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EDITOR'S PREFACE

This special issue of *Research Management Review* is dedicated to the first NCURA university-industry conference (in cooperation with the Business-Higher Education Forum, Association of University Technology Managers, and National Association of College and University Attorneys), entitled, "University/Industry Collaboration: Partners in the Research Enterprise," held in Keystone, Colorado, August 18–20, 2002. Bringing together university and industry representatives, this conference began a necessary, useful and productive dialog on the university-industry partnership in the hope of strengthening what works and of working together on problematic issues.

Intellectual property is central to the university-industry partnership and is a source of much contention at the present time. Dr. Tyler B. Thompson's article, "An Industry Perspective on Intellectual Property from Sponsored Research", begins this issue by laying out an industry perspective regarding intellectual property. His hope is that university understanding of the industry perspective will lead to more collaboration.

The second article, Dr. James A. Severson's "Tectonics in the University-Industry Research Partnership", looks at the "tectonic" (difficult) issues present in university-industry partnerships. These issues are a reflection of the cultural differences between universities and industry, a major theme underlying this relationship.

Mr. Ben J. Dyer brings his broad experience with venture capital and issues surrounding university start-ups to his article, entitled, "Can Universities Make Money on Start-Ups?" He makes several important points in his conclusion, but specifically notes that by choosing to license technology to start ups, universities are committing themselves to partnerships in which the partners may have different agendas and where there may be unintended consequences. Sound familiar?

Dr. Louis Berneman's article, "University-Industry Collaborations: Partners in Research Promoting Productivity and Economic Growth", accurately notes and celebrates academia's long and proud history of partnerships with industry. These successful partnerships happen *despite* their differing cultural values. While focus should remain on solving contentious issues, such as intellectual property, it is very important to pause and celebrate what makes university-industry partnerships work.

In the end, these articles illustrate the complex dynamics of university-industry partnerships. Because academia and industry are fundamentally different creatures that find themselves working increasingly together, both partners must continue to work through sometimes contentious issues in order to maintain these mutually beneficial relationships.

JAMES J. CASEY, JR., J.D.
BRADLEY UNIVERSITY
EDITOR
JUNE 2003

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An Industry Perspective on Intellectual Property from Sponsored Research

Tyler B. Thompson
The Dow Chemical Company

ABSTRACT

Many factors contribute to a successful sponsored research collaboration between industry and universities. A few critical issues get in the way. The conflicting views, interests, and policies among the university technology transfer administration, the sponsoring company, and the individual professor regarding rights to inventions are sources of constant friction that significantly limit industry's willingness to sponsor university research. The Dow Chemical Company has more than twenty years of experience in centrally coordinating a wide variety of successful research collaborations, both in the U.S. and abroad. This article gives an industry perspective on intellectual property issues in the hope that a better understanding of the needs and drivers in the mature manufacturing industries will lead to more flexibility among U.S. research universities.

MAJOR ISSUES THAT DRIVE COMPANY PRACTICES

The Dow Chemical Company has a distinguished history of productive collaborations with our nation's unsurpassed research universities. A glimpse at our program any time over the past decade would show us sponsoring projects at well over 100 institutions, and spending between $5 and $15 million annually. Because all of our projects tend to be driven from the bottom up, i.e., championed by the individual Dow research scientist rather than by corporate fiat––we do not attract big headlines the way some companies do through large block grants to favored universities. But we are convinced that our programs are productive and cost-effective. Companies sponsor university research for a variety of reasons. In my opinion, wise companies do not treat sponsored research as "outsourcing." We do not generally want universities to invent (and patent) for us. We want complementary strength in fundamentals to improve our effectiveness in applications. We want the university to function as an early warning radar system. Sometimes we need some highly specialized facilities or expertise that is beyond our core competencies. The best sponsored projects are those with a *strong home team* inside the company working on a vital internal project. It is seldom productive to toss the university some peripheral project for which we have neither the time nor the expertise.

We derive value in several ways. Knowledge, understanding, data, and personal relationships make our internal research more productive. Much of the research sponsored by Dow is funded

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via unrestricted gifts. The particular emphases of this research include improving generic capabilities, developing tools, and obtaining fundamental data and models. No inventions are expected, and the research does not deal directly with proprietary products and processes. We expect not to pay overhead, thereby getting better leverage in return for "no strings attached."

When we have a proprietary project and inventions are expected or likely, we need a research agreement—a contract that grants the company certain rights in preference to any other party. We rarely require assignment of university inventions to the company. We generally accept the basic ground rules that the university will own sole university inventions, and joint inventions will be owned jointly. We expect to have the first right to negotiate for a royalty-bearing exclusive license, and for that right to last long enough to make a good business decision.

Often the prospect of the university making a sole invention is the worst case scenario. We write the research agreement to protect our interests if it happens, but often that is not what we desire. The best university inventions are those that are joint inventions with the sponsoring company. The very best projects (in our view) are the ones in which the university research teaches us something that enables us internally to make sole company inventions. And that is also a good way to assure a continuing productive relationship with the university and further research funding. Nothing shuts down collaboration as quickly as squabbling over intellectual property. If it becomes apparent that the university is more interested in competing with us than in cooperating with us, the direction of our relationship can change so fast it leaves skid marks! The company does not want to see inventions that it sponsored sold to the highest bidder. Having the first option to negotiate does not assure being able to get a fair, affordable license. We need some assurance that we can license at a price we can afford, not at the highest price the market will bear. Without such assurance, why should we sponsor the research? Sometimes it is better to leave something undone than to expend resources doing something from which we cannot capture value and which may enable our competitors. Why would a business sponsor a project only to see the invention held hostage for what it is worth to their competitors?
As a negotiator for Dow, I seek to avoid the "nightmare scenario":

- The company sponsors research at full cost (student stipend and fringes, 10% of the professor's salary and fringe benefits, supplies, standard overhead).
- The company pays or reimburses the university for patent filing costs.
- The company and the university fail to agree on license terms. The company is left with nothing. The university uses the patent that the company sponsored and paid for to prevent the company from practicing the patent.

Let me emphasize the distinction between company-sponsored and government-sponsored university inventions. Many universities fail to distinguish adequately between what is fair for a company that sponsors a project and what is fair for a company that just walks in off the street to license an invention from a government-sponsored project. They would like to apply the principles of the Bayh-Dole Act in situations where it is legally inapplicable. I've had several conversations along the following lines:

> [University]: *"But you don't ever pay the true full cost of the research. Think of all the infrastructure, the instruments, the intellectual capital, the unique creative environment. Standard university overhead is negotiated with the government—I have studies documenting that it doesn't come close to reflecting the true overhead."*

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> [Company]: "*Fine—so let's talk about the full cost overhead rate. We'll pay it up front in return for assignment of inventions and no further royalties. Let's base it on a fair comparison with the overhead rates for full-cost contract research at competing research institutions: our internal company overhead rates, federal laboratories, private research institutes like SRI and Battelle, and foreign universities.*"

Arguments about "full cost" and who paid for the buildings do not usually enter commercial contract negotiations. When SRI bids on a contract research job for Dow, there is no discussion about not being entitled to free use of the results because another firm paid for a machine vital to the project and a federal agency paid for the new wing on the building. Those factors are merely the capabilities that qualify the institution to bid on the project.

The company has intellectual capital of its own. Industry is a problem-rich environment, and many top companies have superb research scientists with unique expertise. A good collaboration with industry will bring lasting value to the professors, the students, and the university. In addition, the company has a unique capacity to move inventions to the market for the public good. In some universities, particularly outside the hard science and engineering departments, industry sponsorship is viewed with suspicion, and the possibility that a company might actually have some influence over the conduct of the university's research is lamented. We in industry lament that we have so little influence.

Finally, let's think about our interests in the context of our place in society. My company is a major taxpayer. So are the company's half-million stockholders and our U.S. employees. Most of the latter group are hired from American universities where we sponsor research. We serve the public with important goods and services, and we try to be responsible citizens, managing our business for the good of all of our stakeholders: our employees, our customers, our owners, and the communities in which we operate. So why should my company not benefit directly from the university system that we help to support?

MYTHS AND TRUTHS OF CORPORATE SPONSORSHIP

License revenue vs. administrative cost: AUTM surveys consistently show that below the top 25 universities (ranked by license revenue), the amount of license revenue does not even pay the administrative cost for the Technology Transfer and Licensing office. Even in the top 25 universities, how much income derives from *other than* biomedical and pharmaceutical inventions? How much from process patents? How much from the School of Engineering? The answer is usually "almost none."

In university portfolios almost all of the revenue is due to a very small number of inventions. By stubbornly sticking to policies designed to be sure to capture "the big one," universities are driving away much potential support from industry.

University attitude: I think of universities in two categories. In the ones we like to support, the people I negotiate agreements with believe that their job is to help enable industry sponsorship of their professors and facilitate actual technology transfer into the market where it can be used commercially for the benefit of the public. Their most important metrics are the number of industrial projects and the amount of industrial research funding. In the other category are the folks whose only metrics seem to be licenses issued and royalty revenue received, without any

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regard to missed opportunities for collaboration. They seem unable to adjust their bargaining position so as to balance the consequences for the overall good of the university.

Valuation of inventions: Universities, like most inventors, tend to overestimate their fair share of the financial value of their invention, and have little understanding of the investment risk the sponsor has to assume to commercialize it profitably. The university takes zero risk and expects major rewards. Much of our concern in the research agreement is due to the likelihood that, when it comes time to negotiate an actual license, our valuation of the invention and of the university's fair share in it will be vastly different from the university's estimate.

Under the best of circumstances an industrial company captures for its shareholders only a small fraction of the value of any invention––even those made internally under tight control. Benefits are shared with the company's customers, society at large, and competitors. It is said that technology transfer wears shoes. Employees move from company to company. Once it is known that a thing can be done, others will find other ways to do it, regardless of patents, trade secrets, or non-disclosure agreements.

> Let's consider a hypothetical example concerning licensing royalties. Can you imagine that a royalty rate of 0.1% of sales might exceed what's fair and affordable? In a basic chemicals and plastics business, let's say that we have a world scale plant to produce 500 million pounds per year of a product that sells for 50 cents per pound. The company has spent years and hundreds of millions of dollars developing the product, its derivatives, its applications, and its customers. It has invested $200 million in capital in this one plant alone. Now the university has invented (with the company's sponsorship) a dramatically better catalyst, or a significantly improved separation process, or a fundamentally better reactor design. A world-beating process improvement might shave 5 cents per pound off the cost of production, at most, and the competitive advantage might last ten years at best, regardless of the life of the patent. To commercialize this promising invention, the company must invest $5–10 million in further research, design, and a pilot plant study, and perhaps $10–50 million in new capital to implement it. For convenience, let's take the company's future investment to be $30 million. And, by the way, there is a significant risk that it might not work out in the end, for reasons we cannot anticipate. There's always that risk any time you replace tried-and-true established technology with new technology. Let's say that the university worked on the research project for 3 years, at a cost of $300,000 (of the company's money). Even if we grant that the $300,000 was "the university's money," what then is the university's fair share of the net value of this invention? A royalty rate of 0.1% of sales on 500 million pounds per year at 50 cents per pound yields $250,000 per year, presumably for the life of the patent. At a total cost savings of 5 cents per pound, the *maximum* value of the invention is $25,000,000 per year. So the inventor gets 1% of the value in return for putting up about 1% of the investment (using the company's money), and taking none of the technical risk and none of the financial risk. Sound fair?

COMPANY EXPECTATIONS IN SPONSORING UNIVERSITY RESEARCH

Know-how at no additional cost: The royalty-free non-exclusive right to use all sponsored research results *excepting only* patented inventions and copyrighted works. No "trade secrets" are kept from the sponsor. It is all part of the deliverables, including "unpatented inventions."

Free right to practice: If we sponsor the full cost of the research *and the university's patent obtention costs*, it is only fair that we receive a royalty-free non-exclusive license for commercial practice of patented inventions. I never cease to be amazed at how resistant some university administrators are to this concept! In balance, though, if we eventually come to a decision not to practice an invention commercially, we should be willing to give back the free license so the university has a complete, valuable IP package to offer to someone else who will make use of it. An acceptable alternative is for the university to grant the sponsor a free *option* to acquire a royalty-free non-exclusive license for a negotiated field of use. If the option is time-limited, the limit should be generous (say, five years after the patent issues).

First option for exclusive license: Specifically, we have the first right to negotiate for a royalty-bearing worldwide exclusive license with rights to sublicense. This is not as good as owning the invention outright, but it is adequate for most purposes. However, it can seriously complicate

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patenting tactics when there are also joint inventions or sole company inventions being patented around the same time. It seldom results in patent protection as strong as we would have secured, had the whole patent strategy and application process been left up to the company. But we do usually accept it as "ground rules." (I must acknowledge the opposite sentiment about who gets stronger patents. Some argue that the company would almost maliciously file the weakest patent case possible so they can work around it. Our experience has been the opposite. People in industry believe that the university never sends its researchers back into the lab to run some more experiments in order to broaden the claims. And lacking real commercial experience, they tend to file claims that are either too narrow or unsupportably broad and vague.)

Whether having this first option is actually of any value to the company depends on how long it lasts and how the actual license negotiations go. I insist that the option period last at least until after final notice of allowance of claims by the patent office. The expiration of the option period must not be tied to an arbitrary and meaningless point in time, such as disclosure of the invention by the university, expiration of the research agreement, filing of the patent application, or even first office action by the patent office. There are two reasons we insist on this timing. First, until the government officially and definitively pronounces on the merits of the claims, we do not have a legal definition of the intellectual property for which we are to negotiate. Second, it usually ensures that we have enough time to do a good business evaluation and make good decisions. It is not that we always take that long to decide to enter negotiations. It is sometimes in our best interest to get in early and do the business deal so we can get on with commercialization. But this is the critical issue for us: how long is it before the university is free to walk away from us and peddle to our *fiercest competitor* the invention we paid to have discovered?

Fall-back protection in case of failure of negotiations: To protect against the "nightmare scenario," the company wants either a limited right of first refusal or a cap on royalties negotiated in the research agreement. Our language for the "limited right of first refusal" only requires the university to come back to us in the event that we had negotiated for the exclusive license, we had failed to come to agreement, and the university subsequently offered better terms to another party. In those circumstances, the university has to offer us the same deal. An acceptable alternative is a requirement that the university not offer better terms to a third party. There can be difficulty in deciding what might constitute "better terms."

Background Intellectual Property: Companies should be careful not to propose research agreement terms that would unfairly grant the company a free right to practice university background IP which the company did not sponsor. If a university freely offers to bundle such background rights in order to attract further research funding, that would certainly make the opportunity more attractive to a potential sponsor. But I don't think a company should demand it when negotiating a research agreement.

Such terms are, unfortunately, proposed from time to time. The reasoning goes like this: if I sponsor research that leads to an invention "C", and I negotiate for rights to "C", what good is that license if the university also holds rights in inventions "A" and "B" that block my right to practice "C"? The appropriate position for the company is not that it gain *free* rights to "A" and "B", but rather that they be disclosed to the company as soon as possible, and included in the license negotiations for "C". If there is university BIP that clearly would dominate any likely invention arising from new sponsored research in a particular field, the potential sponsor could either require that an OPTION on the BIP be bundled with the research agreement, or negotiate an option up front for a modest fee before committing to sponsor further research. This assures that the university does not sell an exclusive license to another party, even as it is accepting

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research funding from the new sponsor in the same field. Furthermore, if the university has relevant BIP that has already been licensed to another party, that fact should be disclosed to the current sponsor since it would obviously bear on his decision to sponsor the research.

To summarize, when we negotiate a license we need to have everything out on the table. The company and the university should negotiate a complete package, including the subject invention and any dominating background patents that the university controls and still has available to license. The royalty rate should reflect the value of the complete package, and may understandably be higher than the royalty just for rights to the subject invention. If there is potentially blocking IP controlled by the university, the university must recognize it, keep track of it, disclose it to us during negotiations, and include it in the package if they are legally able. To be blunt, if the university wants to play the royalty game, it has to manage its intellectual assets professionally. The argument that the university is such a loose, open, and diffuse organization that they cannot possibly keep track of everything does not find a sympathetic ear in industry.

ALTERNATIVE MODELS FOR RESEARCH AGREEMENTS

Earlier I asserted that U.S. universities are driving away much potential support from industry. I might like to say that they are driving U.S. industry into the arms of the significantly more friendly European universities, but I don't think I could prove it? yet. It is true that European governments generally do a better job of encouraging and supporting industry/university collaborative research, and foreign universities offer significantly more favorable terms to industrial sponsors. Right now we have many collaborative projects in Europe, and the number is growing every year. But most of our European university projects collaborate with Dow people who live and work in Europe. So much of the value we derive from sponsored research comes not from university inventions, but from the intangibles, the unanticipated, the interpersonal relationships. The real value is in making our own research scientists better connected, more creative, and more productive. That's difficult enough when collaborators are separated in different cities. When they are separated by an ocean, it takes a rare and highly motivated champion to make it work.

In the U.S. we are truly fortunate to have a university system with a deep bench. Dow sponsors research at over one hundred institutions. Good people are everywhere. There are over 300 universities in the U.S. and Canada doing graduate research in chemistry, and over 100 in chemical engineering. Scores of undergraduate colleges harbor excellent scholars and enthusiastic students. Many excellent regional universities demonstrate flexible policies and inviting attitudes, and they get some of our business. We will go wherever the talent is, and where we can get the best deal.

So what might a brighter world look like? What kind of terms would I really like to have? Let me describe a couple of alternatives and ask, "Might this be better for the university?"

Develop consensus on "full cost": University research is a bargain. Let's consider this statement from different angles. Indisputably it is cheaper to do a particular research project at a university than to do the same work inside the company. My rule of thumb is about one third. Company costs, fully loaded, are between $200,000 and $300,000 per full-time equivalent (FTE) researcher. Full support of a graduate student or post-doctoral fellow in the university runs between $60,000 and $120,000 per FTE. But in return for this "bargain" the company gives up secrecy, total control over intellectual property, and direction of the research program, including

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choosing and reassigning personnel, easy changes in priority or approach, and frequency of reporting and other communications. The nature of the projects we sponsor in the university is usually more fundamental and less directly and immediately applicable to our needs. And, of course, in the case of a graduate student, the accepted fiction is that a half-time apprentice rather than a fully trained, experienced, independent professional does the work.

Beyond the cheap labor rates of graduate students, there are usually other hidden costs that we do not fully pay. Table I presents a fairly typical budget for nominally "full" support of one graduate student for a year. At $60,000 I admit that this is a bargain budget. It includes one month of summer salary for the professor, and a typical government-approved overhead rate of 57%. I have read studies showing that these negotiated rates are too low, and I believe them (You won't find many people in industry of this opinion.) The item "Tuition remission" is handled in different ways by different universities, and accounting for it is problematic at best, since Ph.D. students in science and engineering typically only take about eight or ten courses over a four- to six-year graduate career.

Table I. Bargain Budget

Graduate student		
Stipend	$18,000.00	
Fringe benefits	$1,800.00	
(student fringe rate)		10%
Tuition remission	$4,000.00	
Professor		
Summer salary	$8,333.33	1 month @ $100,000/yr
Academic year	$0.00	
Fringe benefits	$2,916.67	
(faculty fringe rate)		35%
Total labor	**$35,050.00**	includes tuition
Supplies	$5,000.00	
Travel		
Publication fees		
Total direct cost	**$40,050.00**	
Capital equipment	$0.00	
Overhead	**$20,548.50**	excludes capital & tuition
(overhead rate)		57%
Total	**$60,598.50**	

I offer Table II as an example of a "full cost" budget. At a price of $97,000 it includes part of the professor's salary during the academic year, a more generous allotment for supplies, twice the "tuition remission" amount, and an overhead rate of 80% on total modified direct cost. I believe this to be a very generous estimate of the full cost of one graduate student, by any accounting. The purpose of this comparison is to set the stage for greater flexibility in negotiating terms. Industry would find sponsored research to be much more attractive if only the universities would

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operate on the basis of cost-benefit trade-offs—considerations that are universal business practices. So now let's consider some alternative IP terms.

Non-exclusive free right to practice: At a minimum universities should accept the principle that a company sponsor that pays the full cost of a research project is entitled to the royalty-free non-exclusive right to practice any university inventions that result directly from that project. Many universities today will grant that right to a sponsor that agrees to fully reimburse the university's patent obtention expenses—an additional expense for the company that, coincidentally, is often about the same as the $37,000 difference between Tables I and II. It is important to realize that in some situations the company has no interest in the university (or anyone else) obtaining a patent on the invention, and therefore no interest in underwriting that expense. Sometimes the company would prefer that the results just be published, giving the company the same rights as everyone else.

Table II.
Full Cost Budget

Graduate student				
	Stipend	$20,000.00		
	Fringe benefits	$2,000.00		
	(student fringe rate)		10%	
	Tuition remission	$8,000.00		
Professor				
	Summer salary	$8,333.33		1 month @ $100,000/yr
	Academic year	$3,750.00		5% time for 9 months
	Fringe benefits	$4,229.17		
	(faculty fringe rate)		35%	
Total labor		**$46,312.50**		includes tuition
	Supplies	$10,000.00		
	Travel	$1,000.00		
	Publication fees			
Total direct cost		**$57,312.50**		
	Capital equipment	$0.00		
Overhead		**$39,450.00**		excludes capital & tuition
	(overhead rate)		80%	
Total		**$96,762.50**		

Option for a royalty-free exclusive license in a limited field of use: I express this as an option rather than an outright license, to require the company to make a definite decision within a clearly stated time limit. If the company is not interested in the invention, or cannot make up its mind in a reasonable period of time, then the university's control is unencumbered. Several limitations would be fair. The company should fully pay for patenting. The invention should be one that is

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clearly within the scope of the project statement of work. The negotiated field of use should be limited to the company's established and prospective business interests, as demonstrated by products, processes, and services that are either current or in their R&D pipeline. The license could include negotiated performance requirements and a give-back provision if it becomes clear that the company will not actually use the invention. And, frankly, the license doesn't really have to be free, so long as the price is modest. A one-time license issuance fee of $50,000 would probably not be a barrier for a company with serious intent. The point is that the company's ability to obtain an exclusive license in the field of its business interests would be *assured*. And the university retains unfettered rights to license others outside the field. I believe that such an arrangement would satisfy our concerns in most situations.

CONCLUSION

In conclusion, let me emphasize a few key points:

- First and foremost, manufacturing companies like Dow value American research universities highly. We are all under pressure to focus more on our core strengths and partner with external institutions whenever possible.
- Second, at a quality company like Dow, sponsored university research is not a replacement for a strong internal research program, and it is not a way to save money by outsourcing work we should be doing ourselves. It is a way to improve the speed, productivity, and effectiveness of our internal research.
- Finally, many of our top universities need to realize that they are *not* the only game in town. They could significantly increase the amount of industry-sponsored research funding they receive if they would adopt attitudes and policies that are more favorable to the sponsor.

ABOUT THE AUTHOR

Dr. Tyler B. Thompson's responsibilities at the Dow Chemical Company reside in External Technology. He is primarily responsible for facilitating research partnerships between Dow scientists and outside organizations, mainly universities and federal laboratories. His technical focus includes engineering science, high performance technical computing, and chemical process research. He has been in this position since 1993, following 16 years of research in Dow's Central Research laboratories.

He participated in the preparation of "Technology Vision 2020: The U.S. Chemical Industry" and subsequent activities, including the leadership group for Vision 2020 affiliated with the Council for Chemical Research. The U.S. Department of Energy Office of Industrial Technologies has cited Dr. Thompson as one of its "most contributing partners".

He holds two Bachelor of Science degrees from the Massachusetts Institute of Technology—one in chemistry and one in "Humanities & Science"—and has a Ph.D. in physical organic chemistry from the University of Illinois, Urbana-Champaign. He is a member of the American Chemical Society, the American Institute of Chemical Engineers, and NCURA.

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Tectonics in the University-Industry Research Partnership

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ABSTRACT

Basic research at universities is a source of innovation that supports the development of products and services. Because both universities and companies benefit from the transfer of university developments there is a desire for a better partnership between universities and companies to improve research collaborations and for the development of useful products. However, cultural differences between universities and companies, and the way that research support is obtained and managed, get in the way of better working relationships. The difficult issues that seem to routinely create conflicts are publication rights, the indirect costs of research, the management and licensing of intellectual property, and access to research tools.

Starting with the Morrill Act in 1862, universities, private industry, and the federal government have cooperated to facilitate the movement of knowledge, practices, and discoveries into products, processes, and services. Because of the results of this long-term partnership, it is accepted that basic research at universities supports the development of innovative products that can help maintain competitiveness (Business-Higher Education Forum, 2001). However, as science has grown in complexity, and as expectations have increased for university research to fuel economic growth, tensions have increased around sponsored research, technology access and licensing, and the exchange of research tools.

Tectonics is a metaphor for the difficult issues. The term conjures an image of large plates grinding against each other without much movement but with an occasional dramatic and, at times, cataclysmic result. It is well-recognized that universities and companies are not natural partners and that their missions and cultures can work to inhibit or prevent smooth collaborations. The tensions created by the tectonic issues can be caused and exacerbated by a lack of appreciation of the cultural differences that exist between universities and business. This paper will explore some of these tectonic issues.

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CHANGING ROLES

The traditional role of university research is changing. As traditionally envisioned, the main roles of universities are to train undergraduate and graduate students to enter the workforce, and to conduct basic research. Industry has engaged primarily in applied research and product development, while the government's role has been to fund basic research, provide infrastructure, and make policy. However, there is an increasing emphasis on the interaction of university research and industrial product development, and there are forces that might change the nature of the relationship. In some cases, changes in the relationship between companies and universities have been encouraged by the federal government, an example of which is the formation of science and engineering centers that create consortia of university and industrial scientists for collaborative science.

Among universities, there is an increasing emphasis on licensing technology and on starting companies from university research that will benefit the economy. A report from the National Governor's Association encourages programs that stimulate university interaction with industry? "University-industry technology transfer can be a stimulant, precursor or complement to building a high skills, high wage, state economy" (Tornatzky, 2000, p. 23). To support these expectations, some states have developed programs to stimulate economic growth through collaborative interactions between the universities and local businesses.

Despite the stated desire for closer cooperation between universities and corporations, corporations on the whole still support only a small portion of the research that takes place at universities in the United States. In fiscal year (FY) 2000, NSF statistics estimate that 7.2% of the research expenditures at U.S. universities was provided by industry, while 58.2% was provided by the federal government (National Science Foundation, 2002). This is not to say that companies do not provide significant research funding to university laboratories. In FY2000, industry provided $2.178 billion in research support to university laboratories. As might be expected, support varies dramatically from institution to institution. In the 30 universities reporting the greatest total research expenditures for FY2000, the percent of total research supported by industry ranged from a low of 1% at Columbia University to more than 30% at Duke University (Table I). The top 30 universities in terms of industry sponsored research received over 50% of the total research sponsored by industry, while only representing 34% of the total research expenditures (Table II).

Other factors contribute to the increasing emphasis on partnerships between universities and business and have created an increasing emphasis on the commercialization of discoveries made at universities. While some authors have focused on the Bayh-Dole Act as the reason for this change, others have pointed to other events that have also contributed, such as the expansion of patentable subject matter to include biological organisms, and the general trend to support patent rights that resulted after the creation of the Federal Circuit Court (Mowery et al., 2001).

In general, the pace of innovation has increased in science-based and technology-intensive industries such as computer science, advanced materials, and biotechnology. In many cases funding agencies have promoted collaborative projects either through the development of consortia or the requirement for corporate matches of research support. The recognition that technology development can promote national competitiveness has also prompted the federal

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government to support basic research programs in areas that industry itself has identified as being important for long-term benefit, but that they cannot support because of its basic nature.

Table I
Top 30 U.S. Universities in Total Research Expenditures, Fiscal Year 2000

	Total Research Expenditures ($ millions)	Industry Sponsored Research ($ millions)	Percent of Total
Johns Hopkins Univ.	901,156	15,751	1.76
Univ. of Wisconsin, Madison	554,361	16,127	2.91
Univ. of Michigan	551,556	35,515	6.44
Univ. of California, Los Angeles	530,826	33,427	6.30
Univ. of Washington	529,342	57,405	10.84
Univ. of California, San Diego	518,559	34,541	6.66
Univ. of California Berkeley	518,514	27,851	5.37
Stanford Univ.	454,780	41,269	9.07
Univ. of California, San Francisco	443,013	34,694	7.83
Univ. of Pennsylvania	430,389	32,632	7.58
Pennsylvania State Univ.	427,575	64,393	15.06
Massachusetts Inst. of Technology	426,299	83,082	19.49
Univ. of Minnesota	411,380	26,392	6.42
Cornell Univ.	410,393	12,697	3.09
Texas A&M Univ.	397,268	31,084	7.82
Univ. of Illinois, Urbana Champaign	373,024	12,693	3.40
Univ. of California, Davis	364,789	17,891	4.90
Washington Univ.	362,216	22,691	6.26
Ohio State Univ.	361,399	57,075	15.79
Duke Univ.	356,625	109,791	30.79
Univ. of Colorado	353,528	9,291	2.62
Univ. of Arizona	345,090	22,412	6.49
Harvard Univ.	341,810	12,189	3.57
Baylor College of Medicine	334,175	17,578	5.26
Columbia Univ.	319,693	3,362	1.05
Univ. of Florida	313,692	34,879	11.12
Georgia Inst. of Technology	304,511	64,508	21.18
Univ. of Southern California	300,445	25,298	8.42
Yale Univ.	296,706	14,355	4.83
Univ. of Pittsburgh	294,809	14,676	4.98

Source: Mowery et al., 2001.

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Table II
Top 30 U.S. Universities in Industry Sponsored Research, Fiscal Year 2000

	Industry Sponsored Research ($ millions)	Total Research Expenditure ($ millions)	Industry as Percent of Total
Duke Univ.	109,791	356,625	30.79
Massachusetts Inst. of Technology	83,082	426,299	19.49
Georgia Inst. of Technology	64,508	304,511	21.18
Pennsylvania State Univ.	64,393	427,575	15.06
Univ. of Washington	57,405	529,342	10.84
Ohio State Univ.	57,075	361,399	15.79
Stanford Univ.	41,269	454,780	9.08
Univ. of Michigan	35,515	551,556	6.44
Univ. of California, San Francisco	34,964	443,013	7.89
Univ. of Florida	34,879	313,692	11.12
Univ. of California, San Diego	34,541	518,559	6.66
Univ. of California, Los Angeles	33,427	530,826	6.30
North Carolina State Univ.	32,804	277,946	11.80
Pennsylvania State Univ.	32,632	427,575	7.63
Texas A&M Univ.	31,084	397,268	7.82
Purdue University	29,997	234,536	12.79
Univ. of Maryland, Baltimore	29,892	224,346	13.32
California Inst. of Technology	29,619	222,666	13.30
Univ. of California, Berkeley	27,851	518,514	5.37
Univ. of Minnesota	26,392	411,380	6.42
Univ. of Southern California	25,298	300,445	8.42
Univ. of Texas, Austin	24,740	272,811	9.07
Washington Univ.	22,691	362,216	6.26
Univ. of Arizona	22,412	345,090	6.49
Carnegie Mellon Univ.	21,136	137,980	15.32
Univ. of Texas, MD Anderson Cancer Center	20,271	182,196	11.13
Univ. of Alaska Fairbanks	19,686	102,500	19.21
Univ. of California, Irvine	18,615	158,437	11.75
Univ. of California, Davis	17,891	364,789	4.90
Univ. of Rochester	17,595	197,335	8.92

Source: Mowery et al., 2001.

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CULTURE CLASH

Despite the encouragement from state governments to create university-industry partnerships, universities and businesses are not natural partners. For the most part, these are institutions that differ substantially in mission and culture. Table III highlights some of these differences.

Table III
Mission and Culture Differences between Universities and Industry

Universities	Industry
Mission: Teaching Research Outreach	Mission: Product development Sales and profits
Culture: Academic freedom Publication of results Creation of knowledge	Culture: Protection of intellectual assets Limited distribution of information

Universities see research and educational benefits from their interactions with corporations. These interactions expose faculty and students to real problems and make them part of a team that is looking to solve significant problems. They also give students a glimpse of what it is like to work in a company environment and may provide an employment opportunity for students when they graduate. In some cases, there may be research support from a business to a university research laboratory. If discoveries from the university are transferred to the business, there is also economic benefit from having the university laboratory assist in solving a problem that either provides a new product or improves an existing one.

There are similar benefits to businesses that work with a university research laboratory. Research collaborations using an external expert are one way for a business to engage in pre-competitive research that it cannot conduct internally and may allow the company to expand into new product areas and increase its technology inventory. In many cases, these laboratories are headed by faculty members whose career and areas of expertise in their field were developed through funds provided by the university, and often using funds provided by the federal government. Thus, a company can gain access to expertise that it can take neither the time nor expense to develop and maintain. This might also include equipment and specialized research capabilities that the company does not have or could not afford to obtain solely for a single project.

Companies also can gain access to students from the laboratory and may have the opportunity to hire students as employees. In this way, the company can expand its internal capabilities and the expertise of the laboratory by hiring a student who has learned from an expert in the field.

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Other factors in the university research environment are problematic for the development of better and smoother relationships between universities and businesses. The nature of the funding of university research can create conflicts for future relationships by inadvertently creating conflicting rights. One way to describe university research is that it is investigator-initiated and discovery-driven. Using this approach the university sets priorities for research areas that it wants to support for the future, such as bioinformatics, advanced materials, or nanotechnology. Once these priorities are established new faculty are hired who work on interesting problems in these priority areas. In turn, these faculty members are expected to seek funding for their research through proposals that they initiate with external funding sources. If the researcher is seeking federal support the project is funded based on peer review of the science and the research priorities of the funding agency. Thus, faculty act like entrepreneurs within the university to seek research support from government and private sources.

Faculty-initiated research support can result in a network of agreements that create complex intellectual property obligations. Consider that funding may come to a laboratory from multiple sources? federal and state agencies, foundations, and corporate sponsors. In addition, the research in a laboratory may include materials from laboratories at other universities or corporations and the agreements that facilitated the transfer of these materials may have obligations to the provider. In some cases, consulting agreements also may have obligations for the disposition of intellectual property. Lastly, the laboratory may have research collaborations with other university research laboratories or corporations that have resulted in joint inventorship. These examples represent some of the ways that laboratory funding and the nature of university research create complex scenarios for determination of the university's ability to convey rights to a third party.

TECTONIC ISSUES

If we can establish that universities and businesses desire to work together, then why is there a need for a discussion of tectonic issues and why are the issues so contentious at times? Cultural differences contribute to the conflict.

Publication of Results

Openness and objectivity are core values for universities, and most universities will not allow a third party to influence the right of its research community to publish the results of their research. Thus, contractual language that provides an outside entity, private or public, the ability to control or authorize publication is usually met with great resistance. If universities are unable to get assurance of publication rights, many will "walk away" from such an agreement.

One of the ongoing debates about the increase in university-industry collaboration is that universities will become too close to companies and lose their independence. Allowing a research sponsor to control publication of research results could provide the impression that the university is not independent. Several reports have noted that clinical studies sponsored by pharmaceutical companies tend to report more favorable outcomes to the trial than those not sponsored by companies (Friedberg et al., 1999; Rochon et al., 1994; Stelfox et al., 1998). These observations raise concerns about the independence of universities and the influence of corporate funding on the outcomes of research.

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The preceding discussion is not meant to indicate that there are unacceptable delays in publication. However, any delay must be limited, reasonable, and not indefinite. Universities often agree to delay the publication of results so that the sponsoring company can review a proposed publication to ensure that it does not contain any information that the company considers to be confidential. Similarly, a university is likely to permit the review of a potential publication for patentable subject matter, and allow a reasonable delay for the preparation and submission of a patent application to cover what is identified as patentable. Each university sets the limits of these delays.

Intellectual Property

The ownership of inventions and the licensing of intellectual property developed during sponsored research can be contentious. The university perspective on the debate is based on practical issues related to the obligations that the university may have to other entities that have sponsored research in the laboratory, or issues that involve the longevity of the research program and the fact that the direct cost of funding a project is greatly outweighed by the access gained by the company.

The ownership of intellectual property created in a sponsored research program can be a significant issue during the negotiation of a sponsored research agreement. In general, universities prefer to retain the ownership of inventions made by their researchers, and they take this position for several reasons. First, ownership by the university and the right to license by the company maintains a relationship between the inventor and product development. In many cases, follow-on work by the researcher or additional know-how developed in the laboratory need to be transferred to make the discovery most useful to the company. It is in the public interest for discoveries made at universities to have an opportunity to be developed regardless of the source of funds used to make the discovery. In many cases, this concept is consistent with the university mission and the concepts in the Bayh-Dole Act for technology development for the public interest. The licensing of the invention also allows the university to negotiate diligence requirements that ensure the development of an invention.

The right to participate in royalty distribution is an incentive to inventors to disclose and invent. Burdensome intellectual property provisions can create disincentives for faculty to participate in company-sponsored research. For instance, provisions that limit potential royalty payments for intellectual property that is developed during the project may influence researchers who are interested in receiving royalties to not participate in industry sponsored research programs, or limit their openness in dealing with the company to protect whatever they perceive is valuable intellectual property.

Another approach sometimes taken by companies in negotiating intellectual property terms and licensing is that it is inappropriate for the university to expect royalty payments from the sale of products that incorporate the invention, and the university should be content simply with receiving the actual costs of the research and the indirect costs. In short, "we paid for it, we own it, and that is all you are going to get." This perspective assumes that the cost of the research is the only component of the research, and does not take into account the expertise of the research laboratory. Some of the issues that argue against this approach by companies were discussed above. This approach also treats the university researchers as employees and the research as a work for hire, and not as collaborations. Relationships like these tend to be less interesting for

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university researchers. For the most part, universities are less likely to enter into them. Most researchers want a broader collaboration and do not wish to be viewed as a "job shop."

For universities, another problematic aspect in the management of intellectual property created during the collaboration is the position by the sponsor that the university grant the sponsor a nonexclusive, royalty-free license to background intellectual property that may be required to practice inventions made during the sponsored research. For the most part, universities understand and appreciate that the sponsor needs to have freedom to operate for new inventions. However, this request, made before the creation of inventions, is difficult to grant. Without knowing the nature of any invention it is difficult to identify background intellectual property and assess if there is a dominant patent position. In addition, background intellectual property may have been developed by other researchers on campus. These researchers are entitled under the patent policies of most universities to share in the proceeds of the licensing of their inventions. Thus, a royalty-free license is difficult to grant, especially since one view is that "my intellectual property is going to benefit another laboratory and I am not getting anything for it." Lastly, as mentioned above, research funding may come from a variety of sources, and it is possible that the invention with a dominant position was developed with funds from another sponsor and the university may have obligations to that sponsor that make it difficult to license that intellectual property to the sponsor.

Indirect Costs of Research

During the negotiation of a sponsored research agreement, debates often occur involving the budget for a project and the inclusion of indirect costs (now termed F&A, or Facilities and Administrative). Arguments on the company side vary and may include, "the building is paid for already, why should we pay for it again," "wouldn't you rather have the money support the research and not the library," "our company is in the state and pays taxes that support your school, that should be enough," or "tell us what the components of F&A are and we'll tell you which of those we are willing to pay for."

What these arguments do not take into account are that in most universities, even the full negotiated F&A rate does not completely cover the costs of research (Office of Science and Technology Policy, 2000). Furthermore, the actual indirect costs within most companies are substantially greater than the costs universities apply to research. It is important to keep in mind the source of funds within the company and recognition on the part of the negotiator of the difference in indirect costs between the university and the company. It is possible that the funds for the sponsored research project at the university come from an R&D budget within the company. Therefore, the F&A costs come from the R&D manager's budget. These are direct costs that he has secured in internal budget negotiations and may be independent of the company's internal indirect costs. Thus, the R&D manager thinks in terms of the direct costs of research because that is the budget that the manager has to work with. The manager is trying to maximize the deliverable derived from the funds. Rarely discussed in these negotiations is that companies can obtain tax credits for some types of R&D conducted at universities. However, this advantage may not be directly realized by the corporate line manager.

Another consideration in this issue has to do with whether the company wishes to come into a laboratory for a very specific project rather than for a long-term relationship. Many university laboratories have been developed over time by university funds and funds provided by sponsors, such as the federal government. F&A costs represent the fair share of these development costs

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and places the corporate sponsor on an equal footing with other sponsors, including the federal government.

Access to Research Tools

Frustrations and prolonged negotiations can result in the exchange of research materials, usually involving material transfer agreements. One way to view a material transfer agreement is that it is a document that measures our ability to enable research collaborations. The document formalizes how two laboratories will work with each other, and can range in detail from just the exchange of the reagent so that a research project can proceed, all the way through a more elaborate collaboration agreement that sets forth actions to be taken by each laboratory and how publications and intellectual property will be managed.

From the university perspective, issues considered during the review and negotiation of these agreements include compliance with the terms of the research funding in the laboratory. The National Institutes of Health has provided the academic community with a set of guidelines for the exchange of research materials and has provided grantees with a template document, termed the Uniform Biological Material Transfer Agreement or UBMTA, that it suggests be used for most routine transfers (National Institutes of Health, n.d.). Other sources of funding in the laboratory may have other restrictions on the transfer of materials that need to be reviewed and in some cases resolved.

Concerns arise on the university side of the negotiation because of the speed of response and the prioritization for completion of these documents. Some universities have created specialized groups to manage the negotiation of material transfer agreements, but in other universities the responsibility for these agreements rests in either the office of sponsored research or in the technology transfer office. Thus, the prioritization for completion of these documents competes with other demands in the office. While the researcher may place a high priority on the completion of the agreement to facilitate an important experiment, the demand in the administrative office may be for the completion of a proposal submission in the case of sponsored research, or the negotiation of a license agreement in the technology transfer office.

While the UBMTA provides a framework for transfers within the academic community, there is a lack of standardization for academic-to-business transfers, and each agreement must be negotiated individually. Companies have different classes of materials and the flexibility of the company in the negotiation is directly tied to the value of the material for commercial development. A company perspective is that the material represents an asset of the company and the company has an obligation to its investors or shareholders for that asset. In many cases this is the cultural difference that drives the negotiation. Thus, the university can expect a company to negotiate harder for materials that are either part of a product development stream or are anticipated to be part of the stream.

CONCLUSION

For successful negotiations and collaborations to occur, universities and companies need to understand each other's environment and motivations. Cultural differences between universities and companies contribute to difficult issues in the management of research collaborations. In the university environment the drivers are publications and grants, while in companies the drivers are innovation, products, and profits.

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The tough issues can be summarized as follows:

- The freedom to publish by academic scientists may be problematic for research collaborations with corporate sponsors, but universities are willing to delay publication under specific circumstances.

- Companies desire freedom to use intellectual property created with research funds that they provide. This can be problematic for universities that encourage entrepreneurial faculty to seek research funding from varied sources.

- Universities account for research infrastructure differently than corporations do, and expect that these costs will be part of the budget for a research project. This may be at odds with the motivations of an R&D manager to stay on budget and buy in outside research.

- For the most part, university researchers want access to research tools, but the company wants to protect an asset.

An understanding of the issues that each party brings to the table can contribute to a better understanding of positions and can contribute to finding solutions to create more beneficial collaborations.

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Can Universities Make Money on Start-Ups?

Ben J. Dyer
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ABSTRACT

The ability of universities to license technology to start-ups is complicated by differing views between entrepreneurs and researchers, and by the current financing environment. I reflect on these issues based on my daily immersion in this process and the data I have compiled in *Georgia Innovations*.

WHO IS JOSEPH WISEMAN?

I like to lead off presentations on the current state of venture finance with this question. Joseph Wiseman is the Canadian actor who portrayed "Dr. No" in the first James Bond film. One can hardly think of a more appropriate character for this topic!

Georgia Innovations catalogs and tracks the emerging technology companies in the state of Georgia. It is underwritten by subscriptions from almost everyone in the deal flow in the state—investors, lawyers, accountants, universities, and more. I analyze the aggregate data quarterly, and it is revealing. For the group of 113 companies that we were tracking at the end of 2002, the cost of a single dollar of revenue in CY2002 ranged from $1.75 for health informatics businesses up to $22.20 for fab-less chip start-ups. Compare this to the cost of "buying" a dollar of revenue in a public company, which is often much less than one dollar and comes with the advantage of total liquidity. Early stage investing requires years of patience for the metrics to turn favorable.

Job creation is another interesting statistic. In our data, each job in electronic components costs over $500,000. Life sciences and web services are close behind. Even on the low end, a few sectors like development tools require just over $100,000 per job. It is hard to make the case that early-stage investing is an efficient way to turn investment capital into jobs.

Fewer than 40% of the covered companies have institutional venture investment. Alternative sources of financing include:

- Strategic partners or customers
- Research grants and SBIR's
- Private placements to third-party angels (often facilitated by cocktail party presentations)

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- Friends and family
- Bootstrap (no salaries)
- Stretched balance sheets (delaying the payables)
- Dowries (I'll give you $1 million to merge my questionable investment into your company)
- Service revenues—anything to pay the bills while the plan is executed

Of this mix I believe the cocktail party method shows the most promise at this time. Getting individual investors "liquored up" before a presentation seems to be pretty effective.

Institutional VC may like to drink; they may be drinking heavily to forget the investments they made during the great Bubble. But they are not susceptible to the cocktail party method. At this writing, VC's seem to be captivated by low valuations on later stage deals, PIPE's (private investments in public equities), and spin-off units of larger companies. In Atlanta I have observed considerable interest among VC's in finding cool widgets in the labs for very early stage investing, but I'm not sure whether checks are being written or the VC's are just enjoying the exposure to the gadgetry.

Veterans of venture financing have described the current environment as the worst they have ever experienced. There is no longer an orderly food chain where early stage investors hand off deals to later stage players at ever increasing valuations. Now the valuations tend to go down, punishing those who took the most risk at the beginning and rewarding only those who are at the table when the last bet is placed. This aberration of nature will eventually correct itself when there are no early stage deals that can grow into later stages. But, we are probably looking at another year or two of difficulty in this respect. Institutional investors are rapidly vacating the early stage sector, where the real glories of venture capital have traditionally been earned, and cocktail parties won't totally replace them.

So, for the moment let's suspend disbelief and assume there is venture money to adequately fund start-ups that are commercializing university technologies. What are the diverse viewpoints and issues that arise? We'll talk about a number of these in no particular order.

VIEWPOINTS AND ISSUES

Universities Sell Research, But Start-Ups Buy Development

The entrepreneur in an early-stage company generally has not quite enough money and time to get his or her product to market. The need is for "development" that gets the product ready to sell and enables the company to fulfill its promises to investors. Universities, on the other hand, enjoy the paths of exploration and may be content with discoveries that advance the art but are not necessarily on a direct course to revenue. There is a natural state of tension between these diverging viewpoints.

Universities See Private Industry as a Deep Pocket, But Start-Ups Think Universities Should be Happy to Get Anything

Especially with respect to public institutions, there's the obvious question, "I pay taxes that underwrite this research, so why does the university want more compensation?" The entrepreneur and his or her investors rarely understand the disconnect between tax collections and funding for

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a given project within a university. They think they are doing society a favor by taking a technology to market and creating jobs around it. Meanwhile, the research group is eager for any source of funds that sustain its efforts. Whether it is royalties or an equity sharing, some accommodation is appropriate.

The University Wants to Get Paid, But Sometimes the Start-Up Can't Pay

Very often the institute becomes an accidental investor when unpaid royalties get converted to equity. Those who are putting up the hard cash may dictate these terms, and the choices are a shut-down and write-off versus taking a chance on the equity. An eager research team that is intellectually engaged with a project and is "bonded" with its individual contacts in the start-up company is not about to halt its work for little matters like late payment. Nor can institute management easily redeploy the team to other projects with more certain payment. The decision to license technology to start-ups and to do business with them is a decision to take these risks and inevitably leads to some of this accidental investing.

Neither Party May Be Realistic

Often the university researchers think they want to be in business. On the other hand, the start-up wants the impossible delivered yesterday. Researchers may see the allure of wealth creation, but rarely will they abandon the benefits and comfort of the university environment. There are many serial "entrepreneurs" in the labs who never actually take the plunge into any single company, and the jury is still out on this model. Concepts that "have to work" are more likely to succeed than companies that "ought to work." Making the total commitment, like the proverbial pig at breakfast, can make the difference between success and failure of a company. The original idea is less important than the entrepreneur's ability to adapt that idea to what the market requires. Meanwhile, the start-up leader who is relying on a shared resource may be slow to realize that the world does not revolve around his or her priorities. The breadth of knowledge and talent in a lab is its strength, but also its source of distraction when there are deadlines to meet.

Workers Are Paid Differently

Researchers may be paid in part for a given project but are also interested in other accomplishments, from grading papers to getting published to preparing themselves for advancement. Start-up personnel are paid for specific and focused near-term missions, on which their jobs depend. Commingling these groups can lead to interesting divergences of priorities.

Expand or Corner the IP?

The research group wants to advance the state of the art and expand the intellectual property around a particular concept. The start-up is more interested in cornering and protecting the IP against potential competitors. How does the IP from continuing development in the lab and at the company get reconciled in this context? Who owns the improvements and pays for the patent filings? Do more patent costs generate more royalties or equity, or must they be absorbed in the institute's overhead?

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React to Opportunity or Work to a Plan?

Research groups tend to follow the money, for good reason. They react to contracts and grants and often let those guide their research interests. The start-up has a business plan and is theoretically working toward the specifics of that plan. As mentioned before, there are investor promises to keep and revenue targets to be met before the funding is exhausted. Locking a research group into deliverables driven by this type of planning may not be compatible with the university mindset.

Run or Walk?

While a research group may work at the pace of inspiration, the start-up is generally forced to work at the pace of perspiration. The wolf is literally at the door as investment money is consumed, and there is extreme urgency to get to market. The researcher who is tugged by other requirements, e.g., filling out the next grant application, meeting academic goals, or just pursuing an interesting line of discovery, may not be in synch with the entrepreneur customer who is on the hot seat.

There May Be No Limits

The university research group has staff and budget limitations. Pay scales are inflexible. There is usually no ready pocket of discretionary funding to underwrite a sudden change in direction or pursuit of an unexpected opportunity. In contrast, start-ups often can throw money and people at a problem to meet a particular goal or deadline. Not that the money is unlimited, as has been made clear earlier in this article, but product deadlines, market responses, and investor pressure may compel all-out efforts to get things done.

Call This Number

Universities may be very well organized for teaching and research—their primary missions. For a start-up that wants to buy an end product, this type of organization may be totally inscrutable. There are no sales hotline, no identifiable customer support, and no toll free number advertised on television. The start-up often has to work hard to weave through a combination of licensing officers, project managers, principal investigators, incubators, accelerators, and even helpful alumni. Many give up.

We're on a Mission

The university, whether public or private, generally has a broad mission to educate, advance the art, and promote economic development in its area. There are politics to be considered and major donors to be reckoned with. The start-up just wants to be a customer and to be given priority. It does not help make payroll next week to know that a project delay has created some economic benefit to the region.

The Illusion

The university research group raises money based on ideas. The start-up sells an idea to investors but raises money based on its projections. Both are creating an illusion of future glory, but there

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is a significant difference between attracting a grant for exploration versus attracting venture investment based on a specific expectation of revenue, profits, and an eventual exit value.

CONCLUSION

All that said, what are the conclusions of this article?

1. Raising money for a start-up was never easy, but it was never harder than it is today.

2. By choosing to license technology to start-ups, a university is committing itself to a partnership where the parties may have very different agendas and where there may be unintended consequences.

In this author's opinion, start-ups are an important part of the licensing tableau and always hold the promise of creating a home run through royalties, equity, or the donations of successful founder entrepreneurs. They create positive publicity, intellectual enrichment, and talent appeal well beyond their absolute financial contributions to the research university.

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University-Industry Collaborations: Partners in Research Promoting Productivity and Economic Growth

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ABSTRACT

Universities have a long and proud history of academic-industry collaborations. Companies have partnered with academe to recruit students for their workforces, access materials discovered in academic laboratories, host scientists as visiting scholars, conduct sponsored research and augment their innovation enterprise. Faculty members have also assisted industry by providing consulting services and publishing research results that identify new insights and opportunities of potential commercial value. Innovation in science and technology, much of it enabled by federal research funding and university-industry collaborations, has been a major source of gains in productivity and economic growth in the United States.

The reservoir theory of knowledge, the Bayh-Dole Act, upholding of intellectual property rights, and emergence of biotechnology have all played a significant role in these partnerships. The reservoir theory and Bayh-Dole are discussed in some detail in this article, as are the five goals and past decade of successes of university technology transfer. Our collective experience in creating and maintaining university-industry partnerships and promoting economic growth through commercialization of university discoveries is presented. Finally, the differing cultural values of academe and industry and the challenges these differences present in forging collaborations are discussed.

THE FOUNDATION FOR UNIVERSITY-INDUSTRY COLLABORATIONS IN THE U.S.

Reservoir Theory

The expansive growth of university-industry relations in the U.S. emanates from a prescient decision following WWII attributed to Vannevar Bush.[1] The decision—that the federal

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government should fund inquiry driven research in universities (a simple concept taken for granted today)—has been a pillar of this nation's improved health, unparalleled economic growth, and unrivaled national security.

In what has become known as the *reservoir theory of knowledge*, Vannevar Bush theorized that the U.S. government would use tax dollars to fund basic research in academe. Bush hypothesized that this research would generate new knowledge, produce research results with commercial potential, and educate knowledge workers and a future generation of political, business, and academic leaders. With only one adjustment to this concept, the reservoir theory of knowledge has been a huge success. That adjustment was to give to the university generating the new knowledge the right to manage and benefit broadly from its commercialization. The enabling legislation affecting this change was the Bayh-Dole Act.

Bayh-Dole Act

Public Law 96-517, commonly known as the Bayh-Dole Act of 1980, was signed into law on December 12, 1980 and became effective in July 1981. Along with the reservoir theory of knowledge and other fortuitous environmental factors, the Bayh-Dole Act is the basis for the current practice and success of university technology transfer in the U.S. In brief, Bayh-Dole:

- Established a uniform policy governing inventions made at universities using federal research funds;
- Gave universities the right to take title and own such inventions;
- Encouraged universities to forge ties with industry to commercialize these inventions;
- Obligated universities taking title to file patent applications and seek to commercialize the inventions;
- Reserved for the federal government a non-exclusive right to practice the inventions and to "march-in" to gain access to inventions not commercialized;
- Urged universities to give preference in licensing to small companies;
- Mandated that products based on university discoveries and licenses be manufactured primarily in the U.S. for the U.S. market;
- Required universities to share a portion of licensing income with faculty inventors; and
- Required universities to use any remaining income, after expenses, to support scientific research and education.

The success of the Bayh-Dole Act is demonstrated by the expansion of university patenting and licensing activity as illustrated below. This growth, however, would not have been realized if not for other concurrent factors including the emergence of biotechnology and enforcement by the U.S. courts of intellectual property rights and their value.

- In 2000 the number of sponsored research agreements at universities, primarily funded by the federal government, was 130% greater than the number in 1991.

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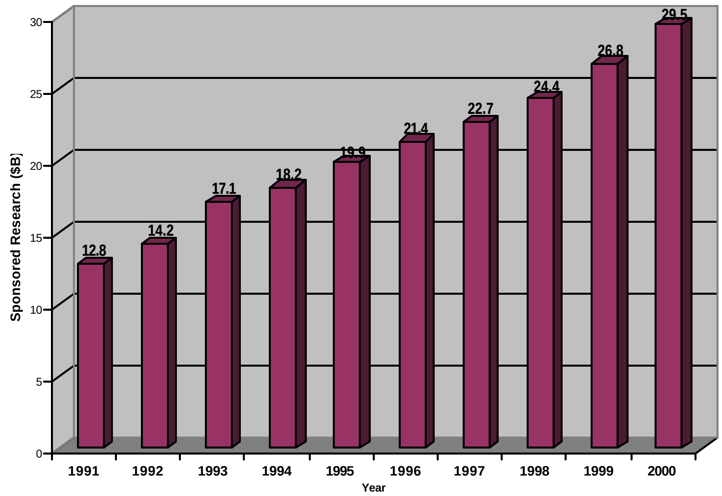
Figure 1: Sponsored Research



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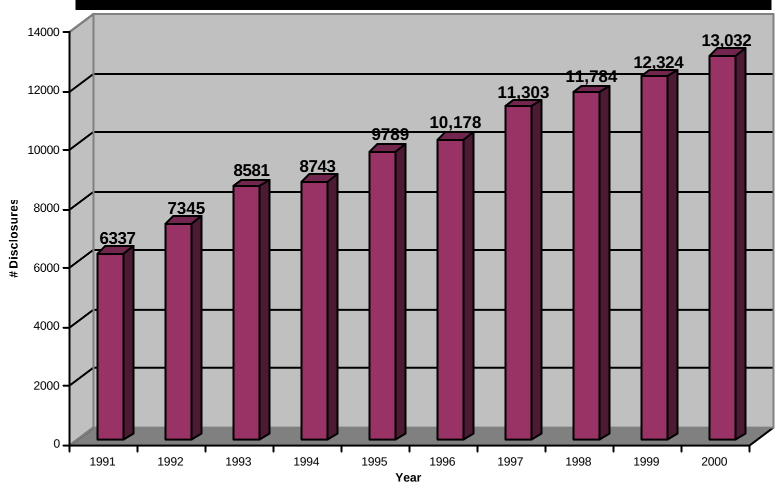

- The number of technology disclosures from faculty during the same period increased 105%.

- Patenting activity has likewise grown significantly with the number of patent applications for this period 301% greater than in 1991 and issued patents 135% greater than in 1993.

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Figure 3: Total U.S. Patent Applications Filed

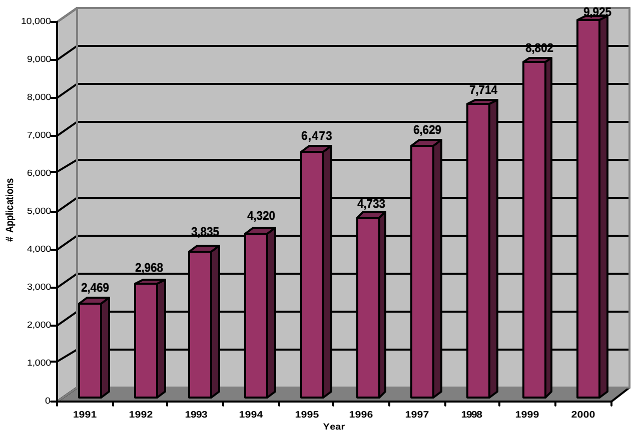
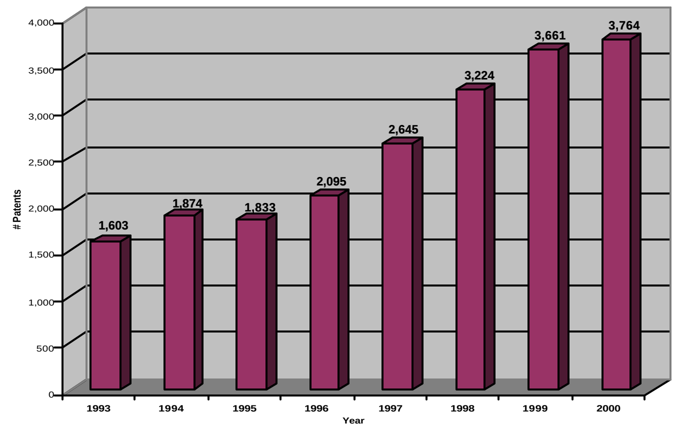


Figure 4: U.S. Patents Issued (FY1991 & 1992 data not available)



- Licensing activity has also increased significantly. The number of agreements in 2000 was 241% greater than 1991, while licensing income was 486% greater than in 1991.

Figure 5: Licensing Activity

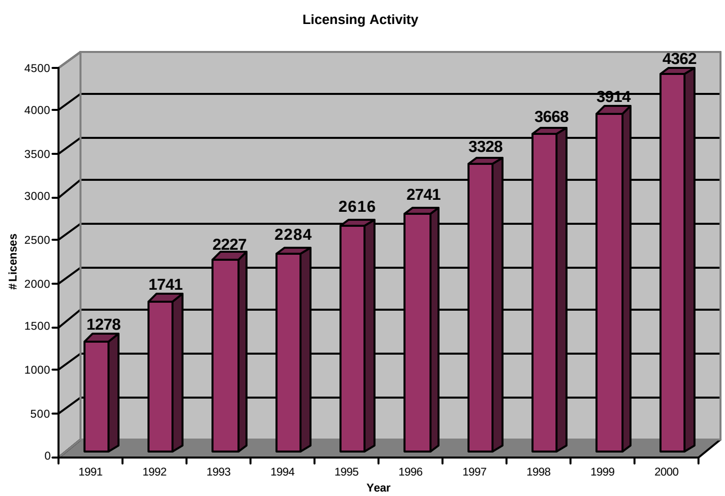
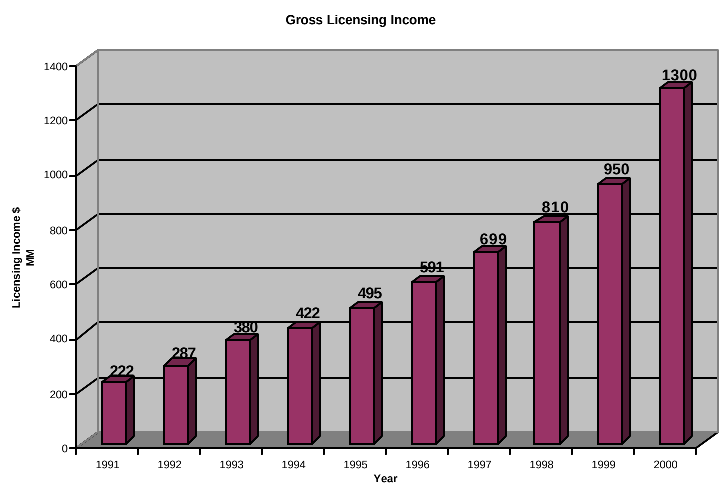


Figure 6: Gross Licensing Income



The data indicate that the reservoir theory has worked extremely well. Approximately $200 billion invested in academe in basic research has yielded close to 100,000 invention disclosures, 50,000 patent applications, 25,000 licenses, and 2,500 new start-up ventures in the ten-year period 1991–2000.[2]

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THE GOALS AND INTERESTS OF UNIVERSITY TECHNOLOGY TRANSFER

Research universities partner with industry and transfer technology to achieve five goals:

- Facilitate the commercialization of university discoveries for the public good;
- Promote economic growth;
- Reward, retain and recruit faculty and students;
- Forge closer ties to industry; and
- Generate income for education and research.

In recent years, the academic community has become increasingly more accepting of the notion that commercialization is a logical and natural extension of the research enterprise. As a result, more universities are becoming comfortable with and adept at applying the new knowledge that they have created and stored.

PROMOTING ECONOMIC GROWTH

Our collective experience of the past two decades, information gleaned from the AUTM Annual Licensing Surveys, and analyses by economic development experts indicate that research universities must and do play an active role in promoting regional economic growth and that this laudable goal requires partnerships, cooperation, and concerted efforts by a multitude of academic, political, and commercial stakeholders. The evidence suggests that:

- Research universities need to:
  - Serve as anchors, magnets, and leaders to attract, grow and create companies;
  - Provide access to their knowledge assets (people, resources, and facilities) to support economic growth;
  - Create education and research programs that are aligned with strategic industry technology clusters to support workforce development and create new technology-based business opportunities; and
  - Facilitate the commercialization of research results by structuring fair and reasonable licensing, start-up, sponsored research and faculty consulting agreements.

- Regions that seek to grow their economies need to:
  - Identify and build upon existing industry strategic technology clusters and local university research strengths;
  - Focus on helping companies in their region grow and become more successful; and
  - Support angel investors and entrepreneur networks.

- Vibrant regional economies have:
  - Strong research capacity and demonstrated ability to convert academic research results into successful commercial activity[3];
  - Capital—intellectual, management, financial and technological—to launch new ventures;

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- Effective public-private investment partnerships to seed new ventures without relying solely on venture capital; and
- One or more major research university.[4]

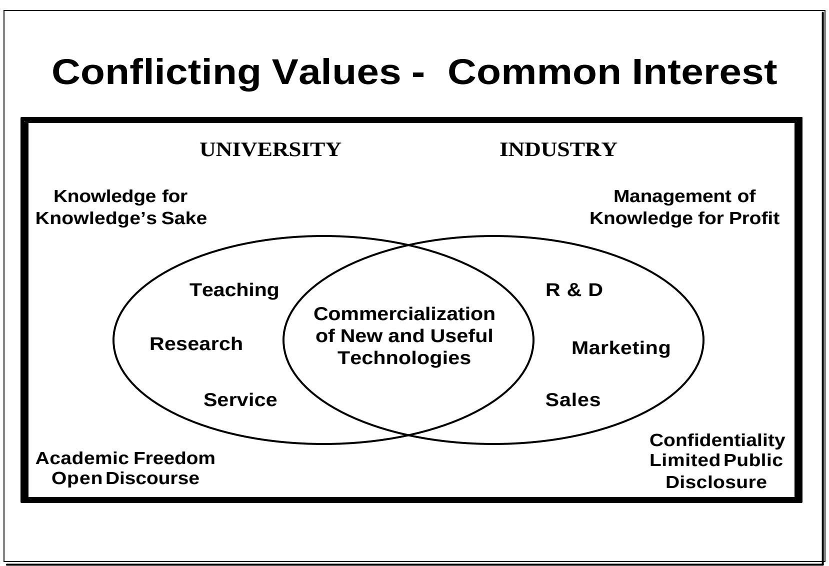
CHALLENGING ISSUES IN UNIVERSITY-INDUSTRY COLLABORATIONS

Twenty years of experience in university-industry collaborations have led us to a better understanding of the challenging issues that are potentially contentious in structuring these collaborations—restrictions on publications, ownership of intellectual property rights, access to research tools, recovery of indirect costs, managing institutional and individual conflicts of interest and commitment, managing risks, and launching new ventures. Although a comprehensive discussion of these issues is beyond the scope of this paper, a brief discussion to highlight the issues may be instructive.

Publications/Restrictions

Universities' unwillingness to restrict or delay publication of research results (beyond a brief period to permit filing patents) is among the cultural values of academe that most distinguishes us from industry. Academia values the search for knowledge for knowledge's sake, freedom to publish, and open discourse. Companies seek knowledge for profit, competitive advantage, confidentiality, and limited discourse. Our common interest is in the commercialization of new and useful technologies.

Figure 7. University–Industry Conflicting Values–Common Interest



Ownership of Intellectual Property (IP)

The Bayh-Dole Act gives universities the right to take title to and patent those federally funded inventions they seek to commercialize. Life science companies in the U.S. understand and accept

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the adequacy and value of contractual rights to commercialize inventions and do not get involved in protracted and unproductive discussions about ownership. Unfortunately, too many companies in non-biomedical fields and companies outside the U.S. continue to pursue ownership rights to patents.

Typically universities seek to control prosecution of patents in all types of license agreements. However, a number of universities, including the University of Pennsylvania, now routinely grant to companies taking exclusive licenses the right to manage patent prosecution so long as the universities' asset positions are not negatively affected. This concession accomplishes two objectives. First, allowing companies to direct patent prosecution often overcomes their concerns about ownership. Second, and perhaps more importantly, granting this right overcomes concerns about the quality of university patent filings and, more importantly, rests with those who best understand how the technology will be commercially exploited and the right and responsibility to manage prosecution.

The quality of university patents is often justifiably maligned by industry licensees. University patents are often filed with little advance notice and very early in the discovery process. This is done to ensure appropriate scientific recognition for the faculty inventor and to secure intellectual property rights prior to impending publication. Limited patent budgets generally do not permit universities to file foreign national patent applications without an industry licensee. University patents are also often filed before there is a defined commercialization strategy or product profile.

Access to Research Tools

Universities are increasingly aware of their responsibility *not* to restrict access to research tools created with public research funding. NIH has promulgated guidelines to assist us in this regard. University technology managers are also increasingly more realistic about the value of research tools in the drug discovery process and generally do not seek to obtain "reach through" royalties from non-exclusive licenses for use of research tools. In addition, universities are becoming much more efficient and effective in working with faculty to simplify procedures related to material transfers.

Indirect Cost Recovery (ICR)

Currently established federal indirect cost recovery (ICR) rates do not cover the full costs of research (often due to caps on administrative costs). Companies claim that since institutional indirect costs have been reimbursed by federal sponsors, companies should not be obligated to pay indirect costs and that universities charging indirect costs to companies are in effect "double-dipping." Universities establish with federal sponsors indirect cost recovery rates as the primary sponsors of research, in effect providing these sponsors with a volume discount. Many universities willingly subsidize the cost of federally funded research in that such research is integral to our missions. There does not appear, however, to be any justification for providing the ICR rate volume discount and subsidies to industry sponsors. Many universities, seeking perhaps to be more accommodating to industry partners, continue to discount ICR rates to companies, making it difficult for those institutions who out of principle or economic need seek full indirect cost recovery.

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Conflicts of Interest (COI)

Managing institutional and individual conflicts of interest (COI) and commitment is perhaps the greatest challenge today in the academic-industry innovation enterprise. Many universities and all academic medical centers conducting clinical research have established or are in the process of promulgating or revising policies and procedures for managing conflicts of interest. Most institutions have in place policies for managing faculty conflicts of commitment by prescribing the number of days a faculty member may be engaged in extramural activities.

The American Association of Medical Colleges (AAMC) has proposed policies for managing *individual* COI and these guidelines have become a standard.[5] The AAMC COI guidelines mandate a "presumptive prohibition" for faculty to be engaged in clinical research in which they have financial interests in the outcome of research, except in situations where "compelling circumstances" warrant. University faculty COI committees are struggling to adhere to these AAMC COI standards and thereby regain the public's trust in the conduct and outcomes of research while permitting faculty to be engaged in translational research activities.

Managing *institutional* COI may prove to be even more challenging. Having a financial interest through patents and licenses in and of itself is deemed by some to create a financial interest in the outcome of research, thereby creating an unmanageable COI. The dilemma is Solomonic: universities and their faculty deserve to participate in the wealth (value) enabled by our intellectual property; but the public must have confidence that the research we conduct and the patient care decisions being made are done so without regard to financial interests. Conflicts of interest cannot be avoided, but they must be managed.

Managing Risks

Technology transfer activities, by their very nature, create risks. Universities are among the most risk-adverse institutions and are loathe to be involved in any activity that may risk our most precious assets—reputation and endowment. Companies, investors, and entrepreneurs are far more accepting of risks. In partnering with the private sector, universities must seek to manage, rather than avoid, risks associated with technology transfer and commercialization. We seek to manage these risks by defining the scope of license grants, limiting the acceptance of confidential information from commercial partners, minimizing publication restrictions, disclaiming warranties, restricting use of name, requiring indemnification, and imposing diligence requirements and termination consequences to assure timely commercialization of licensed technologies.

Start-up Ventures

Creating new ventures to commercialize university discoveries presents both an enormous challenge to university technology managers and a tremendous opportunity for promoting economic growth. The previously discussed challenging issues are even more pronounced in start-up ventures. Universities are commercializing discoveries through start-ups to promote economic growth and because institutional and faculty interests encourage us to do so.

Technologies appropriate for licensing to start-up ventures are revolutionary in nature, often described as disruptive and paradigm shifting. These technologies represent platforms upon which multiple products can be developed. However, in today's difficult financial market,

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successful new start-ups need more than a platform technology. Investors also want a well-defined lead product with a clear commercialization plan.

Start-up ventures permit universities to participate in equity appreciation in new ventures, even if the university licensed technology fails. Income generated from equity liquidity events are likely to precede by years income produced from royalties. Finally, universities create start-up ventures to satisfy a growing number of faculty who are interested not only in traditional forms of academic recognition, but also in the potential financial rewards of start-ups.

CONCLUSION

In summary, the question is not whether universities should forge closer ties to industry through partnerships and collaborations. Nor is the question whether universities should play an active role in promoting economic development. Rather, today, the relevant question is "how" universities should do so. Different universities will define and preserve academic core values differently and adopt differing strategies and tactics in the "innovation enterprise." All universities will seek to structure collaborations that provide companies with the competitive advantage they seek while preserving core academic values.

Companies, investors, and entrepreneurs are urged to understand and accept that these core values must be preserved. Industry partners must accept universities' obligation to publish research results and educate students with minimal confidentiality restrictions. Companies are also urged to accept university ownership of IP and work with us to collaborate on patent prosecution. Companies must not seek to restrict access to research tools that need to be made broadly accessible. Companies should pay at least the government-negotiated rate for indirect cost recovery. Companies must understand that individual and institutional conflicts of interest and commitment must be managed to preserve the public's confidence in the academic research enterprise. Finally, companies, investors, and entrepreneurs must grant to universities and our faculties an opportunity to participate in the wealth our discoveries help engender.

The two worlds—university and industry—can be bridged. In fact, their widely divergent missions and institutional obligations (public vs. private interests) can be complementary, synergistic, and beneficial to all.

ACKNOWLEDGMENT

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ENDNOTES

1. Bush, V. (1946). *Endless Horizons* (Washington, DC: Public Affairs Press).
2. Data shown in Figures 1–6 is from the AUTM Licensing Survey. Information provided in this section is from the FY 2000 Survey Summary.

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3. Cortright, J. & Mayer, H. (2002). "Signs of Life: The Growth of Biotechnology Centers in the U.S." The Brookings Institution Center on Urban and Metropolitan Policy, 2.
4. Milken Institute.
5. Association of American Medical Colleges (2001). *Protecting Subjects, Preserving Trust, Promoting Progress – Policy and Guidelines for the Oversight of Individual Financial Interests in Human Subjects Research*. Task Force on Financial Conflicts of Interest in Clinical Research (Washington, DC).

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