probability of inventing around a non-opportunistic claim

Figure 7: Segment C of an extensive form patenting strategy game following off of patent nice grant



As Figure 7 is the analog of Figure 5, so Figure 8 (**Segment D**) is the analog of Figure 6. The potential lawsuit is challenging the patent office's refusal to grant a patent for a non-opportunistic claim. As in Figure 6, to sue and settle is unlikely. The nodes vend/no vend, avoided/not avoided, the probabilities p_{g2}, p_{a2}, p_m, and p_{bl}, and the prices have the same meanings as they do in Figure 7.

The payouts for segment D of the game are as follows:

$\Phi = (1-p_{g2})p_{s4}(1-p_{bl})(1-p_{a2})p_m$

$\Gamma = (1-p_{g2})p_{s4}(1-p_{bl})(1-p_{a2})(1-p_m)$

$H = (1-p_{g2})p_{s4}(1-p_{bl})p_{a2}$

$I = (1-p_{g2})p_{s4}p_{bl}$

$\vartheta = (1-p_{g2})p_{s4}p_{a2}$

$K = (1-p_{g2})p_{s4}(1-p_{a2})p_m$

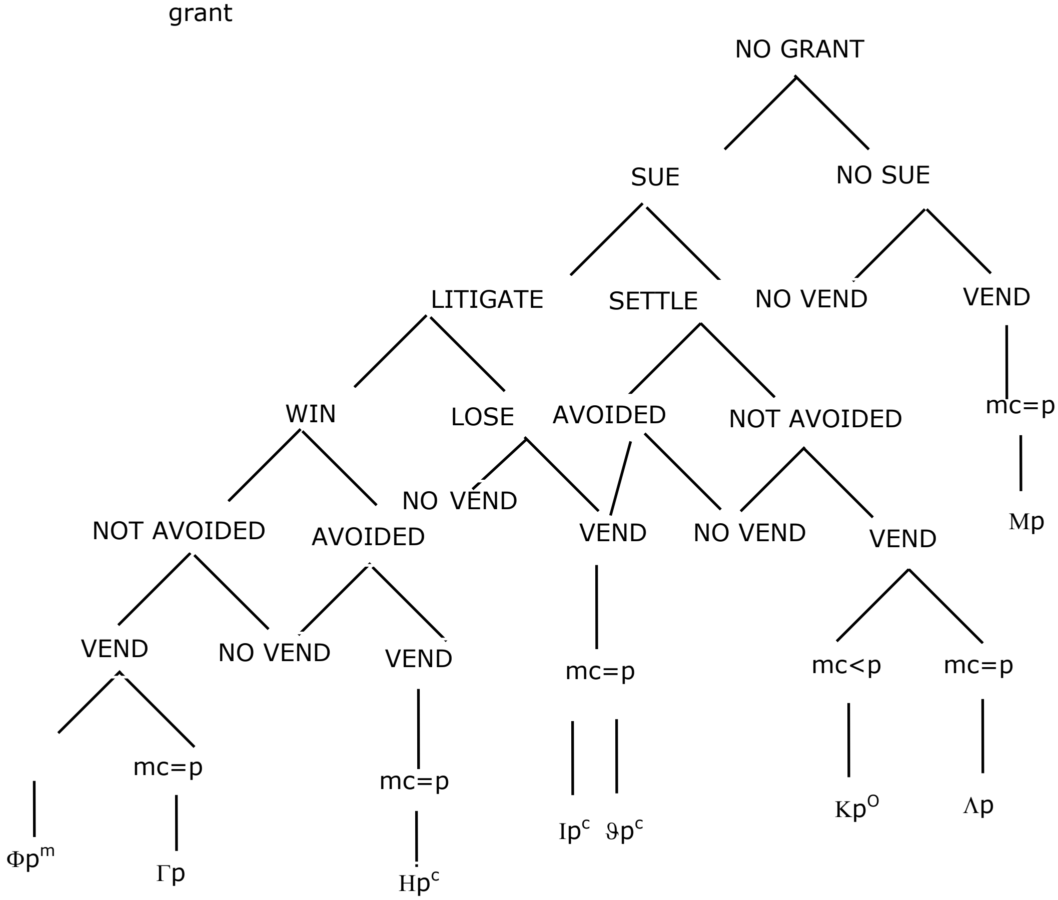
$\Lambda = (1-p_{g2})p_{s4}(1-p_{a2})(1-p_m)$

$M = (1-p_{g2})(1-p_{s4})$

where:

p_{s4} = probability of challenging the refusal of a non-opportunistic claim

Figure 8: Segment D of an extensive form patenting strategy game following off of patent nice no grant



The final segment of the game returns to trade secrets. The sue choice in Figure 9 (**Segment E**) is the innovator's choice to sue either a former employee for breach of a confidentiality agreement, and/or to sue the former employee's new employer for inducing the breach. Having sued, the innovator then has the choice to either litigate or settle. However, whether the innovator chooses to litigate or settle, the secret is now in the public domain and essentially open to anyone, thus marginal cost pricing will be based on the marginal cost following the innovation, p^c. It should be noted that there are also legal means by which the secret can be disclosed, such as reverse engineering. Vend/no vend has the same meaning as in all other segments, as does the probability p_{bl}. The payouts are as follows:

$N = (1-p_{ts})p_{s5}(1-p_{bl})$

$\Theta = (1-p_{ts})p_{s5}p_{bl}$

$T = (1-p_{ts})p_{s5}$

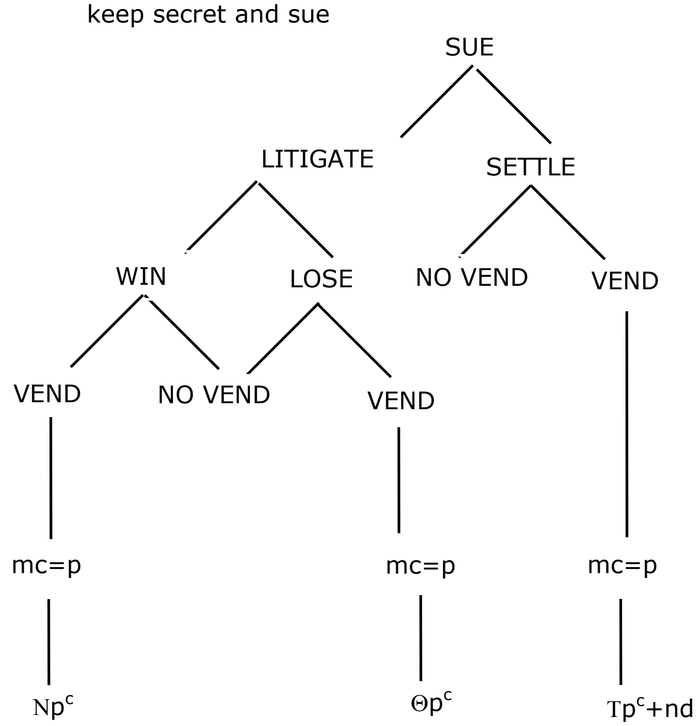
where:

p_{ts} = probability of keeping a trade secret

p_{s5} = probability of suing to enforce a confidentiality agreement

nd = negotiated damages on settlement

Figure 9: Segment E of an extensive form patenting strategy game following off of do no patent fail to keep secret and sue



Several things bear notice regarding how we have structured this game. First, the decision to litigate or settle is treated as deterministic. When faced with such a node, the players will take the expected values of the payouts and choose the strategy that yields the highest expected value. Based on this choice the players will decide to fight or negotiate and do not change their tactic. Second, the goods produced by the new technology are assumed to be homogeneous with goods produced using prior and/or potential competing technologies. Third, oligopolistic pricing occurs off of the settlement nodes because players will agree to license or cross license their technology to one or more competitors, thus breaking the monopoly of the patent but presumably not making the technology universally available. Marginal cost pricing occurs under a patent situation because of the minor innovation argument advanced by Shy

(1995). Basically, the innovation allows the innovator's marginal cost to fall below that of his competitors but not by enough to allow pricing from the point of marginal cost equal to marginal revenue to yield a price lower than the industry's then current marginal cost. Given the assumption of homogeneous goods, the innovator will price at its marginal cost, drive all of the competitors from the market and hope to recover the costs of innovation from normal profits on the increased market share (Shy 1995). It should be remembered that because of the assumption of homogeneous goods, any attempt to price above the industry's marginal cost prior to the innovation by the innovator will attract entrants using the old technology. For the sake of completeness the game should reflect the fact that at any point following invention there should be a node of merger of or takeover by the innovator by another player. These nodes were not included in this rendition of the game because they complicate the game without significantly altering the conclusions we draw. Finally, the game shows no payout at most of the no-vend nodes. In fact, at any of the no- vend nodes that do not show a payout, the player would have the choice of publishing and receiving the publishing benefit or not publishing.

4. What does the Industry Say?

In an attempt to ascertain where we are between points A and C in Figure 3 in western society, we undertook a survey of the intellectual property offices of industry participants. The majority of these responses come from Canadian publicly funded research organizations. While these results may well contain an inherent government bias, they yield results that suggest that we are not at point C in Figure 3 and may well be approaching point A. We conducted the survey in December of 2000 and January of 2001, contacting some 15 public and private research organizations in Canada, the United States, and Australia, and received responses from 4 Canadian and 2 Australian publicly funded organizations.

The responses that we do have suggest that there is a perception that participants in the industry follow an opportunistic patenting strategy. The patents that are claimed are perceived by the governmental intellectual property managers as overly broad and upon occasion claim prior art as novel. Given the admittedly complex task of determining exactly what rights a claim covers, how valid such perceptions may be is open to question. Yet it is perhaps trite to observe that according to received economic theory it is the agents' perception of reality that generally drives decision making once the assumption of full, complete and symmetric information is relaxed. There is also the unanimous response from received responses that industry participants utilize blocking patents. They use the property they hold in a procedure, through their patent on the procedure, to curtail the commercialization of the results of the research programs of potential competitors. While none of the respondents noted difficulty in obtaining patented technologies for research purposes, they have universally commented on the presence of blocking patents in the industry. Curiously, while this apparent opportunistic behavior is practiced by the industry, none of the respondents reported availing themselves of the existing legal remedies to protect themselves from this sort of activity. While the Canadian patent system allows for an application for re-examination (Patent Act s. 48.1), and a subsequent appeal to the Federal Court of Canada (Patent Act s. 48.5), and while the American patent system similarly allows challenges to issued patents on the basis that it is over-broad or fails in one of the novelty, utility or invention criterion for patenting (U.S. Patent Act s. 134 for appeal to the patent office and s. 141 for appeal to the United States Federal Court of Appeal), all of our respondents deny availing themselves of these avenues. Similarly, the European Patent Office's recent opposition provisions (EPO homepage), allowing potential interested parties to challenge the novelty, inventiveness, or utility of a claim at the EPO either prior to the issue of a patent or within ninety days after issue, have not been used by any of the respondents.

These findings appear consistent with a market structure where the incumbents are using their intellectual property to create a barrier to potential entrants. The failure by the respondents to protect themselves from the apparently opportunistic behavior of other industry participants that they reported, suggests that the respondents have reasons for their failure to act. Given that the use of the procedures highlighted above requires access to both extensive personnel and financial resources that all of the respondents have the ability to command, one reason that comes readily to mind is that they desire to see the industry remain in the hands of several large private and governmental organizations. This essentially creates a patent wall that the existing participants can hide behind, without fear of new entrants, because the entrants would have to attract both substantial human and financial capital before becoming a credible entry threat. Since a credible threat of entry is necessary to force marginal cost pricing in contestable market theory (Baumol, Panzar and Willig 1982), this suggests that if such a threat can be avoided the incumbents can enjoy greater than normal profits. The government sector could be involved in such activities for a variety of reasons, ranging from profit maximization to attempts to create national comparative advantage in the international industry—and, perhaps ominously, lack of sophistication. A fourth possibility for explaining such behavior could be that instead of viewing itself as a whole, each of the governmental research institutions views itself as a separate entity and, while government as a whole may have an incentive (that is greater social welfare) to abstain from this sort of behavior, it may be that for the research institution, taken separately, the costs of combating such behavior exceed the gains available to a single government research organization, and thus they do not act. In the private sector, the settlement of law suits between incumbent industry participants such as the Aventis-Monsanto suit (AGNET 2001) and the rush of mergers that the industry encountered in the late 1980s and early 1990s, could also be consistent with this interpretation.

As was noted earlier, our survey data suggests that industry's preferred strategy is naughty. Given this, it should be possible to extrapolate the relative values of the probabilities from the payouts in the game. The preference of naughty over nice suggests that the expected payout from naughty exceeds the expected payout from nice. Knowing that the expected payout from naughty exceeds that of nice allows some determination of the magnitude of the probabilities. If p_{bl} is less than or equal to 0.5, which does not seem unlikely, one should be able to expect the courts to get it right at least half the time, then one should expect $p_{s1} > p_{s3}$ and $p_{s4} > p_{s2}$. This would mean that it is more likely that you would have your patent challenged if you behaved opportunistically than if you did not, and that you would be more likely to challenge the refusal of a patent if you did not behave opportunistically than if you had, provided that you can expect the courts to arrive at the correct decision. Given that our responses to this point indicate that neither the breadth of a patent nor the appropriateness of a claim for issue have ever been challenged in the courts by the respondents, coupled by the dearth of reported litigation over either issue in the press, it is possible that $p_{s1} \approx p_{s3}$ and that they both approach zero. Similarly, the lack of litigation to challenge a refusal to issue a patent reported by both our respondents and in the press—the Harvard mouse case being the glaring exception in Canada—suggest either that $p_{s2} \approx p_{s4}$ and that both probabilities approach zero, or that $p_{g1} \approx p_{g2}$ and that the probabilities of a grant approach one. Again, our survey data would suggest the latter. Indeed, one of our respondents observed, "it appears that the PTO [United States Patent and Trademark Office] is granting everything with a view towards letting the courts straighten it out." The recent Supreme Court of Canada decision in the Harvard mouse case suggests that the perceptions of our respondents may be somewhat skewed and that grants may not be as readily available as they believe.

If the probabilities of being sued and of having a patent granted are as we have suggested, it would be irrational to expect profit maximizers to act other than opportunistically—which is precisely the behavior we observe in the industry. This tendency is exacerbated given the likely probabilities of being invented around and thus facing competition. Intrinsically it would seem that the probability of having an existing patent invented around should be lower the broader the patent claimed. This would suggest that $p_{a2} > p_{a1}$. Again, this is consistent with our finding that naughty is the preferred strategy.

Finally, all of our respondents admit attempting to keep trade secrets. It would seem that the choice between attempting to keep a trade secret and applying for a patent is in part driven by the probability of being able to keep the secret. The closer p_{ts} comes to one, the more likely the decision maker is to opt for utilizing trade secrets rather than some form of registered intellectual property. This observation should be tempered by the observation that innovators make the patenting decision for several different reasons. In licensing negotiations, for example, it may be possible to reduce transaction costs by patenting prior to the negotiations rather than having to negotiate confidentiality agreements prior to the licensing negotiation. Therefore, while the game has forty-one possible payouts, the survey identifies two dominant strategies: patent and behave in an opportunistic fashion; or keep trade secrets. While both of these strategies, by received economic theory, must be profit maximizing and thus privately optimal (otherwise they would not be pursued), neither is socially optimal. The naughty strategy is not socially optimal because it fails to achieve point C in Figure 3. The trade secret strategy is not socially optimal because it uses information asymmetry to extract monopoly rents.

5. Policy Implications

It is clear that within our sample the freedom to operate provisions inherent in the intellectual property regime are not sufficient to afford society the ability to reach point C in Figure 3. Again, subject to the modeling method we used, from our sample it would appear that opportunistic behavior on the part of industry participants substantially contributes to the failure to achieve the greatest possible welfare enhancement from innovation in agriculture biotechnology.

The recent policy change of the US PTO may help to alleviate opportunistic behavior in the sector, particularly if the initiative is followed by other governments. The PTO in its revised policy directive (MPEP 7R1 Feb. 2000) has undertaken to become more stringent in assessing biotechnology patents for the criterion of patentability. This should decrease p_{g1} and create a greater incentive for industry participants to choose the nice strategy over the naughty one. But the industry has to believe that the policy change is likely to occur. The PTO faces a huge logistical challenge to achieve this goal because it is short of qualified patent examiners. This shortage leaves the average patent examiner only about thirty hours to examine each patent (Phillips and Dierker 2001). This problem could be somewhat alleviated if patent offices worldwide reach an agreement about the current state of the prior art.

With its opposition system, the European Patent Office has another means to limit the sort of opportunistic behavior our survey reveals. By allowing challenges to the claims of novelty, usefulness, and inventiveness within nine months of the grant of a patent, the European system should allow industry participants to police the behavior of their competitors more cheaply than systems like those of the US that rely on litigation to challenge the appropriateness of the granting of a patent. This assumes that the lack of litigation that our survey found is a product of high litigation costs and not a tacit attempt to bar entry to the industry through a patent wall.

Again, assuming that the lack of litigation revealed in our survey is not a tacit attempt to bar entry, lowering litigation costs should make challenges of over-broad or otherwise opportunistic patents more prevalent. This would, in terms of the game presented here, raise p_{s1}, thus making the nice strategy more appealing than it presently appears to be. Similarly if governments were to undertake to challenge opportunistic patents in the courts through the auspices of their research organizations, then p_{s1} could be increased and non-opportunistic behavior may prove more appealing.

The welfare enhancing effects of intellectual property rights were, in part, generated in our models by constraining government. Relaxing that constraint, although clearly beyond the scope of this paper, may go some distance to generating the additional welfare enhancement that our models reveal we are losing from opportunistic behavior limiting freedom to operate. One possible approach is for government to tender research to private institutions on some form of lump sum payment, with the opportunity for the contract to shift to some sort of cost-plus payment scheme. Government could obtain the intellectual property should the contract move into cost plus, while the private institution would retain the intellectual property should it stay within the lump sum payment portion of the contract. Other options should also be possible.

6. Conclusions

Subject to our assumptions, we have shown that although it is a second best policy, adopting an intellectual property rights regime can be welfare enhancing. We further demonstrated that the welfare gains from an intellectual property rights regime can be increased if that regime has effective freedom to operate provisions. We then demonstrated that there is good reason to believe that the current system as it exists in Canada is not generating all of the welfare gains possible.

We attribute the failure of the system to generate all of the potential welfare gains at least in part to opportunistic behavior in the agricultural biotechnology industry. At the time we cannot ascertain whether the failure of other participants in the industry to utilize the available mechanisms to control opportunistic patenting strategies is due to high transactions costs, particularly litigation costs, or the more rapacious, although admittedly likely tacit, attempt on the part of industry incumbents to control entry. While we have identified some potential ways that government can intervene to achieve greater freedom to operate, and hence greater welfare enhancement, until we can determine whether or not the failure of the industry to regulate its patenting behavior through the existing mechanisms is a result of high transactions costs or of seeking excess profits, achieving all of the potential welfare gains may prove problematic.

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