INDUSTRY-UNIVERSITY TECHNOLOGY TRANSFER:

MODELS OF ALTERNATIVE PRACTICE, POLICY, AND PROGRAM

A Benchmarking Report of
The Southern Technology Council
A Division of the Southern Growth Policies Board

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Executive Summary

This paper analyzes university-industry technology transfer from the perspectives of the stakeholders involved, the linkage mechanisms between universities and industry, and the fit between the two. It has two primary audiences; first, academic leaders and others considering steps to increase levels of industry-university interaction, or steps to improve the quality of the existing interaction at institutions; and second, public officials anxious to find ways to promote state and regional economic development through helping businesses flourish through successful technology transfer from neighboring universities. Given the mission of the Southern Technology Council, particular attention is paid to potential state economic development outcomes of these relationships. The analysis is couched in terms of a model of the processes of technological innovations which includes several key concepts:

- Technological innovation involves a life cycle of stages or phases which are qualitatively distinct, nonlinear, and recursive.
- The processes are influenced by factors at different levels, which range from very macro to very micro.

  The different stages/phases and levels have organizational counterparts which bring quite different perspectives and interests to the innovation process (e.g., academic researchers versus corporate developers).

The paper describes the expectations, interests, and perspectives of different "stakeholder" groups who are involved in university-industry technology transfer:

- *Companies*, although generally seeking to enhance business competitiveness, will partner with universities for a variety of reasons, including intellectual property acquisition, access to potential new hires, and access to cutting-edge ideas and expertise. Experience indicates, however, that these outcomes are often attenuated for small firms, because of a variety of mismatches with university practices and policies.
- *Universities* will partner with industry for reasons of mission and resource acquisition, and for opportunities for strategic partnerships and application settings.
- *Researchers* in the university will seek partnerships for resources, personal entrepreneurial opportunities, and a venue for doing paradigm-shifting research.
- *State government* will be significantly motivated by aspirations regarding economic development and state or institutional prestige, and the economic geography of technology transfer outcomes (what happens where).

Various university-industry linkage mechanisms, which encompass the full range of the technology life cycle, are analyzed in terms of strengths and weaknesses.

- *Industry-Sponsored Contract Research* is seen as accomplishing many of the mutual objectives of companies and institutions, although it may not address state economic development goals. Intellectual property issues are a recurrent issue in executing research agreements, particularly as they pertain to "background technology" which either the company or the university brings to the project. Although there have been some efforts to craft master agreements between company sponsors and universities, these have shortcomings in terms of generalizing across company settings and performing units within the university. Small company participation in university-conducted contract research has been low, and represents a particular problem in terms of institutional mission and economic development goals.

- *Company-Sponsored Research Consortia* are an increasingly-popular vehicle for performing industry-focused research in the university. They have advantages in terms of securing long-term, large-scale funding for the university, as well as leveraging the investments of companies. Small company participation is weak, however, and there have been many uncertainties about how to commercialize technology emerging from consortia. Without concerted effort by state or local government, there is no geographic focus to consortia, which delimits their regional economic development impact. Consortia are increasingly being combined with one-on-one project relationships with participating companies, which leverages the benefits for industry and the university.
- *Consulting Arrangements* have been lucrative and intellectually-stimulating for involved faculty and advantageous for companies, particularly since consultants are, in effect, part-time employees of companies when engaged. They can also function as a bridge to other types of industry relationships with the university, such as research sponsorship. There are shortcomings for the university, however, in that these arrangements may be rife with potential for conflicts of interest and commitment, and they may deprive the institution of mission-relevant work that could be done under its imprimatur. Consulting is ostensibly geography-neutral, and may or may not positively impact local and state companies. However, there is little systematic information about the impacts of consulting.
- *Licensing of University-Developed Technology* is rapidly growing and has benefits for both companies and institutions. However, licensing agreements and their oversight are increasingly complex, and demand a significant investment in capacity on the part of universities. Standard licensing practice may or may not benefit state economies, depending on the geographic mix of licensees. Recent research by the Southern Technology Council indicates that there can be significant out-migration of technology, and subsequent value-adding economic activity, with upwards of 85% of licensing deals in the South involving out-of-state companies.
- *Joint Development and Commercialization of Technology,* particularly involving start-up companies, is a qualitatively distinct and somewhat controversial approach to technology transfer. It typically involves the university in novel licensing arrangements, such as taking an equity piece rather than cash, and also demands intensive due diligence by the institution. Universities which do well at this activity tend to have strong links to (or operate) a local business development infrastructure. On a cautionary note, the involvement of the university in fostering start-ups seems to produce the most negative reactions on the part of faculty and administrators.

This domain of university-industry technology transfer will benefit significantly from benchmarking of performance and practice. Institutions can understand how they compare with their peers in terms of various performance metrics (e.g., royalties per $10 million of R&D, fraction of licenses involving start-ups), as well as learn about "best practices" that are related to such outcomes. Recent benchmarking studies conducted by the Southern Technology Council are described.

University involvement and success in technology transfer is highly dependent on the nature of the "organizational culture" of the institution. The shared values, knowledge, rewards, and incentives of a university can either facilitate or impede technology transfer and industry partnerships. Recent studies of faculty and administrator attitudes regarding technology transfer indicate that there is in general widespread support for university involvement therein, but this support is severely attenuated among faculty and administrators who are not personally involved in industry partnerships and in institutions which have low rates of technology transfer. Moreover, there is significant apprehension about university involvement in entrepreneurial commercial development. All of these attitudes and related practices vary as a function of discipline and unit.

To close, although all of the practices, policies, and programs we review have produced positive results, none of them constitute a magic bullet for industry-university cooperation. Reasons for less than optimal results include the heterogeneity of needs and goals among the different stakeholder groups, a failure to embrace business principles which support benchmarking and best practice identification, and the overarching influence of organizational culture. Universities are advised to be flexible and customer-oriented in their partnerships with industry. There appears to be no single model that satisfies all stakeholder interests.

THE ECONOMIC CONTEXT

Regional economic development has become a significant driver of public support of higher education. The economic environment - now and for the foreseeable future - is one which will handsomely reward those individuals, companies, countries, and states which are able to pull together creative and skilled people, leading edge science and technology, capital, and smart disciplined management to serve far flung markets with new products and processes. Many of our leading companies today did not exist twenty years ago, and most of these are exploiting the commercial potential of science that is not too far removed from the laboratory. Clearly, knowledge embodied in technology has become the vehicle by which economic value is created.

Ironically however, the ways in which knowledge expresses itself as the dominant factor in economic growth are qualitatively different from other historically- prominent inputs. For example, it is inherently difficult if not impossible to develop a monopoly position in knowledge, except in increasingly narrow and temporary domains. Knowledge derives from personal inspiration and world-class science being exercised concurrently in thousands of settings. The work on sequencing the human genome is an example. The efforts of laboratories around the world are available to all in very short order through sophisticated databases and electronic transfer of information.

Moreover, as Professor Thomas Kuhn[1] has pointed out, new theoretical or empirical understandings in a field will disrupt or obsolete much of the pre-existing knowledge base. In effect, the target is always changing, and new paradigms of inquiry are adopted. Similarly, the application of new knowledge into commercial ventures derives from a similar uncontrollable impulse in human behavior - the entrepreneurial spirit. The bottom line is that no player can long dominate or control the innovation processes unleashed in a technology-rich information-based economy. At best, one can be nimble and cover as many bases as possible.

One major organizational strategy that has evolved in the past several years to address this state of affairs is that of <u>partnerships.</u> Rather than trying to do or be all things, organizations have learned that they can leverage their resources by joining their competencies and resources in creative engagements with other entities. University-industry technology transfer relationships are an important venue for all parties to advance their interests in the context of a technology-based economy, and it is worth examining <u>how</u> they go about this endeavor. However, before the how, let us first look at the why. What are the interests and expectation of various stakeholders in the process of university-industry technology transfer? In addition, how can we put these observations into context, as part of some larger conceptual model?

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[1] Kuhn, T. *The Structure of Scientific Revolution.* (2nd ed.). Chicago: University of Chicago Press, 1970.

A Conceptual Model

University-Industry technology transfer relationships are one strand of activity in a larger set—the processes of technological innovation. Technological innovation involves the successive transformation of knowledge (often derived from scientific research) into practical artifacts, tools, or practices which are subsequently deployed to users, via public dissemination or private markets. Without going into the huge theoretical or empirical literature on technological innovation, which has been described elsewhere,[2] there are a few key concepts of relevance to our topic:

- Technological Innovation involves a life cycle of stages and phases which are qualitatively distinct (e.g., research, development, technology adoption, implementation). Viewed retrospectively, this life cycle has the appearance of being quite linear (e.g., research leads to development) but usually is not during its execution.

- The processes are influenced by different levels of factors, which range from very macro (e.g., government policy, market structure) to very micro (project manning, group dynamics, organizational rewards and incentives). All levels of influence operate concurrently, and one can "explain" the success or failure of the innovation process by the influence of each, although that explanation is likely to be incomplete.

- The different stages/phases and levels have organizational counterparts (e.g., a corporate R&D group, a Congressional policy study entity), which bring quite different perspectives and interests to the innovation process (e.g., researchers see the world being driven by knowledge creation; corporate product development people are attuned to market preferences). Moreover, since the different stages/phases and levels have organizational counterparts, there is a profound need to understand and manage linkage relationships within this large landscape of activity.

All of this suggests a complex, context-sensitive, multi-layered, and interdependent approach to understanding university-industry technology transfer.

Expectations, Interests, and Outcomes of University-Industry Technology Transfer

As has been suggested above, we are defining "technology transfer" rather broadly to include not only formal agreements regarding the disposition of intellectual property, but knowledge transfer via cooperative research, collegial professional interaction, consulting, employment of students, and various other modes of engagement. In assessing these mechanisms, it would be useful to think about the expectations, interests, and outcomes of a variety of stakeholders including:

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[2] Tornatzky, L.G. and Fleischer, M. *The Processes of Technological Innovation.* Lexington, MA: Lexington Books, 1990.

industry (large and small), university (including individual faculty), and a relatively new player – state government.

Companies

At first glance, it would appear that companies simply want to increase their competitiveness, expand market position, and/or maximize profits as a result of university-industry technology transfer. Of course, this is true; but how these outcomes get realized differs as a function of the type of partnership or mechanism, as well as the needs of particular companies. For example, large companies with strong in-house technological capacities to maintain may have a primary need for highly-trained scientists and engineers. In contrast, companies with shrinking R&D capacities may have a prime need to leverage their existing assets by contract research arrangements with universities. This need may be exacerbated in companies operating in markets with short product life cycles and where intellectual property is typically handled through trade secrets. Thus, for some companies, access to a hiring pool of bright undergraduate or graduate students is far more valuable than the university-based research which they might support, while for others the opposite is true.

The patent system … thereby added the fuel of interest to the fire of genius in the discovery and production of new things.
- Abraham Lincoln, 1859

In other industry or technological domains, for example pharmaceuticals, formal (and exclusive) acquisition of intellectual property is much more critical to business success, and in its absence companies may not participate in university partnerships. This appears to one of the main reasons for the relative scarcity of biotechnology consortia. In still other settings, companies are primarily positioning themselves to get early access to world-class fundamental science, and to the best ideas from the brightest minds, which they in turn will mature via internal applied research and development. For example, in some industries first-to-market in a rapidly changing product environment may be much more important than licenses and patents.

A 1996 survey[3] of life-science companies illustrates these complexities. For example, while over 60 percent of companies had achieved benefits such as patents, product development, and increased sales which they attributed to their interactions with universities, almost an equal fraction of the companies (56 percent) reported that they relied on the relationship to "keep staff current with important research". In addition, while 53 percent reported that they used the partnerships to provide new ideas for products, only "29 percent of companies reported that they depend somewhat or very much on faculty members to invent products that the company will license". Given the varying types and levels of involvement of companies with universities, a growing trend is to move from episodic engagements to more inclusive strategic partnerships.

Companies' expectations and goals are significantly colored not only by the characteristics of their industry, but also by where the participating firm is in terms of its own organizational or product development life cycle. For example, new entrepreneurial firms have few degrees of

[3] Blumenthal, D., Causino, N., Campbell, E. G. and Louis, K. S. "Relationships between academic institutions and industry in the life sciences - an industry survey". *The New England Journal of Medicine,* 334:368-373, 1996.

freedom in time or money. They must get first generation products to market, maintain the competitive advantage of their technology (either internally developed or acquired), and limit spending that is not clearly tied to immediate commercialization objectives. All things equal, it has been very difficult for smaller US companies to meaningfully partner with research universities.

Universities

Academic institutions - and units therein - foster technology transfer relationships for a variety of reasons, some short-sighted and others more strategic and positive. Among the former is the perceived decline in federal support of research, and the resultant ongoing search for replacement funding. Industry money is thus seen as a tactic to maintain or enlarge the support of fundamental research and maintain status among the peer communities of academic science, and in fact the share of basic and applied research at universities funded by business has increased from 3.0% in 1975 to 7.2% in 1998. At the same time, the share supported by the principal patron of university research - the Federal Government - has decreased from 71% in 1975 to 59% in 1998.[4]

In the view of more traditional academic administrators and faculty, however, industry involvement in university research is viewed as a temporary instrumentality or aberration, not as a permanent shift in how research should get done. Not surprisingly, when universities enter into industry relationships with this as a goal (unspoken or otherwise) the "partnerships" are often flawed in flavor and practice. Nonetheless, a newer cadre of research administrators and faculty is viewing the same environment in a more strategic manner, assuming that industry partnerships are real, growing, and a positive harbinger of the future. These two alternative interpretations of reality provide a focus for various "cultural" disputes within universities.

One can also look at the same facts from an organizational theory perspective as well. As interpreted by one student of these phenomena,[5] a relative decline in federal support of academic research introduced an environmental stress which "punctuated" the equilibrium of the system, which in turn yielded a spurt of innovation in university-industry linkage mechanisms. The issue is whether this innovative activity will continue to flourish as long as the public sector achieves a new equilibrium.

Nonetheless, there is growing evidence that universities are capable of getting beyond pecuniary interests and promoting technology-transfer partnerships as an expression of larger mission goals and new organizational visions. For example, recent work by the Southern Technology Council[6] has uncovered examples of universities, particularly among Land Grant universities, which have redefined scholarship to encompass and spotlight "outreach", and embedded technology transfer therein. In these institutions, partnerships with industry are an integral part of organizational

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[4] National Science Board. *National Patterns of Research and Development Resources: 1998.* Arlington, VA: National Science Foundation, 1999 (NSB 99-335). Tables B-2(a+b) and B-3(a+b). Data are percentages of expenditures in constant 1992 Dollars.
[5] Baba, M. L. "Innovation in university-industry linkages: University organizations and environmental change". *Human Organization,* Vol. 47, No. 3 Fall, 1988.
[6] Tornatzky, L.G. and Bauman, J. S. *Outlaws or Heroes? Issues of Faculty Rewards, Organizational Culture, and University-Industry Technology Transfer.* Research Triangle Park, NC: Southern Growth Policies Board, 1997.

identity. Examples include "The Wisconsin Idea" and mission statements at Michigan State University, North Carolina State University, Carnegie Mellon University, and elsewhere.

Researchers

Project investigators, both university-affiliated or industry-based, have various interests and objectives pertaining to technology transfer relationships. Faculty may become initially involved for one reason, and over time, develop another set of goals. As noted above, for many faculty industry support has in fact become a growing source of research funding. This is particularly true for junior faculty.[7] It is also relatively clear that over the past two decades faculty attitudinal support of partnerships with industry has grown to a majority opinion[8]; although as we will see, this support is contingent upon what is exactly involved in the relationship.

Sometimes, faculty become involved in these relationships because they provide a venue for doing problem-focused and/or interdisciplinary work, which presents an appealing intellectual challenge for many faculty. The "paradigm-shifting" nature of cooperative science becomes a lure in itself. A few years ago, a national study was conducted of academic researchers involved in one-on-one cooperative research projects with industry partners.[9] In exploring the benefits that academics derived from these relationships, there were many self-reports of whole new lines of inquiry or new ways of looking at research problems that emerged from the dialogue with industry.

It is also true that the character of industry engagements often leads to the awakening of entrepreneurial urgings among university faculty. Many faculty members have a deep personal interest in the practical application and commercial success of their brain-child; although, in terms of operating rewards and incentives, they are still driven by tenure and promotion criteria that emphasize discipline-based publication and curiosity-driven inquiry.

Despite these countervailing influences, the role-model of the successful faculty-entrepreneur is becoming more prevalent. These individuals started appearing in number in the 1980's, working at the cutting edge of their science while also working closely with new or existing companies interested in their discoveries. Since this phenomenon emerged, a whole generation of graduate students have been trained in labs in which entrepreneurialism is encouraged and has been rewarded, and they are also looking for the same opportunities. Not infrequently, these newly minted researchers will "interview" the technology transfer office when they are being considered for a faculty post at an institution.

State Government

Perhaps the most neglected perspective in discussions about university-industry technology transfer is state government. This is unfortunate. About two-thirds of the top 100 research-

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[7] Behrens, T. and Gray, D. "Unintended consequences of cooperative research: Impact of industry sponsorship on climate for academic freedom and other graduate student outcomes." *Research Policy*, 1999, in press.
[8] Lee, Y.S. "Technology Transfer and the research university: a search for the boundaries of university-industry collaboration". *Research Policy*, Vol. 25, 843-863, 1996.
[9] Johnson, E. , Tornatzky, L.G., and Schlaaf, L.R. *Cooperative Science: A National Study of University and Industry Researchers. Volume 2.* Washington, DC: National Science Foundation, Productivity Improvement Research Section, 1984.

> **"As the principal beneficiaries of technology-based industry within their borders, the states should be encouraged to play a greater role in facilitating the development of these industries, both through their support of research universities and by facilitating the interaction between these institutions and the private sector."**
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> **Report: *Toward a National Science Policy*; Committee on Science, House of Representatives, 1998**

intensive universities in the US are state-supported. In addition, virtually all states have in the past decade developed technology strategies and programs which are more-or-less incorporated into state economic development activities. Most of these rely heavily on industry-university linkage mechanisms. These include a variety of approaches, such as state funding of applied research focused on prominent state industries, support of commercialization assistance such as technology-oriented business incubators, funding of centers of excellence, and investment in laboratory space and equipment.[10] From the perspective of these state initiatives, university-industry technology transfer involving "their" state-supported institutions needs to take on certain characteristics. While building the industry-funded research portfolio or expanding the license royalties for "State U" are admirable goals, more important are follow-ons such as anchoring value-adding economic activities in the state and/or insuring the flow of state-subsidized newly-minted science and engineering graduates to state-based companies . The "where" of the resultant innovation process is critical to this group of stakeholders.

Interestingly, universities are increasingly sensitive to the perspectives of state government and local economic development. In a recent survey of university-linked leaders undertaken by the authors, 65% of respondents indicated that they would be quite interested in learning about best practices and policies in "university involvement in economic development".[11] This level of interest was only exceeded by their concern about how to more effectively partner with industry in sponsored programs.

PRACTICE AND POLICY MODELS: STRENGTH, WEAKNESSES, AND EXEMPLARS

There are a number of discreet mechanisms which can be deployed to advance university-industry technology transfer. For example, one analyst has documented 28 types of university-industry "linkages"[12], by date of appearance and function. Other analyses have tried to consolidate interaction mechanisms into broad categories.[13] Nonetheless, whether there are five

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[10] Berglund, D. and Coburn, C. (eds.). *Partnerships. A Compendium of State and Federal Cooperative Technology Programs.* Columbus, OH: Battelle Press, 1995.

[11] Tornatzky, L.G., Waugaman, P.G., Gray, D. and Bauman, J. S. Dear Colleague Letter Report, June 24, 1999. Southern Technology Council. National Science Foundation Grant # EPS – 9819351.

[12] Baba, M. *op cit,* 1988.

[13] Waugaman, P.G. and Porter, R. J. "Mechanisms of interactions between industry and the academic medical center". In Porter, R. J. and Malone, T. E. (eds.), *Biomedical Research: Collaboration and Conflict of Interest.* Baltimore: The John Hopkins University Press, 1992; also, see Gray, D., Behrens, T. and Oldsman, E. "Industry-university linkage mechanisms in the United States". In Brimble, P. (Ed), *Modalities of University-Industry*

or twenty-eight categories of university-industry technology transfer mechanisms, each has its own "footprint" of impacts on stakeholder goals and expectations, as well as novel or exemplary policies and practices embedded therein. In this section, we will review a range of technology transfer arrangements. Consistent with a life cycle model of technological innovation, some of these approaches are focused on the knowledge-creation phases; others are closer to the stages of the product development cycle.

1. Industry-Sponsored Contract Research

Contract-supported research, involving various arrangements, is by far the most common element in collaborative arrangements between business and academia. Industry-sponsored research expenditures at US colleges and universities reached $1.71 billion per year as of 1997,[14] and a large fraction of this is executed through contractual relationships. The basis of these arrangements, of course, is that the research projects conducted by university scientists are seen to be of value to the business sponsor. Companies are investing not only in the outcome of the sponsored project (or group of projects), but they also have expectations that the research will be done on time, within budget, and the expected results will be delivered. By "expected results," we do not mean specific findings, but that the agreed-upon experimental questions will be addressed and hopefully answered. Companies, of course, are also seeking to realize other objectives, such as access to potential hires among the cadre of graduate students who perform most of the work.

There are a variety of contract research relationships which have been developed, each of which more-or-less meets the goals and expectations of the industry and university participants, but the simplest form is the one-on-one single project research agreement. The agreement usually pertains to a single project, or a group of closely-related research tasks, sponsored by one company at one university. The university agrees to accomplish specific research, and the company agrees to pay the university to do so.

There are common elements to all such agreements: (1) a statement of work or scope of work; (2) understandings regarding the publication and/or disclosure of research results or methodologies; (3) understandings regarding rights to any inventions or intellectual property resulting from the research; and (4) understandings regarding the protection of any confidential information exchanged between the parties.

Carefully crafting the agreement is an essential element of keeping a good project from going sour. A properly-developed agreement will recognize the needs of the sponsor, the practical limitations of the university to deliver, and the characteristics of both organizations. There have been a large number of "model" agreements[15] developed and disseminated by various national

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Cooperation in the Asia Pacific Economic Cooperation Region. Bangkok, Thailand: Ministry of University Affairs, 1997.

[14] National Science Foundation, SRS*, Selected data on Academic Science and Engineering Research and Development Expenditures, Fiscal Year 1997.* Washington, DC: U.S. Government Printing Office, 1999, Table B-36.

[15] Government-University-Industry Research Roundtable, Industrial Research Institute. *Simplified and Standardized Model Agreements for University-Industry Cooperative Research*. Washington, DC: National Academy Press, 1988;

organizations since industry-sponsored research has become fashionable. Both universities and companies have developed their corporate "standard" agreements as well. However, the unique needs of individual projects, and the high number of both performers (universities) and sponsors (companies) make the process of crafting an agreement which will meet both sides' needs a tricky business indeed. Some of these options are presented below.

One-on-one research agreements generally support the goals and interests of both industry and the university. However, to the extent that they migrate toward companies buying research time for very applied efforts, they will deviate from the more central academic goals of advancing basic knowledge. Nonetheless, contract research also serves another institutional goal quite well: graduate education and the support thereof. In many settings (particularly engineering schools) contract research - with appropriate agreements - has supported much thesis and dissertation work. In one institution we know of, groups of industry-funded, student-executed, projects have been "bundled" together so that students will get their theses or dissertations supported, but in addition, they will learn how to work in a team setting with their peers.

Since the industry participation in one-on-one contract research is in no way steered by geographic considerations, the payoff in state-based economic development is often quite uncertain. To remedy this, many states have launched programs in which contract research with state-based companies is encouraged by sweetening the mix with state matching money.[16]

The Master Agreement

As the number of projects sponsored by one company at one university increases, there is a tendency to move toward a "master agreement," which contains the "boiler plate" common to any project. This may include such items as publication rights and duties, rights to inventions and intellectual property, and financial accountability. The master agreement is intended to prevent long and costly renegotiations of these provisions each time the sponsor and a faculty member decide to initiate a project. Negotiations are then focused on such matters as the scope of work, time period, and budget. Master agreements work well when a company has a large portfolio of research at a single institution, and the research work underway adapts well to the boiler plate provisions so that they need not be revised or invented anew for an individual project. Master agreements work well in those institutions where considerable business sponsored research goes on and the sponsors tend to be large companies, who come back again and again.

The major limitations of master agreements are their inability to transfer well between varying divisions in some large companies, or between varying research projects at a single university.

Government-University-Industry Research Roundtable. *Intellectual Property Rights in Industry-Sponsored University Research.* Washington, DC: National Academy Press, 1993; Reams, B.S. *University-Industry Research Partnerships: The Major Legal Issues in Research and Development Agreements.* Westport, CT: Quorum Books, 1986.

[16] Berglund, D. and Coburn, C. *Op Cit,* 1995.

The major limitations of master agreements are their inability to transfer well between varying divisions in some large companies, or between varying research projects at a single university.[17] For example, what may work well for the agricultural products division of a large chemical company may not work at all in the company's specialty chemical division. What may work for researchers in a department of mechanical engineering at a university may not suit the kind of projects which will be done in a department of biochemistry. In fact, universities may get into trouble with their own faculty, miss opportunities, and alienate their sponsors when they try to make "one size" of standard provisions "fit" all situations. Practitioners experienced with master agreements point out three guiding principals for crafting successful master agreements: (1) Negotiations proceed better when a technical person takes the lead for the company; (2) Such arrangements are easier when the company is large, has several technical groups in many locations, or when the company anticipates sponsoring several projects; and (3) Master agreements work well when each party's goals and objectives are understood by the other party, and the projects are somewhat similar in technical orientation.[18] In addition, the nature of master agreements is evolving such that crafting individual project agreements is more menu-driven, and can more easily accommodate some of the variances described above.

Model research agreements have attempted to present uniform provisions, but the exceptions outnumber the rules.

A final point is that small companies are generally loathe to become involved in omnibus arrangements of this kind, and usually do not support more than one or two research projects at any one time. The limited impact of master agreements on research sponsored by small companies matters most, perhaps, to state economic development officials trying to foster greater linkage between a state university and small companies within the state. However, some universities which are located in an environment populated by entrepreneurial technology-based small companies are making strenuous efforts to re-invent the master agreement for this clientele.

Intellectual property issues in contract research

Research agreements with companies generally include intellectual property provisions. The guiding principle is that the sponsoring company has the preferential opportunity to acquire the rights to any intellectual property which results from the research, most commonly by licensing the rights.

There are industries, however, including heavy manufacturing, basic metals, and the like, where companies often insist on obtaining title to any inventions which may occur through assignment. This can be quite troublesome to many universities. Universities often have policies which require them to retain title, and preclude any negotiation on the matter. Even when the company is willing to license intellectual property, the extent to which the company wishes to establish license terms in advance and include them in the research agreement can be difficult for universities. This is especially so when the value of the intellectual property is not fully

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[17] Petrick, I.J. and Reischman, M. M. "The inherent tensions of university-industry master agreements". *Proceedings. Technology Transfer Society Annual Meeting. 1995.*

[18] *Ibid. P.216.*

understood at the onset of a research project, or even whether any licensable intellectual property will emerge from the work. Often, universities will be unable to accept advance understandings of license terms in research agreements because of tax regulations. The Internal Revenue Service has ruled that research conducted for a for-profit sponsor, when the intellectual property has been licensed to that sponsor in advance, is "proprietary" in nature. Conducting even a small amount (over 10%) of such "proprietary" research in a building financed with bonds can threaten the tax-exempt status of those bonds. Universities will avoid this at any cost.

Because there are a large number of companies, and a relatively large number of academic institutions doing industry-sponsored research, there has always been confusion as to what practices are most appropriate. The "model" agreements mentioned above have attempted to present uniform provisions, but it is our impression that the exceptions outnumber the rules. Those institutions which seem to do better at industry-sponsored research are guided by a few principles and an appropriate attitude, rather than a rigidly-defined transaction model. That is, they approach engagements as if companies are valued customers, and work diligently and promptly to craft research agreements that will meet the needs and concerns of all involved.

The Issue of Background Technology

As industry-sponsored project research becomes more cooperative, and the degree of business participation increases in terms of the development of the scope of work, the background research, and even the conduct of research projects at the university, new problems emerge to challenge the "models." For example, in some settings there is bench-level scientific cooperation between university and industry personnel. In these cases it is inappropriate to assume *a priori* that inventorship automatically resides with the university investigator. This uncertainty is also relevant to the issue of background technology.

Background technology includes that information and perhaps even intellectual property embodied in trade secrets or patents, which either the sponsoring company or the university bring to the project. Background technology is the result of previous R&D conducted by either the company or the university. As research becomes more collaborative, with business sponsors participating directly in the conduct of research, dealing with the issue of background technology is likely to become more common.

A company's background technology may be in the form of trade secrets, patents (either pending applications or issued patents), or simply preliminary experimental results which could lead to further discoveries. If the company brings unpatented background technology to a university research project, it may develop a formal interest in patent rights resulting from the sponsored project with the university. If the sponsored project results in an invention, and that invention incorporates company background technology therein, then company researchers may be co-inventors of the technology.

If the company's background technology is embodied in patent applications or patents, those patent rights may dominate any patents resulting from the research conducted at the university in the context of the sponsored project. In this situation, the university's patents cannot be practiced without also practicing the dominant or "background" patent owned by the company.

Therefore, the company which owns the background patent becomes the only viable licensee for the new patent, limiting the university's ability to market the new patents.

A university's background technology may be in the form of patents or patent applications resulting from prior research, or it may lie in preliminary research which begins or underlies the potential invention, but in itself does not constitute a patentable invention. A university may place unpatented background technology "at risk" when it presents a research proposal to a company. This problem can be prevented by making such a presentation under the terms of a confidentiality agreement. This step identifies the information as confidential, therefore the proposal cannot be considered a public disclosure. It also can limit what the company can do with the information, preventing the company from legally using the information to plan its own follow-up research.

The interest of a university in intellectual property dominated by a company's background technology is not likely to be valuable to the university, but could be very valuable to the involved company. In effect, only the company may be able to use the intellectual property, and it could mean a lot of money for the company. The value of intellectual property acquired from a university may arise from the ability of the company to prevent competitors from practicing the invention, thereby protecting a competitive advantage. In this circumstance, it may be difficult for a university to capture the invention's value from net sales. In turn, because of the background technology, the university is effectively precluded from finding an alternative licensee which could profitably use the intellectual property. The question then becomes how much should the sponsoring company be expected to pay for such property?

Often, a university may consider intellectual property that its researchers have created with the sponsor's background technology to be more valuable than it is. The resulting negotiations with the company may become acrimonious and strain the overall relationship. A university which over-values its background technology or its contribution to joint inventions may find itself losing business sponsors to institutions that businesses consider more reasonable.

In summary, industry sponsorship of research projects can be a boon for both company and academic participants. However, the mutual benefit that can derive from these relationships is contingent upon successfully managing a complex set of legal and operational issues primarily concerned with intellectual property. In addition, no university has adequately solved the many problems of involving small companies in sponsored research.

2. The Consortial Approach.

One increasingly popular approach to industry partnering has been industry-university centers and in particular the multi-sponsor, multi-performer consortium approach to industry-funded

There may be upwards of 1,000 industry-university centers of various types in the US, accounting for a significant fraction of industry-supported academic research.

research. In this arrangement a group of faculty (typically with the leadership of a visionary investigator) develops an agenda of potential research projects, generally clustered around a technology domain (e.g., coatings, polymer composites) and attempts to pull in industry participation and usually financial support. The federal government, particularly the National Science Foundation, has been particularly invested in this approach through various centers programs (Industry-University Cooperative Research Centers, Engineering Research Centers, State Industry/University Cooperative Research Centers, and Science and Technology Centers).

One programmatic illustration of this type of arrangement is the National Science Foundation Industry-University Cooperative Research Centers Program (IUCRC)[19]. These centers vary widely in terms of size, number of participating companies, and the role that companies play in actually setting, supporting, and participating in the execution of the R&D agenda. Some university-based consortia have upwards of 20-30 companies participating, and annual research budgets that exceed seven figures. In contrast to most of NSF's other centers programs, companies provide the bulk of project funding, take an active role in choosing which projects are conducted, and sometimes participate in the bench level science itself.

According to one survey[20] there may be upwards of 1,000 industry-university centers of various types in the US, accounting for a significant fraction of industry-supported academic research. Most industry-university centers leverage industry support with government funding, and also tend to reinforce inter-disciplinary or multidisciplinary work. One observer has labeled these vehicles for consortial partnering as the most important development in the character of university research in the past two decades.[21]

How does this vehicle or mechanism track against the expectations and goals of various stakeholders as described above? Companies that do participate realize several technology transfer objectives. For one, they usually provide a great venue for hand-picking among graduate students for future employees. Second, participating companies can leverage their investments several times over given co-investment by other companies. Third, these organizations typically provide participating companies with a strategically useful window on early stage research. In fact, according to research from the IUCRC program, member firms reportedly invest as much on follow-on internal research projects as they invest in the center itself.[22]

For institutions, such consortial arrangements often provide a huge influx of long-term research funding. After the fits and starts of launching these programs, many of them last for years.

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[19] Gray, D.O. and Walters, S.G. *Managing the Industry-University Cooperative Research Center. A Guide for Directors and Other Stakeholders.* Columbus, OH: Battelle Press, 1998.
[20] Cohen, W., Florida, R., and Goe, W. R. *University-Industry Research Centers in the United States.* Pittsburgh, PA: Carnegie Mellon University, 1994.
[21] Feller, I. "Technology Transfer from Universities." *Higher Education: Handbook of Theory and Research,* XII. New York: Agathon Press, 1997
[22] Gray, D.O. and Walters, S.G. *Op Cit, 1998.*

Also, depending upon the mix of funders and the nature of the work performed, having a "Center" of this sort tends to reinforce institutional prestige. For faculty investigators, consortia can provide long-term research support, as well as (if they are personally constituted to make it happen) an intellectually robust source of ideas on new research directions. From a mission perspective, institutions can not only take credit for advancing knowledge creation, but they also argue that such centers contribute to economic development aspirations.

In fact, the latter proposition is much less certain. Studies of the NSF IUCRC program, for example,[23] indicate that most industry participants are Fortune 500 multinationals, and are not necessarily state-based nor state-oriented. This is true of virtually all center programs. Moreover, the track record of smaller, entrepreneurial companies participating in consortia is relatively weak. Recent analyses of the IUCRC program indicate less than 10% of member companies are small businesses.[24] There are only a few documented instances of start-up companies emerging from university-based consortia. To some extent these shortcomings may be a by-product of the extent to which this mechanism focuses on relatively fundamental research and the earlier stages of the innovation process.

Unresolved Issues of Consortia

One weakness of consortia arrangements is that they are often unfocused when it comes to technology transfer and commercialization. For example, it is common practice that when intellectual property comes out of the work, and is protected via patenting or copyrighting, that all participating companies get a non-exclusive license thereto. Often this will include a provision that the license is for "internal use", which is a somewhat ambiguous term. There are rarely clear paths for a single member company (or a partnership of member companies) to pursue productization and commercialization of research conducted for the consortium at large.

For thoughtful state economic development officials, consortia can be a mixed blessing. On the one hand a large successful consortium undeniably adds to the R&D assets of the state. On the other hand, for reasons described above, there are usually few ways that follow-on technology development and commercialization can be successfully anchored locally. This is particularly so when the involved university is located in a state with a relatively modest concentration of R&D-intensive companies, often resulting in <u>no</u> member companies having in-state roots.

There are some examples of novel approaches to address the shortcomings and retain the positive aspects of consortia. One has been the evolution of omnibus centers which encompass both a consortia approach, and one-on-one research contracts with individual member companies for proprietary and often exclusive technology development. Second, some states have grafted state-funded programs onto industry and federal-agency consortia that support the state-based development of emerging technology. One good example of this phenomenon has been the Edison Welding Institute, which began as a much smaller campus-based cooperative research

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[23] Hetzner, W.A., Gidley, T.R., and Gray, D.O. "Cooperative research and rising expectations: lessons from NSF's Industry/University Cooperative Research Centers". *Technology in Society*, Vol. 11, pp. 335-345, 1989.
[24] Gray, D.O. and Tarant, S. *National Science Foundation Industry-University Cooperative Research Centers Program-Membership Report.* Raleigh, NC: North Carolina State University, 1999.

center. Sometimes, state interventions have included the subsidizing of participation by state-based small companies.

Unfortunately, it has been difficult for federal agencies, which often provide the seed or base funding for consortia, to work in a truly collaborative manner with state economic development leadership, and vice versa. As this paper was being initially written, the National Science Foundation was conducting a well-orchestrated phaseout of the only one of its consortia programs which formally required significant substantive and financial participation by states - the State/Industry/University Cooperative Research Centers program. Both the federal and the state "partners" had difficulty in bridging the gap between their respective worlds.

3. Consulting Arrangements

The consulting arrangement is one in which a faculty member accepts an engagement, on a private basis, with a company needing expert advice. The company usually establishes a special employment relationship with the consultant. At the same time the consultant has parallel obligations to his full-time employer (the university) that may conflict with his obligations to his part-time employer.

Consulting functions as a very useful "bridge" or brokering role between the needs and perspectives of the industry community and the expertise and talents of the university community.

Consulting has been a traditional academic-business interface, and there is little accurate data illustrating its extent and its financial impact. Because of the unique status of faculty members, universities have been reluctant to collect much information from faculty on actual time spent or income derived from consulting engagements, much less its impacts on companies or the economy. Nonetheless, consulting functions as a very useful "bridge" or brokering role between the needs and perspectives of the industry community and the expertise and talents of the university community.[25] In our own experience, science and technology officials from other countries often express great admiration and envy for the open and flexible consulting rules in place at US universities.

From the viewpoint of a company which engages faculty members as consultants, consulting is a transaction in which a company derives benefit from the faculty member's scientific or technical expertise in a field of interest to the company, but in which the company does not need or chooses not to have full-time staff expertise. While the faculty consultant is working on the company project (and billing the company for his time), the company considers the consultant a part-time employee or contractor of the company, and subject to the company's policies and rules. This is one area in which adept small companies can play as well as their larger counterparts. Often they are better able to identify key science and technology needs, and presumably find them in the university. Typically, however, the small company that is most able to use faculty consultants has strong ties to and knowledge of the university.

[25] Bessant, J. and Rush, H. "Building bridges for innovation: the role of consultants in technology trasnfer." *Research Policy*, 24, 1995, pp. 97-114.

Viewed from the academic perspective, consulting is a transaction which allows the faculty scientist or engineer to utilize his scientific or technical expertise beyond the academic setting. It has numerous benefits for the faculty member and the institution: (1) it supplements traditionally modest academic salaries; (2) it provides faculty members an important and instructive exposure to the issues and problems confronting business; (3) it can provide contacts for placing graduate students and post-doctorates; and (4) it can provide a ready mechanism for technology transfer when the technology is know-how in the public domain, such as process improvements. Traditionally, universities will provide faculty members release time of up to 20% of their total effort (one day per week). Compared to other employment situations, this is a liberal arrangement.

While not generally acknowledged, universities as institutions can also derive programmatic benefit from faculty consulting. They may be a precursor to a larger relationship with the university that is transacted "through the front door," such as sponsorship of research projects, participation in a center program, or hiring of graduates. Consulting relationships also are useful to fill in the cracks of complicated university-industry technology transfer deals as well, such as oversight of the transfer of a licensed technology.

Those faculty who are the most heavily involved in consulting tend to be <u>better</u> performers in terms of research and teaching responsibilities.

Finally, as was the case with contract research relationships, there is no visible linkage between consulting activity and state economic development, although in fact that connection might be quite significant. Consulting has no built-in economic geography, and much of it is performed for Fortune 500 companies, who do not think in terms of state economic impacts.

Unresolved Issues in Consulting

Nonetheless, as part of general concerns about academic-business research relationship, tensions in managing the consulting relationship have also surfaced. This may be more apparent in the life sciences, where consulting for companies has rapidly grown of late. Previously, consulting for businesses had been somewhat restricted to giving sporadic seminars, providing "state of the art" briefings, and doing scientific evaluations of in-house research programs. For example, in the engineering disciplines there is a long tradition of knowledge transfer through consulting. More recent experiences in the life sciences have included participation in ongoing research projects being conducted by the company's staff in the company's labs, and participating in the organization and evaluation of clinical trials to evaluate and gain approval to sell a new product. These new engagements begin to look and feel like collaborative research or technology licensing to university administrators, who wonder if the safeguards provided to both the faculty member and the institution by research agreements and licenses are missing.

These more intensive consulting engagements create qualitatively different tensions between the university, the faculty member, and the company:

- There is the question of conflicting obligations. What does a consulting engagement oblige a faculty member to do which is in conflict with his obligations to his full-time employer? For example, what happens when a company claims that a consultant-professor is a co-inventor on a patent application it has filed?

- There is the question of the use of time and facilities upon which the university has first claim. Is a consulting engagement detracting from a professor's performance of his teaching and research duties, or enhancing them? In the view of a university, if a faculty member spends too much time, or makes too much money on a consulting engagement, it may be a curse for the institution, rather than a blessing. Fortunately, the existing data (albeit out of date) suggest that those faculty who are the most heavily involved in consulting tend to be better performers in terms of research and teaching responsibilities.[26]

- If a professor's consulting engagements involve him and his students in original research for his client, administrators tend to view this as an uncompensated use of university resources. Strictly speaking, faculty are not supposed to use university resources when they consult. Such activities may create serious problems if the result is a notable success, because understandings regarding the interests and roles of all parties may be vague.

Fortunately, the tensions which can arise in consulting relationships are manageable. The key tools are full disclosure and managerial review and oversight. Adopting these tools and practices has been a bit slow in universities because department chairs and deans do not consider themselves managers, and faculty members do not consider themselves subject to management. The proper role of successful universities is managing tensions, not abolishing or avoiding them.

In addition to issues regarding various conflicts of interest, consulting relationships have other potentially negative ramifications, particularly in terms of other goals of various stakeholders. For example, if a university has taken the innovative step of acknowledging and proclaiming its mission obligations in economic development, and in partnerships with industry, it can take little credit for such activities when they are accomplished in the private context of consulting relationships. In addition, there may be the potential for larger industry-funded research projects which get co-opted by consulting engagements, thus depriving the university of the benefits of work that comes through the "front door", such as graduate student support.

Unfortunately, most of our conclusions about consulting are based on popular wisdom and expert opinion rather than empirical research. Our attempts to identify research on faculty consulting have produced little. This is a field in need of additional data-based analysis.

4. Licensing of University-Developed Technology

Licensing of university inventions usually occurs when research has proceeded to the point that a discreet invention has occurred, or a portfolio of a number of related inventions had been built. In some manner, the licensee company has become sufficiently impressed with the potential of the invention to invest effort and resources in its development. The Association of University Technology Managers (AUTM) has surveyed US research organizations for the past several

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[26] Boyer, C. M. and Lewis, D. R. *And on the Seventh Day: Faculty Consulting and Supplemental Income.* ASHE-ERIC Higher Education Report No. 3. Washington, D.C.: Association for the Study of Higher Education, 1985.

years. Its latest survey [27] shows that there are 14,274 licenses in effect, and that universities and research institutes received $574.6 million in royalty revenue in 1997. In addition, as part of the total benefit package derived from licensing deals, institutions received at least $163 million in license-related research funding.[28]

The license agreement is the most common mechanism by which the university transfers <u>tangible</u> intellectual property to companies. We submit that technology is transferred in many ways, but the formal mechanism for transferring tangible intellectual property, embodied in patents, trademarks, copyrights, tangible biological materials, and even in rare cases know-how embodied in trade secrets, is the license agreement. The license agreement is an "arm's-length" transaction which sets forth the conditions of a transfer, the obligations of both parties, and the means of compensation and further protection. Compensation is often critical, because few licenses are paid up-front, but involve the payment of royalties based on revenues from the future sale of goods and services.

The tangible intellectual property is usually owned by the university, and the license obligates the university to maintain the patent rights, to provide the licensee reasonable access to the know-how needed to practice or use the technology (usually the domain of the inventor, who might work with the licensee under a research contract or a consulting arrangement), and to refrain from licensing to others (provided of course that the license is exclusive). The licensee agrees to diligently pursue commercialization (and to varying degrees, account for his progress), pay the university payments and royalties in consideration for the license, and to oppose any infringement on the intellectual property rights licensed.

Increasingly, universities are not licensing inventions to large companies, but to smaller start-up or early-stage companies which are short on cash and taking greater risks.

License agreements can be quite brief and straightforward, or quite complex, depending on the value of the technology, the parties' positions in the technology, and the commercial field or fields which relate to the technology. Licensing terms are often the subject of protracted discussions as both sides seek to protect their interests while providing sufficient incentive to the other side to complete the transaction. The goal of all licensing arrangements is a "win-win" outcome in which both sides are happy.

As license arrangements mature in scope and complexity and commercially important products emerge, universities are discovering that their obligations in licenses are not trivial. For example universities have become parties to major litigation when their patents have been infringed upon, and licensees have moved to protect their interests. In most of these cases, universities have foregone royalties to help finance the considerable cost of litigation, and have donated the time and effort of inventors to assist counsel in preparing and conducting litigation. In technical areas such as biotechnology, patent protection may not be as strong as companies would like. Often overlapping claims and "submarine patents" which surface after products have been developed

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[27] Association of University Technology Managers. *AUTM Licensing Survey, FY 1997*. Norwalk, CT, Association of University Technology Managers, 1998.
[28] According to the AUTM report, this figure appears to be significantly understated, because of poor or inconsistent institutional tracking of these data.

and marketed have created situations where universities as patent holders have become involved in complex and expensive steps to clarify patent rights such as interference actions, patent reissues, and patent defenses in the US and in other parts of the world as well. In the worst case, universities have sometimes found themselves liable for poor stewardship of intellectual property or mismanagement of license agreements when such actions have caused harm to licensees. The message here is that if academic institutions are going to participate in business transactions, even as a licensor of technology, they will be expected to behave as properly as the law would require any for-profit organization in the same role to behave - that is, competently, professionally, and ethically.

Technology-based companies have been able to leverage their internal R&D by acquisition of university-developed technologies, and thus remain competitive in world markets which are increasingly dominated by technology-based products.

Although the license agreement is the typical arrangement for transferring tangible university technology to an established business with sufficient capital and resources to develop the technology, it is also used in start-up and spin-off arrangements. The license may be written differently, and the university's considerations, diligence requirements, and obligations will be somewhat different, there is generally a license agreement at the heart of a spin-off or start-up deal.

As larger companies have focused their attention and resources on "core activities," they have tended to "outsource" research and product development, thereby minimizing risk. This has meant that increasingly, universities are not licensing inventions to large companies, but to smaller start-up or early-stage companies which are short on cash and taking greater risks. This is especially true in the biomedical industries. Combining data from the AUTM 1996 Licensing Report[29] and the previously-cited 1997 edition, revealed that over the two years 57% of new licenses were awarded to small companies, and 581 new companies were formed based on university technologies. Generally, universities will take less in "pre-market" cash payments from the small company, but larger royalty payments and perhaps stock shares and warrants, which then peg return to the university to the future market value of the developed technology.

For all licensing arrangements, universities are learning to be more flexible when doing deals, depending on the nature and needs of the industries into which their technologies are being licensed. Truly, the needs of electronics companies, and their licensing strategies are quite different from those of pharmaceutical companies. AUTM again reports on some interesting variations. In 1997, 70% of all licenses, and 87% of all license income were related to life science inventions. This indicates that the industries related to physical sciences (electronics, chemicals, computing, communications, metals, etc.) license in less new technology, and pay lower royalties and up-front payments when they do. It is important for universities to understand this when crafting relationships with physical science-related companies, especially for collaborative research relationships which might yield licensable inventions. One cannot look at the physical science opportunities in the same way as one views biotechnology deals.[30]

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[29] Association of University Technology Managers. *AUTM Licensing Survey, FY 1996*. Norwalk, CT: Association of University Technology Managers, 1997.

[30] Petrick, I.J. and Reischman, M. M. "Strategic Development of Engineering Policies for Patenting and Licensing" Society of Research Administrators' Journal. XXVII, 3-4 (Winter 1995/Spring 1996). p.13.

> **Unless a technology transfer office is well-staffed with people with business acumen, it will not be able to provide the necessary due diligence for a start-up venture.**

Both universities and larger companies have thrived from licensing arrangements. Universities have accrued royalty revenues as well as significant amounts of new research support that is part of licensing deals. By the same token, technology-based companies have been able to leverage their internal R&D by acquisition of university-developed technologies, and thus remain competitive in world markets which are increasingly dominated by technology-based products.

Often, however, the traditional licensing approaches and mentality have fallen short in terms of working with start-up or small companies, for reasons described below. In addition, when universities focus on maximizing royalty revenues from licensing deals, state economic development outcomes will suffer. The latter will be particularly sensitive to <u>where</u> the value-adding economic activity of product development, manufacturing, and marketing takes place. Recent work by the Southern Technology Council,[31] which is described in more detail below, indicates that at least among southern universities, upwards of 85% of licensing deals involve companies located outside the home state of the institution.

5. Joint Development and Commercialization of Technology

One of the more novel and proactive university-industry technology transfer linkages involves joint development and commercialization of technology. It is novel in that it is more clearly a partnership than many of the other approaches, and somewhat controversial in that it often puts universities into roles or activities that many believe are inappropriate. In contrast to the usual licensing practice, joint commercialization implies a much more intensive and time-extensive involvement on the part of the university in their partner's business. In many cases, the commercialization partner is a new or small company, and due diligence for the university is more concerned with oversight of business development issues such as management and capitalization, as opposed to simply enforcing the terms of a licensing agreement.

This approach assumes that some technology with commercial potential (usually a cluster of related inventions or a single "foundation" technology) has resulted from university research. It also assumes that the commercialization path, or the best route for bringing the application to market, lies in building a business versus licensing to an existing company. This situation involves continued transfers throughout the product development cycle.

Operationally the university will still license the technology, but the license will have different terms and oversight requirements. For example, the new/small enterprise licensee will be unable to swallow a deal with lots of cash up front, or with obligations for early and large minimum royalty payments. Rather, the university may opt for a significant equity share in lieu of royalties. Similarly, the faculty inventor—who may be the impetus for the start-up—is likely to take an equity share in the enterprise. Either by university policy or technology management

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[31] Tornatzky, L.G., Waugaman, P.G. , and Bauman, J.S. *Benchmarking University-Industry Technology Transfer in the South. 1995-1996 Data.* Research Triangle Park, NC: Southern Technology Council, 1997.

practice, he/she is usually discouraged or prohibited from assuming a role as a principal, director, or manager of the company. Similarly, while the inventor will usually be permitted to consult or do contract research for the company, this is usually proscribed by policy and conflict-of-interest management procedures. Unfortunately, if these restrictions on the subsequent role of the faculty inventor are too onerous, and his/her contributions are critical to the success of the new enterprise, their net effect may be to discourage subsequent investment and put the business at risk.

In contrast to other licensing deals, the technology transfer office's role does not relax subsequent to the formal transfer of intellectual property. After all, we are not only transferring technology, but starting a business. Unless a technology transfer office is well-staffed with people with business acumen, it will not be able to provide the necessary due diligence, including consideration of business plans, venture management, sufficient capitalization of the venture, and marketing strategies.

This micro support structure is paralleled by a macro structure. Recent work (described below) by the Southern Technology Council has characterized those institutions which are able to do successful technology transfer via start-ups. It is very clear that universities need to be linked to an external entrepreneurial support structure, as well as energized by an internal mission and vision that supports these activities. For example, the University of Alabama-Birmingham has operated a major incubator, been involved in the development of a local venture fund, and has historically impressed upon faculty the legitimacy and desirability of becoming involved in technology transfer. Similarly, Georgia Tech has a technology-oriented incubator on campus, operates a state-wide pre-seed Faculty Research Commercialization fund to support proof-of-concept work, and is closely linked to a robust Atlanta-based business development infrastructure.

Given all of the barriers and problems regarding joint commercialization, why bother? For a university, the presence of its own local version of Silicon Valley can be very rewarding, as a draw for hiring researchers, a setting to place graduates, and as practical outcomes to convey to state legislators. For many faculty members, this approach to technology transfer has the allure of an entrepreneurial, potentially lucrative personal outcome. For state and local governments, a focus on technology transfer involving start-ups (most of which will be local) is extremely supportive of economic development goals.

Nonetheless, it is important to highlight the significant opposition to this approach to technology transfer among large segments of the university community. For example, in one national survey of 985 faculty members,[32] only 26.5 percent of respondents were in favor of the university taking an equity position in firms based on university research, and a minority of 44.1 percent were in favor of providing start-up assistance to new technology firms. Ironically, 88.1 percent were in favor of the university being actively involved in regional economic development. In another study[33] survey data were obtained from over four hundred faculty and administrators. They

[32] Lee, Y.S. *Op Cit*, 1996.
[33] Campbell, T. and Slaughter, S. "Faculty and administrators attitudes toward potential conflicts of interest, commitment, and equity in university-industry relationships." Unpublished paper in review, University of Arizona, Department of Management and Policy, 1997.

found that faculty who were not involved with industry were the "least supportive of university investment in entrepreneurial activities, particularly the funding of spin-off firms".

THE OPPORTUNITY OF BENCHMARKING

As is suggested above, all of the mechanisms described have significant problems and areas of weak performance. Unfortunately, there is a paucity of clearly-defined best practices and/or practitioners in many areas of university-industry technology transfer. Despite nearly two decades of growing activity in these relationships, as a field of established craft this endeavor has been relatively slow to mature.

> **"Benchmarking is the systematic comparison of elements of the performance of an organization against that of other organizations, with the aim of mutual improvement."**
> **- C.J. McNair**

This might be contrasted with how the corporate world - particularly manufacturing organizations - has approached the improvement of key business functions. Under the conceptual framework and philosophy of quality management, companies have used the metaphors and methods of "benchmarking" to gather practical information about how to do better in performing well-defined activities that are relevant to larger business goals. By illustration, the American Productivity and Quality Center has performed cooperative benchmarking analysis, involving hundreds of companies, in areas as disparate as activity based cost Management and shared services.

The general approach to benchmarking involves the following sequence of steps: (1) Define a domain of key organizational activity (e.g., working with start-up companies); (2) Identify either via quantitative performance data or reputational information the "best practitioners" in that domain; (3) Document and describe in operational detail the practices of "best practitioner" institutions; and then (4) Disseminate the findings to other organizations who can then replicate the practices of their more developed peers.

Two examples of recent work by the Southern Technology Council (STC) illustrate the potential for using this general approach to improve the practice of university-industry technology transfer.

Performance Benchmarking

At a simplistic level, benchmarking involves trying to determine what process (or "practice) inputs are related to outcomes of interest. STC has conducted three waves of performance benchmarking on the outcomes of university-industry technology transfer, focused on the research-intensive universities of the South. In each, we have defined every university's standing on several performance metrics, each of which is constructed to be easily understood by various stakeholders and to be comparable across institutions through the use of ratios and normalized scores (e.g., royalties per $10 million

> **"'What gets measured gets done' has never been so powerful a truth."**
> **- Tom Peters**

of research expenditures). In order to preserve some confidentiality, the performance metrics are displayed by state, in graphical form, such that each institution is represented by an icon (a cap and gown) with no identifying information. In parallel, each institution receives a confidential report which shows exactly where they rank in terms of the overall distribution of performance metrics. Similarly, in the public report (and in the best practice analyses described below) we identify in the text the "best-in-class" institutions in terms of outcome metrics, and add descriptive and laudatory text. The most recent university-industry performance benchmarking analysis involved 50 research institutions from 14 states[34]

Practice Benchmarking

However, the power of benchmarking increases when one couples practice benchmarking with performance metrics. That involves more detailed qualitative analyses of the best-in-class institutions on some domain of practice, program, or policy. For example, in one of our first benchmarking analyses,[35] we found that a number of practices in managing external patent counsel were correlated to performance outcomes such as patents awarded and royalty income. In another analysis,[36] we looked more closely at those institutions which were high performers in terms of licensing intellectual property to local start-up companies. We found a fairly consistent pattern of organizational characteristics including: (1) linkage to local business development infrastructure, particularly incubators; (2) involvement in novel mechanisms of very early stage capitalization (e.g., money for prototype development); (3) enabling personnel policies which made it easy for faculty members to get involved in their new ventures during leaves; (4) conflict-of-interest policies and practices which involved close management but few outright prohibitions; (5) creative use of physical facilities and laboratories to enable access by start-ups; and (6) a prevailing organizational culture which encourages faculty and institutional involvement in entrepreneurial ventures.

> **"Knowledge is power, if you know it about the right person."**
> **- Ethel Watts Mumford**

One other STC practice benchmarking effort[37] is worth noting in that it illustrates the necessary collaboration involved. In a partnership with the National Business Incubation Association (NBIA) we conducted a national analysis of program practices in technology business incubation. In this case, the study group of best-in-class programs was defined by reputation rather than by any pre-existing national performance measures. To launch our incubator best practices benchmarking study the team ran a mini work session, involving incubator managers who would be "subjects" in the study, at an annual meeting of the National Business Incubation Association (NBIA). At that session the group helped the study team to define relevant practice domains, review checklist questionnaire procedures, and review interview protocols. To close the loop, when the

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[34] Tornatzky, L.G., Waugaman, P.G. , and Bauman, J.S. Op Cit, 1997.
[35] Waugaman, P.G., Tornatzky, L.G., Vickery, B.S. *Best Practices for University-Industry Technology Transfer: Working with External Patent Counsel.* Research Triangle Park, NC: Southern Technology Council, 1994.
[36] Tornatzky, L.G., Waugaman, P.G., Casson, L., Crowell, S., Spahr, C., Wong, F. *Benchmarking Best Practices for University-Industry Technology Transfer: Working With Start-up Companies.* Research Triangle Park, NC: Southern Technology Council, 1995.
[37] Tornatzky, L. G., Batts, Y., McCrea, N.E., Lewis, M., and Quittman, L.M. *The Art and Craft of Technology Business Incubation. Best Practices, Strategies, and Tools from More than 50 Programs.* Research Triangle Park, NC: Southern Technology Council, 1996.

incubator study was completed, the same group was involved in editing, critiquing, and correcting the practice descriptions in the report, which were in effect written by a committee of sixty! To close the loop, we held a briefing of a similar, albeit larger, group at another NBIA meeting when the final version of the report was in hand.

Benchmarking and the Issue of Geography

All of these examples illustrate both the power and the operational difficulties of benchmarking various aspects of university-industry technology transfer. This is an extremely useful set of tools and methods which needs to be applied more frequently across the field. All of the linkage mechanisms that have been briefly discussed in this paper - and others that weren't - could be subjected to more systematic performance and practice benchmarking analysis.

However, one stakeholder group in the business of university-industry technology transfer can gain even more leverage through benchmarking data. That is, state and local government with deep and abiding interest in the geography of technology transfer. For example, of the various findings from STC benchmarking of university patenting and licensing performance, the one metric that aroused the most interest among state economic development officials was the fraction of licenses and/or royalties that involved in-state companies. Recent data from the Association of University Technology Managers[38] indicates that 83% of start-up companies built around university inventions tend to have local addresses. For economic development practitioners, geography matters a great deal. High value-adding industry and associated high-paying jobs, that are located in-state, are prime indicators of success.

Recently, the Southern Technology Council completed a 50-state analysis that starkly highlighted the issue of economic geography in university-industry relations.[39] Conducting a re-analysis of an existing National Science Foundation database of 19,426 recent bachelors and masters graduates in engineering and the sciences, STC asked some very simple questions: which states are winners and losers in the migration of this precious human commodity, and why? The findings clearly indicated that some states have a positive "balance of trade" in recent science and engineering graduates (keeping their own graduates and attracting those from elsewhere), while some state's universities are functioning primarily as farm teams for other state's industries. Not too surprisingly, subsequent analysis of migration outcomes pointed to the importance of factors such as state support of higher education (e.g., lower tuition levels), having an in-state nucleus of technology-based industry, and technology wage rates. Yet to be determined are institutional practices or policies which may also contribute to taking an in-state job. Aside from the intuitive and emotional appeal of this line of analysis (judged by follow-up calls and interviews, everybody is interested in encouraging Joe and Jolene to stay at home), it illustrates the ability of a benchmarking approach to highlight important public policy issues and possible solutions. It also indicates how the different strands of the technology-based, high skills "new economy" are inextricably connected.

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[38] Op Cit, 1998.

[39] Tornatzky, L.G., Gray, D., Tarant, S. A., and Howe, J. *Where Have All the Students Gone? Interstate Migration of Recent Science and Engineering Graduates.* Research Triangle Park, Southern Technology Council, 1998.

THE IMPORTANCE OF ORGANIZATIONAL CULTURE

After spending the previous pages discussing practices, polices, and mechanisms related to university-industry technology transfer, we would like to close by arguing that all of these can be undone or overcome by another more subtle set of factors that operate within institutions. Simply put, the organizational culture of universities can often be much more important in either a positive or negative sense than the operational remedies or roadblocks just discussed.

For many decades the traditional model for university research has been the free-standing individual investigator with a team under his or her supervision, conducting independent science and not acting as an agent of the sponsor. However, many of the university-industry linkage mechanisms discussed in this paper are somewhat or significantly at odds with that ideal vision. Whether that ideal was ever in fact as prevalent as assumed, it wilts as university faculty become involved in technology licensing, with a Small Business Innovation Research (SBIR) project, or as part of industry-supported multi-project consortia.

Nonetheless, the old organizational culture is largely intact in many academic institutions, and is often reflected in extant policies and procedures. These may include tax-exempt revenue bonds discriminating against proprietary research or state constitutions effectively prohibiting faculty members in state-supported universities from participating in new ventures deriving from their inventions. As a result much energy is expended in trying to transition to a new academic culture that is more accommodating to these external engagements.

Academicians who receive some portion of their research funding from industry actually published more in influential journals, and were involved in more academic service activities, than their peers who did not receive industry support for their research.

We construe "organizational culture" to encompass the often informal system of shared values, practice knowledge, rewards and incentives that will either influence faculty members to become involved in technology commercialization and industry relationships or deter them.

Moreover, the organizational culture of a university exists at many levels, and in various organizational settings that are more-or-less insulated from one another. For example "low culture" exists in the everyday world of the academic department, center, or institute, where much of the work of research actually takes place. This is also the level at which most of the more critical decisions are made about the tenure and promotional fate of individual faculty members. At this level, there is often a set of values which place primary emphasis on the importance of traditional academic pursuits such as the research article published in a refereed discipline-based journal, and corresponding beliefs that faculty members who are involved in technology transfer relationships with industry will be correspondingly weak on those valued activities. To complicate this further, even at the level of the department there are huge differences across disciplines in terms of cultural values and practices, with some units being supportive of industry partnerships and others being quite hostile.

However, recent research suggests that the "facts" underlying those negative beliefs may be dead wrong. In a national survey[40] of researchers involved in life-science fields, it was found that academicians who receive some portion of their research funding from industry actually produce more in terms of the usual criteria. That is, they published more, were involved in more academic service activities, and published in journals that were just as influential as those of their peers who did not receive industry support of their research. Only for that group of academicians who received more then 66 percent of their research support from industry was there a drop in the usual indices of productivity. A confounding reality is that even federal research support is not free of industry perspectives since many of the agency funding programs require or encourage industry linkages.

However, truth is not the same as perceived reality in terms of organizational culture and the prevailing values and beliefs. These have contributed to the evolution of a "two cultures" phenomenon in many departments in which the minority of industry-focused faculty are more-or-less tolerated by the prevailing majority. For example, in a study[41] comparing the views of faculty and administrators who are either involved or non-involved in technology transfer, the latter are opposed to having faculty salaries be market-driven by industrial demand and to faculty involvement in entrepreneurial approaches to technology transfer.

Another level of university organizational culture also operates among senior administrators such as deans, chief research officers, CEOs, and Provosts. The contribution that this cadre of individuals makes to the institutional environment regarding technology transfer is primarily in the area of strategy, mission, and goals. For example, some institutions are elevating the status and visibility of the technology transfer function, often to that of an Assistant/Associate Vice President level. Again, there is wide variance across institutions in the extent to which there is explicit language that acknowledges the intellectual legitimacy and mission relevance of university-industry technology transfer activities. More importantly, there is even greater variance in the extent to which language is translated into behavior by senior managers. In a survey study[42] analyzing faculty perceptions of their institutions, it was found that faculty from those institutions with "higher levels of technology transfer activity (as measured by patent applications over the past four years) have significantly more ... positive views about their institution's culture and climate."

"We hired [our technology transfer manager] to create conflicts of interest; and we will use our legal help to resolve those conflicts."

Nonetheless, it is possible to change the culture and norms of an academic institution. One fairly simple method is to inform faculty members about the hows and whys of technology transfer. For this approach[43] one can conduct half-day faculty briefings of small groups of faculty, including presentations by their peers who have been more actively involved in industry

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[40] Blumenthal, D., Campbell, E. G., Causino, N., and Louis, K. S. "Participation of life-science faculty in research relationships with industry. *The New England Journal of Medicine,* 335:1734-1738, 1996.

[41] Campbell, T. and Slaughter, S. *Op Cit*, 1997.

[42] Stralser, S. "Faculty attitudes and perceptions about technology transfer". Unpublished dissertation, University of Michigan, Center for the Study of Higher and Postsecondary Education, Ann Arbor, MI, 1997.

[43] Tornatzky, L.G. "Changing academic cultures: An 'experimental' intervention." Paper presented at ORSA/TIMS Joint National Meeting, San Francisco, California.

partnerships. Such an approach has been used by the Southern Technology Council, which has reached over 300 faculty members over the past four years. We also know of one case in which an institution involved in an upgrade of its technology transfer function conducted 15 informational seminars to faculty members over a two-year period. This same university went from the second tier in terms of its technology transfer performance, to a regional "best-in-class" institution.

This is also an area where much can be gained by benchmarking novel and positive approaches to reward and incentivize faculty involvement in technology transfer. The Southern Technology Council (STC) has recently completed a large, albeit preliminary, effort of this sort[44]. We have documented over forty examples in which universities (and state governments) have created supportive organizational culture in the areas of (1) formal acknowledgment programs for faculty inventors or entrepreneurs (e.g., award dinners); (2) positive language in mission, strategy, or goal statements; or (3) recognition in tenure criteria or processes. Notably rare have been instances in which an institution has tried all of these approaches in an organization-wide integrated manner. However, we strongly believe that those institutions which do exercise top-to-bottom leadership in building a responsive culture will be among the national leaders in doing university-industry technology transfer. A positive culture can override other policy or practice glitches. We are reminded of one particular institution which has in fact made great strides in improving industry partnerships and technology transfer performance. Their Chancellor has been heard to say: "We hired [our technology transfer manager] to create conflicts of interest; and we will use our legal help to resolve those conflicts." In short, where there is a cultural will, there also exists a practical way.

IMPLICATIONS

The basic message for both university technology transfer managers and companies seeking technology partnerships, is fairly straightforward: the world is complex. There are no single or simple approaches to university-industry technology transfer. Every approach is context-specific, and will be more or less a fit with the perspectives and aspirations that stakeholders bring to the process.

By the same token, it is difficult for any technology transfer function or office to do all things well. Each of the approaches that we have discussed in brief has its own operational idiosyncrasies and craft knowledge. Each may also be more pertinent to one university context, mission, or strategy than another. It is incumbent upon universities and their industrial partners to choose those linkages and approaches that are most suitable for their environment.

Moreover, as this discussion is engaged it is important that certain critical stakeholders be at the table. In particular, we believe that publicly-supported universities have an obligation to be agents of economic and business development in their states. That implies that state government leadership and state-based industry leadership needs to be a part of strategy and program

[44] Tornatzky, L.G. and Bauman, J. *Op Cit,* 1997.

development for the university technology transfer function. It also means that licensing to start-ups and involvement in entrepreneurial development needs to be part of the mix.

Of course, none of this happens unless faculty members and departmental leadership take ownership of technology transfer as a valid scholarly activity and a prominent expression of organizational mission and culture. This discussion and culture-building needs to be facilitated by university leadership at all levels. One can not assume that it will happen spontaneously. In particular, university leaders need to sensitize the academic community to the legitimate economic development aspirations of their community, state, and region.

Finally, we urge universities - and their state government sponsors - to accept the responsibility of paying for all of this. A robust technology transfer function is an essential ingredient in being a world-class university, and it needs to be appropriately staffed, funded, and deployed. It is also a part of the larger strategy of states and nations to remain economically viable in a rapidly-changing global economy.

The Southern Technology Council

The Southern Technology Council (STC), formed in 1986, is a division of the Southern Growth Policies Board that is concerned with technology creation, transfer, and application in the South. Its mission is to strengthen the regional economy through the more effective development, commercialization, and deployment of technology. It fosters cooperative initiatives among regional science and technology organizations (industry, government, and education) and functions as a forum for information and recommendations about best practices, strategies, policies, and programs.

Members of the STC are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, Virginia, West Virginia, AT&T, BellSouth Telecommunications, Entergy Corporation, Marshall Space Flight Center, Southwestern Bell, and the Southern Technology Applications Center. The Southern Legislative Conference is also represented on the Council.

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