JOURNAL

of the Association of University Technology Managers

Volume XVI Number 1

Summer 2004

1974–2004 AUTM 30 years of innovation™

AUTM®

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Printed in the USA

Editor's Preface

This year, we celebrated the 30th anniversary of the Association of University Technology Managers (AUTM). Our organization has experienced tremendous growth in the years since its founding, and AUTM members have devoted themselves to the process of transferring new technologies from universities and nonprofit institutions to the commercial sector for the benefit of the public. With this in mind, it is only fitting that we reflect upon the impact of university technology transfer in this issue of the *AUTM Journal*.

The first article, "The Economic Impact of University Technologies," is a commentary drawn from Alfred R. Berkeley III's presentation at the 2004 AUTM Annual Meeting℠. From his perspective as the former president and then vice chairman of Nasdaq Stock Market Inc., Berkeley is well-qualified to comment on the role that AUTM and its members have played in our nation's economic growth, particularly with respect to the creation and development of entrepreneurial companies. He also expresses his opinions on what our economy will require in the future, and he challenges AUTM and its members to play an even greater role in future economic growth.

In the following article, "Inside the IPO Black Box: University Licensing to Companies that Go Public," Joshua B. Powers, Ph.D., assistant professor of higher education administration at Indiana State University, examines a national dataset of 181 initial public offerings (IPOs) involving 311 licensing links to 86 U.S. universities. To ensure a satisfactory time frame for analysis of a company's performance following its IPO, Powers limits his analysis to companies that went public during the five-year period between 1996 and 2000 and then follows their performance through April 2004.

Powers provides the reader with answers to three questions: (1) How has university licensing to start-ups and small companies been manifested in terms of IPOs? (2) What has been the nature of the licensing arrangements? (3) What has been the post-IPO performance of the companies? While some of the results presented by Powers will be familiar to the seasoned AUTM professional, there are some surprises embedded in this article. Powers concludes with a number of well-reasoned suggestions for technology transfer professionals to consider in their future licensing endeavors.

The next article is "Technology Licensing to Nontraditional Partners: Nonprofit Health Product Development Organizations for Better Global Health" and is authored by Charles Gardner, Ph.D., associate director for health equity, The Rockefeller Foundation, and Cathy Garner, Ph.D., chief executive officer, Centre for Management of Intellectual Property in Health Research and Development. Their article presents an emerging opportunity for the transfer of university technologies to benefit people in developing countries.

According to Gardner and Garner, 90 percent of the world's efforts in health sciences research and development currently are being directed toward solving the health problems of 10 percent of the world's population. To address this inequity, philanthropic organizations have created public-private partnerships (PPPs) to expand existing product-development pipelines and accelerate the development of safe, effective, affordable, and accessible products for the prevention and treatment of diseases that afflict the poor.

More than $500 million already has been raised to fund these efforts, and Gardner and Garner provide examples of several existing licensing arrangements between universities and such PPPs. The authors urge technology transfer professionals to consider dual licenses for commercially valuable products, that is, licensing to a for-profit entity in commercially attractive markets and to a PPP in less-lucrative markets. They also propose that the PPPs may provide the only viable licensees for products that have limited commercial value but that may be beneficial to people in developing countries.

This *AUTM Journal* concludes with the article "Measuring the Impact of University Technology Transfer: A Guide to Methodologies, Data Needs, and Sources." The authors, Robert A. Lowe, Ph.D., assistant professor of strategy and entrepreneurship at Carnegie Mellon University and president of Wellspring Knowledge Management Systems, and Suzanne K. Quick, Ph.D., director of information systems, communication, and planning in the University of California's Office of Technology Transfer, provide guidance for readers seeking to measure the impact of university technology transfer on local and regional economies.

As Lowe and Quick emphasize, there is no single measure that will provide sufficient information on the many aspects of technology transfer. The authors offer two approaches to assessing local and regional economic impact: (1) evaluations of direct vs. indirect impacts and (2) benchmarking analyses utilizing appropriate counterfactual simulations. In addition, the authors provide, as an example, a project being conducted at the University of California that aims to develop an information infrastructure that will provide data in support of the types of assessments discussed in their article.

The editors are grateful to the authors of these articles for their willingness to share their thoughts and concepts with the readers of the *AUTM Journal* and devoting the time and energy necessary to produce these articles and work through the editing process prior to publication. The members of the Editorial Advisory Board also are deserving of gratitude for assisting in the selection of abstracts, and, then, carefully reviewing and commenting upon various draft versions of these articles. Thanks also to the *AUTM Journal's* Managing Editor Lisa Richter and her colleagues at The Sherwood Group Inc. for their efforts in making this an outstanding publication.

We believe that you will find this edition of the *AUTM Journal* useful and informative. Planning for the second 2004 issue of the *AUTM Journal* is already under way, and manuscripts are being reviewed. We trust that our readers will join us in looking forward to this upcoming issue that will focus on the pros and cons of licensing to start-up companies.

The *AUTM Journal's* editors and Editorial Advisory Board appreciate and solicit suggestions and comments regarding the *AUTM Journal.* Please send your comments to us via e-mail at autm@autm.net.

Thank you.

— Leona C. Fitzmaurice, Ph.D.
Editor

Guest Commentary

The Economic Impact of University Technologies

Alfred R. Berkeley III

Introduction

As part of the 30th anniversary of AUTM celebration during the 2004 AUTM Annual Meeting^{SM}, former President and Vice Chairman of the Nasdaq Stock Market Inc. Alfred R. Berkeley III shared his views about economic development spurred by technology transfer and the ultimate societal benefits during the plenary session. Here is part of what he had to say.

It was an honor for me to be invited to address the 2004 AUTM Annual Meeting and, particularly, the 30th anniversary meeting. It was clear from the attendance and the international representation that AUTM itself and technology transfer in general is moving into a new growth phase. From my perspective, this recognition, growth, acceptance, and prestige are long overdue.

I am blessed with a rather unique perspective of what the members of AUTM do and the association's importance to the country and to the world's standard of living. I had the privilege of being the president, and then the vice chairman, of the Nasdaq Stock Market Inc. NASDAQ is often referred to as the engine of America's growth, but I prefer to see it as one piston in that engine. To me, technology transfer is an adjacent piston, and every bit as important.

NASDAQ grew to be the largest market in the world, in terms of dollars traded, because the companies it lists became the engines of growth in technology. While NASDAQ serves all sorts of companies, the technology sector dominates its indices and its market capitalization. Interestingly enough, NASDAQ began as the market for those young risky technology companies that the other markets did not want and would not accept.

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The statistics on financial and technology literacy in our country are appalling and frightening. Only a small fraction of our citizens understand the link between technology and our standard of living, and almost none understand wherefrom come the technologies that have so lightened mankind's burden of labor and so improved our health and extended our lives. Few people even remotely grasp the thousands of cascading technologies and inventions that created the modern automobile, the television, the computer, or the drugs we take for granted.

AUTM members know that many of the breakthroughs come from scientific research carried out in universities and federal laboratories. AUTM members are the critical interface, the boundary interface, between the world of science and the world of commerce. AUTM members are the filters, the throughput valves. If technology transfer is efficient and effective, the conversion rate of science to commerce will be high, and the world economy and mankind's standard of living will improve. As this funny little species called man crowds the world and crowds out other species, technology will become the critical determinant of the quality of life for our grandchildren.

The basic factors of production are pretty well-understood. Wall Street refers to them as men, money, and materials. In the old days, men meant physical labor; today, it means mental labor—it means know-how, it means technology.

We are forced into doing more with less, and we stretch the earth's resources. There are just not enough materials to work with in the old, wasteful, rape-the-earth fashion. I live on the Chesapeake Bay and can tell you from firsthand observation, and from the good scientific work of the Chesapeake Bay Foundation, that fish, oyster, and crab stocks are low and that the more than 3,000 sewage treatment plants that empty into the bay and its tributaries—each meeting federal guidelines on effluents—simply overpower the regenerative powers of a bay that, on average, is eleven feet deep. Technology will be the only way we solve these large-scale mega problems. So we shall not find a higher standard of living in the old materials. With new know-how, with new technology, we may find a higher standard of living and new materials, but we will not find the new materials without good science transferred into commercial applications.

Nor will we find a higher standard of living in the capital markets, at least not in the traditional sense of living off our capital. An even smaller group of Americans understands the link between the financial markets, technology, and our standard of living. NASDAQ, operating under some profound insights developed by Gordon Macklin and Joseph Hardiman, broke the choke hold the traditional exchanges had on public risk capital and democratized access to risk capital in a way that profoundly changed the nature of our economy. There are important lessons in the evolution of America's capital markets that may be important in the evolution of technology transfer. Let me provide a little background that few Americans know or think about.

We have enjoyed a booming technology sector in our economy for about 30 years. It was not always so, and its future was not foreordained. It was the insights of a few bold policymakers in the 1970s that moved our economy away from being a debt-oriented economy and toward being an equity-oriented economy. In the 1950s and 1960s, commercial banks were the dominant source of capital for businesses. America had more than 13,000 banks, and the memory of the depression scared most investors away from the stock market. In 1950, only 4 percent of American households owned equities or equity mutual funds. If I remember correctly, we were a nation of about 170 million people. Large industrial companies, automobile companies, steel companies, railroads, and banks dominated the economy and the financial indices. We had modest household savings, but we were relatively lucky in that the recent war had been waged on other people's soil, not ours. Our basic infrastructure, though aging, was intact. But the only source of pooled savings that an entrepreneur could approach was a commercial bank.

The problem with banks is that they are in the business of avoiding risk, of limiting risk. It was not, and still is not, appropriate for your savings account to be put at risk, particularly at the level of risk that a start-up business involves. Banks did what they should have done, which was to say no to the entrepreneur. We were headed toward being a debt-oriented economy, with large concentrations of power in the hands of established companies and large barriers to entry of new people into their circle.

Four specific policy decisions were made that would allow America to tap the power of its entrepreneurs. One was the passage of the Employee Retirement Income Security Act (ERISA). This act did more than create fiduciary obligations on the part of pension-plan sponsors and managers.

ERISA allowed fiduciaries to allocate a portion of the plan's funds to non-traditional investments, meaning investments that did not pay interest or dividends. This took away a decades-long legal precedent that had basically forced fiduciaries to invest in companies that did pay dividends and interest. This simple change had a profound effect. It allowed pension fund managers to invest in early-stage companies, companies that were using cash, not generating cash, companies that had no business paying out cash and that did not have any cash to pay out anyway. The chosen way for pension plans to invest in early-stage companies became the venture-capital partnership. The amazing growth that America has enjoyed in venture capital has come from this legal policy. Venture funds are creatures of the pension industry.

The second profoundly important policy change that occurred in the 1970s was the reduction of the capital-gains tax. During World War II, America had had taxes on capital gains as high as 90 percent. After the war, this was lowered to 50 percent. The problem is that, while taxing the gains on a winning stock might seem reasonable, the winners are probably only one or two holdings out of a portfolio of holdings, some of which fail and some of which break even or prosper slightly. Taxing the winner at 50 percent makes the whole portfolio too risky. Investing in equities was just too risky, and debt became relatively more attractive. This too was propelling America toward a debt-oriented economy. In the 1970s, capital-gains taxes were lowered to 28 percent, and the risk-reward equation shifted slightly toward equities.

In the early 1980s, Congress passed legislation that enabled ordinary citizens, regardless of where they were employed, to set aside savings for retirement in a tax-deferred way. The 401(k) plan led to a large increase in savings, and most of these savings were pooled in mutual funds. The fund industry began to grow by leaps and bounds. As funds managers sought competitive advantages, they tended to specialize. Some specialized in investing in newly public companies. This began to create a market for the venture capitalists' maturing investments.

The last link in this emerging new ecology of finance that supports the life cycle of the technology company was the development of the NASDAQ. At a time when the traditional markets were raising their listing standards to avoid the problems that come to markets that have companies fail, NASDAQ was opening its arms to essentially all companies. (Over the years, NASDAQ has raised its standards a bit, but not much more than the rate of inflation.) The key insight that Gordon Macklin had, and which has been a lasting legacy to the country, is that the decision on whether to invest should be the investor's decision, and not pre-empted by a market through its own efforts to enhance its reputation by having high standards. In the complex adaptive system that is free enterprise, no one person, or management team at a stock market, can outguess the collective wisdom of the marketplace. Gordon Macklin, and Joseph Hardiman who succeeded Macklin, understood that tough Darwinian competition was better for the economy and the country over the long term than any feel-good philosophy in the short term. Their tough-minded commitment to free enterprise was challenged many times, but they stood fast. The most recent challenge to NASDAQ's free-market philosophy came after the dotcom bust, when many voices asked, How could you have possibly let those dotcoms come public? Most people do not realize that financial excess and overbuilding are characteristic of every wave of new technology in the United States. The railroad booms, both before and after the war between the states, saw stock prices soar and thousands of short-line roads built, many parallel to others. The bottom line was that NASDAQ created a way for people who bought shares in young, risky companies to sell shares. Being able to sell easily and cheaply dramatically lowers the risks of ownership and dramatically deepens the pool of risk capital available to small, risky companies. Some will succeed dramatically; most will fail. NASDAQ has listed about twice as many companies in its history as it lists today. While that sounds bad, it is actually good.

Let's talk for a moment about pricing. You would think that prices are what finance is all about. The media is fixated on the price of individual stocks and indices. I would submit that pricing is important in the business of technology transfer as well, and I will share the lesson we have learned in finance. When I arrived at NASDAQ in 1996, the cost for one dealer to trade with another using our Selectnet communications system was $5 per trade. It did not seem unreasonable, as a typical trade might involve $30,000 in principal value, and, without the NASDAQ, it was hard to find the other side of the trade. But those prices had nothing to do with our costs, which were much lower. We had been holding an artificially high price because the market was inefficient. We were discouraging business and inviting competition. Today those prices are closer to ten cents per trade. I do not know the business of university technology transfer very well, but I have been on its periphery enough to have the sense that technology transfer offices would have a lot more business to do if they substantially lowered the getting-started costs of licensing a technology and then got a larger share if the product was a commercial success. Structure win-win deals with a keen understanding of the different risks that exist in the early stages of commercialization as compared to the later stages.

What have we said so far? We have said that America was on its way to being a debt-dominated, highly concentrated economy in the 1950s and 1960s. We have said that a few basic policy decisions were made that have made all the difference to our standard of living. It is worth noting that each of these policy decisions was contentious at the time.

We have said that lowering the tax rate was essential, that allowing fiduciaries to invest in risky companies was essential, that allowing individuals to direct their own retirement savings was essential, and that allowing a market to trade shares in risky companies was essential. You know the results: add a bit of technology (such as semiconductors, software, and recombinant DNA), stir with newly liberated entrepreneurial zeal, and nurture in a bird's nest of well-conceived public policies, and our economy boomed.

What are the lessons of the financial markets for the technology transfer business? AUTM members have some of the same policy initiatives that the financial markets enjoy. There is the process of securing patent protection, which is in some ways very similar to the financial industry's securities registration requirements under the Securities Act of 1933. Patent applications define property rights for unique ideas, and they become transparent after they are granted. This transparency is important, but the legal terminology contained in issued patents is arcane and complex. The financial-services industry understands that securities-registration statements are no fun to read and that the essential parts need to be translated into simple terms for a broader public consumption. The whole area of investment research is common-language sales literature putting complex technical and competitive concepts within the public's grasp. I do not see a lot of plain-language discussion of the commercial potential of university patents. It appears that universities continue to think that their customer is

the large commercial company that will actually license the patent. No doubt that is a customer, but universities are selling themselves and the public short if they do not find a way to communicate in plain language with the public about the meaning and the promise of their patents. There is no reason that some patents, like some stocks, should not be presented to the public in an interesting way. Why aren't patents as newsworthy as stocks? Why aren't patents tracked, with their cumulative impact recorded and reported upon? Some AUTM members are bound to be as able storytellers as are the financial pundits. And AUTM members are actually dealing in a more meaningful subject, because most of the banter about stock is about the random movement of their prices.

The Bayh-Dole Act is an important centerpiece to university technology transfer success and should be defended at all costs. It continues to be under attack. But where does Bayh-Dole fit into the policy spectrum? I would suggest not only that the Bayh-Dole Act is an empowering act, an act that actually allows some things to happen that otherwise would not, but also that it is very similar to the capital-gains tax cut that I mentioned was so important in revitalizing our economy after the recession of 1974. The alternative to the Bayh-Dole Act is government or common ownership of the fruits of publicly financed invention. Public ownership of the few commercially viable inventions is directly analogous to a high capital-gains tax on a successful investment. It destroys the economics of investing in a portfolio of inventions. You cannot justify the risks if your few winners are going to be taken from you. AUTM itself and every one of AUTM's institutions should get energized on defending the Bayh-Dole Act from the attack it is under now.

Finally, there is another lesson in the financial industry that may help. The financial markets are just that, markets. University technology transfer is a market too, but the search costs, in the jargon of an economist, are too high. The market is not efficient. It does not have NASDAQ. A number of us have been trying to crack this nut. The Community of Science is an effort started at Johns Hopkins University in the late 1980s that is slowly gaining scale. It started as a dating service for scientists looking for funds and funds looking for scientists. It has more than $40 billion, yes, billion, of unawarded, unspoken for, unclaimed grant money. A few universities have realized what the Community of Science has and have become aggressive users. Ohio

State is a good example, as are Michigan, Wisconsin, University of Washington, and the North Carolina and California systems. More than 600,000 university-based scientists participate in the system. This is earlier in the food chain than are AUTM members. Technology transfer offices inherit the output of the efforts of these scientists. AUTM members need a market of completed intellectual property. It needs to be standardized the way the Community of Science has standardized the record structure for grants and scientists. AUTM should either do this itself or ask the Community of Science to add it to its system. (Think twice before trying to do this independently. The Community of Science has invested more than $40 million and twelve years to get the critical mass it needed to be successful. These projects sound easy, but are actually hard. The technology is not difficult. Getting to critical mass is difficult.)

NASDAQ and the other financial markets provide a go-to place for people seeking information about what's happening in the market. Technology transfer needs a go-to place as well. AUTM is the natural locus of such an effort. (AUTM might want to build on the Community of Science technology and outsource part of the effort to the Community of Science, but AUTM members should want to build a sense of brand for AUTM that provides a neutral territory for participating institutions.) This is a place where the media and the policy world can get accurate, unbiased information on what is really happening in technology transfer. How many times have you heard anecdotal stories about the basic research that provided the foundation for such and such a product or industry? We need to focus a series of doctoral dissertations on documenting a broad range of technology transfer successes. Without good data, it is hard to win the policy wars.

It has been an honor for me to share my thoughts on technology transfer. I believe that AUTM is at the critical interface, the boundary interface, that will define how goes our standard of living over the next one hundred years. There are other important interfaces, but none has the leverage that AUTM has. After all, AUTM members are marketing completed research, documented inventions. Getting both new and older inventions into commercial use is a noble goal; allowing good inventions to sit unexploited is rather like putting your light under a bushel. We have been admonished about wasting our talents and our resources since Biblical times. The energy at the 2004 AUTM Annual Meeting was electric. It felt to me just the way the software

industry felt in the late 1970s when new people were entering and upsetting the old order. Look at how we have all benefited from that revolution. I want to be part of the revolution AUTM members are launching—expanding access to the power of our inventors—just as software democratized access to the power of the computer.

Inside the IPO Black Box: University Licensing to Companies that Go Public

Joshua B. Powers, Ph.D.

Abstract

No studies have comprehensively investigated companies that have gone public built in whole or in part on a university technology. Reaching an initial-public-offering stage is an important company and university licensor milestone, one with symbolic and financial importance and a highly visible economic impact measure. This study presents what is known about these firms and their university licensor relationships from a national dataset of 181 IPOs involving 311 licensing links to 86 U.S. universities. Issues of particular interest to university licensing professionals are discussed, as are implications for technology transfer practice and policy.

Introduction

Few business events have attracted more attention in recent months than Google's decision to go public, that is, make an initial public offering (IPO) of its stock. While much commentary has focused on the offering size, the potential boost to Internet stocks, and who will gain financially, what is somewhat less well-known is that Stanford University stands to benefit by the event, both symbolically (chief executive officer founders were Stanford students) and financially (Stanford owns company stock as part of an exclusive licensing agreement through 2011 for its PageRank technology).

Google notwithstanding, little is known in a comprehensive way about IPO companies built in whole or in part on a university-licensed technology despite a wealth of licensing deal information embedded in IPO disclosure documents. Hence, we have an incomplete picture of how universities contribute to economic development. In 1993, AUTM started tracking start-up

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company formations, a useful way of documenting how universities and other research-and-development institutions contribute to small-business creation, a driving force of the U.S. economy.

Starting a new business, however, is risky, especially for the kind of research-and-development-intensive company most likely to license a typical early-stage university technology. Thus, tracking the downstream performance of start-ups is useful but largely absent from the study of university commercialization. Some examples of downstream performance are provided in AUTM's annual surveys as case studies, anecdotal stories in major media outlets, and university Web pages and annual reports. What attracts attention are blockbuster successes such as Google and Stanford University or spectacular failures like Boston University's Seragen Inc. Comprehensively, little is known about the long-term performance of start-ups that license university technology.

This study seeks to help fill the knowledge gap by investigating companies that have gone public based largely or in part on a university-licensed technology. An IPO is a coveted milestone of company achievement and a means of raising substantive capital. It sends a signal to the marketplace that the company has reached a level of maturity consistent with it being considered successful. University licensors also view it as an important measure of accomplishment because it is a highly visible example of economic-development contribution with sizable financial benefits if stock equity is held by the university.

The specific research questions of interest for this study were as follows:

- How has university licensing to start-ups and small companies been manifested in terms of IPOs?
- What has been the nature of the licensing arrangements?
- What has been the post-IPO performance of the companies?

Method

The sample of 181 companies was drawn from Securities and Exchange (SEC) Commission IPO documents. Investigating IPOs offers a valuable window into university licensing because, when a company files IPO documents with the SEC, it is the first time that many aspects of the company and its risk factors are publicly disclosed. Furthermore, IPO companies are generally young and small, the exact kinds of companies that the federal

government encourages universities to partner with for regional and national economic-development purposes.

Three hundred eleven licensing deals between 86 U.S. universities and 181 private companies were identified from a set of 136 research universities investigated. The time frame for IPO was the five-year period 1996 to 2000, chosen so as to also investigate post-IPO firm performance through April of 2004. Post-IPO performance in terms of the current circumstances of these companies and their stock performance since the IPO was obtained through Lexis-Nexis and Yahoo Finance.

Two content analysis methodologies were used. Classical content analysis,[1] the counting and frequency of numbers, words, themes, or phrase occurrences, was used to capture firm location patterns, firm-university alliances, licensing exclusivity choices, the size and extent of equity deals, and various stock-performance measures among others. Theoretical content analysis,[2] organizing themes into categories to make inferences, was used to identify ways that faculty inventors were involved in the firm as well as the nature of any publication restrictions.

Results

IPO Firms with University Licenses: A Snapshot

The first research question focused on how licensing to start-ups and small companies has been manifested in terms of IPOs. Table 1 offers a national snapshot of IPO activity for the period 1996 to 2000.

Thirty-five states were the source of university-licensed technologies to pre-IPO firms located in 31 states. The top five states in terms of being a source of university-licensed technologies to pre-IPO companies were California (53), Massachusetts (39), Texas (26), New York (20), and North Carolina (14). The top five states in terms of the number of licensing deals with pre-IPO companies in the state were California (102), Massachusetts (34), Pennsylvania (23), Washington (21), and New York (17). Among those states with at least six licensing deals (i.e., ones at least moderately successful with IPOs in the state), the five with the highest in-state licensing percentages (i.e., universities within a state licensing to firms within the state) were Utah (67 percent), Texas (57 percent), Massachusetts (50 percent), Georgia (50 percent), and North Carolina (33 percent).

The above data are revealing. First, approximately one-half of all licensing

Table 1
Geographical Distribution of IPO Activity: 1996–2000

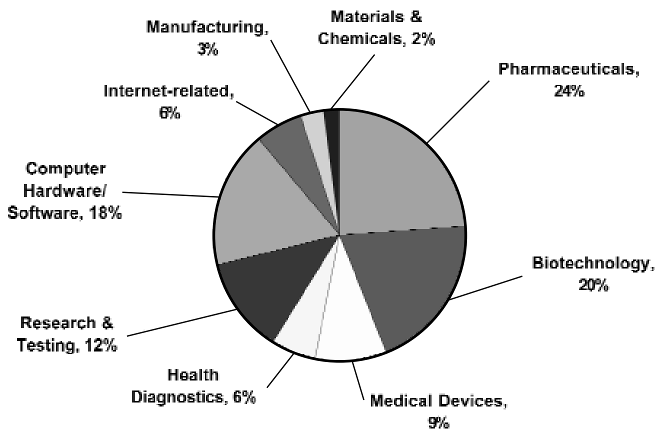
State	Number of Technologies Sourced in Universities in the State	Number of Licensing Deals with Pre-IPO Companies Located in the State	Number of IPO Companies Located in the State	Percentage of In-State Licensing from In-State Universities
Alabama	2	0	0	0%
Arizona	1	1	1	100%
Arkansas	4	0	0	0%
California	53	102	52	30%
Colorado	3	10	4	30%
Connecticut	12	10	6	30%
D.C.	3	0	0	0%
Delaware	1	1	1	100%
Florida	11	7	7	29%
Georgia	9	8	4	50%
Illinois	13	9	4	22%
Indiana	5	1	1	100%
Iowa	7	1	1	100%
Kansas	2	0	0	0%
Kentucky	2	0	0	0%
Louisiana	1	0	0	0%
Maine	0	1	1	0%
Maryland	9	10	6	20%
Massachusetts	39	34	26	50%
Michigan	7	1	1	100%
Minnesota	3	3	3	67%
Missouri	9	3	1	0%
Nebraska	1	1	1	0%
New Hampshire	0	2	1	0%
New Jersey	6	5	4	20%
New Mexico	1	1	1	0%
New York	20	17	10	18%
North Carolina	14	6	3	33%
Ohio	5	5	2	40%
Oregon	2	2	2	0%
Pennsylvania	12	23	11	22%
Rhode Island	1	0	0	0%
Tennessee	5	2	2	0%
Texas	26	14	9	57%
Utah	5	6	5	67%
Virginia	3	2	2	50%
Washington	9	21	7	29%
Wisconsin	5	2	2	100%

activity to pre-IPO firms was sourced in two West Coast states (California and Washington) and five Northeast states (Massachusetts, Connecticut, New York, New Jersey, and Pennsylvania). Seventy percent of all pre-IPO firms were also located there. Considering that the average distance between university licensor and licensee firm was 1,121 miles, much licensing activity is clearly occurring between opposite coast regions. This finding is not surprising given the long history of entrepreneurial areas such as Silicon Valley and Boston's Route 128 corridor, both with sizable amounts of life-giving venture capital. However, a deeper data analysis revealed that approximately one-third of all licensing deals are in-state. Ninety percent of these deals involved distances of less than 50 miles, and 40 percent were within the same city.

Thus, licensing activity to pre-IPO firms is bifurcated. Universities appear to be pursuing both an in-state, regional economic-development strategy, often licensing to start-up firms, while also pursuing a national licensing strategy, likely driven by where potential clusters of private licensee firms are located. This finding is reinforced by the fact that a greater proportion of local licensing deals had fewer alliances with universities, suggesting that those firms with the resources to search nationally for technologies do so in the belief that a deeper portfolio is advantageous. Unfortunately for those universities pursuing a start-up strategy in regions not known as hotbeds of entrepreneurial activity, their local licensing is higher risk while their longer distance licensing efforts and management are more expensive.[3]

Figure 1 shows how the IPO firms were distributed by industry. As can be seen, more than one-half of the companies were in the life-sciences arena—pharmaceuticals, biotechnology, medical devices, and health diagnostics. Considering that many of the companies in the research and testing category are also focused on life-sciences technologies, as are a few in the other categories, it is clear that approximately two-thirds of the IPO companies operated in the life-sciences arena. This pattern also implies higher-risk licensing. Product incubation times for firms involved with clinical trials are often ten or more years from idea to product sales,[4] assuming Federal Drug Administration approval is obtained. Thus, sufficient capital to sustain the firm during that period is critical and often lacking, especially when the firm is located in a region that has little venture capital available

Figure 1
IPO Firm Industries



for investment. Life-science firms also may be forced to pursue an IPO sooner than is normally warranted when resources are scarce, or in the case of the 1996 to 2000 window of time, out of a belief that the market would be especially favorable for an IPO. Considering that approximately 80 percent of the IPOs in the dataset involved large capital offerings (i.e., stock offerings aimed at raising more than $10 million), it is clear that most were seeking sizable sums of capital to sustain operations.

Licensing Arrangements

The second research question focused on the nature of the licensing arrangements with pre-IPO firms. A first issue of note centered on equity deals (i.e., stock shares provided to a university licensor in lieu of or as a supplement to traditional upfront payments). Because equity deals represent a material risk to a potential stockholder, their existence and, often, their amount typically would be revealed in IPO documents. Twenty-four percent of the firms in this study had equity deals with universities and/or with faculty inventors. The average deal among those that disclosed amounts was approximately 188,000 shares with a range of 2,000 to 1.3 million shares. A number of equity arrangements also included stock options and antidilution clauses.

The percentage of IPO deals with equity was considerably higher than the 11 percent calculated from the 1998 *AUTM Licensing Survey™*,[5] the

midpoint of the period of interest to this study. This result suggests that equity deals may be more likely to lead to an IPO event, perhaps as an early signal to the market of university commitment to the success of a company or as a means of preserving a firm's precious cash during the earlier, higher-risk days of the company's existence. This finding implies that if a university takes equity in a start-up company as part of a licensing deal, the likelihood of the company reaching the IPO stage may be enhanced—a result that would benefit both the university and the company.

A second issue explored from the data was the nature of licensing exclusivity. Much commentary has been offered regarding the wisdom and efficacy of ceding broad rights to the development of a university-licensed technology to a single firm.[6] These concerns have been especially acute around early-stage technology licensing when no clear application is evident. Some have argued, for example, that the patenting and exclusive licensing of gene sequences and stem-cell lines to one company is not in the public interest because it limits rather than enhances the potential development of broad-based health applications.[7] Technology transfer practitioners argue, however, that few companies would risk licensing a basic technology with a long, expensive, and risky incubation period without exclusivity protections.

An analysis of the study data revealed that at least three-quarters of the licensing deals with universities involved the granting of an exclusive, typically worldwide, license. Although not all of the licensing deal commentary made clear what kind of license was involved, among the majority that did report this information, the percentage with exclusive licenses appeared somewhat higher than the 61 percent reported for start-ups and small companies in the 1998 *AUTM Licensing Survey*, the midpoint of the period of interest to this study. Because the AUTM data does not break out how many of the small companies are public, it may be that these differences are less pronounced, suggesting that this comparison should be viewed with caution. Nevertheless, as discussed later in this paper, it appears either that most private company licensing is exclusive or that exclusive licensing may provide a small to moderate advantage in reaching an IPO.

A third issue investigated was the exploration of two noted conflict-of-interest issues: faculty involvement in companies and company control over publication rights. Both issues have garnered attention, some arguing that involvement of faculty members in managerial or board positions distracts them from their primary campus-based responsibilities and may bias their research when they hold a position or equity stake in a company for which they do research.[8] Others have raised concerns over undue company control on publication.[9] From the technology transfer professional's viewpoint, consummating and nurturing a licensing deal is often predicated on ongoing faculty involvement in product development.[10] Furthermore, limiting restrictions on publication to no more than short delays is critical to balancing a university's public-interest responsibilities with the realities of needing to evaluate potentially proprietary technologies.

An analysis of the IPO documents revealed that many of these firms do not seem to have an intentional linkage to faculty or made no reference to the inventor. When it was clear that faculty inventors did have firm involvement, the most common way was on a special scientific advisory board (approximately 18 percent of the firms in the dataset). Faculty members were serving in an officer capacity (chief executive officer or on executive team) and often also as a board member with almost the same frequency (approximately 15 percent of the firms in the dataset). While occasionally it was mentioned that the faculty member was on sabbatical or university leave, many appeared to serve in company and university roles simultaneously. They also, at times, received stock, for example, through their direct roles with the companies or under the terms of university policies regarding distribution of license-agreement income to inventors.

An analysis of the language surrounding a publication-gatekeeper role for a licensee revealed essentially three types of relationships. Among the licensing deals that discussed this issue in adequate detail, the first type involved clear and emphatic language indicating the faculty inventor's right to publish with little or no restriction or delay (approximately one-quarter of the licenses). The second type (approximately one-half of the licenses) articulated some control by a company to delay publication, sometimes with and sometimes without a specific stated number of days to exercise this right. The third type (approximately one-quarter of the licenses) only articulated a company's right to refuse permission to publish research results and appeared to allow the company alone the right to determine whether the information to be published was proprietary information. In this third type of relationship, if a faculty inventor wished to publish research results related to the licensed technology, the language of the license agreement

appeared to force the faculty inventor to rely on the benevolence of the licensee.

Post-IPO Performance

The third research question examined post-IPO performance. Post-IPO performance is an important issue as many newly public companies remain high-risk investments with many years remaining to profitability. For university licensors holding equity, this is important. Cashing in equity has become an important source of technology transfer revenue as evidenced by case examples (e.g., Dartmouth College with Medarex, Massachusetts Institute of Technology with Akamai Technologies). Equity in a private company has value only when it can be sold, typically at an acquisition moment (i.e., a company purchases the company that holds the university-licensed technology) or after going public (i.e., stock can be bought and sold on the open market).

The first part of this analysis investigated the current state of the IPO companies as of April 2004 to see which ones were still in existence, which had been acquired or merged with other firms, and which were financially distressed or had failed altogether. Ninety-six of the 181 IPO firms were still in existence and trading on a major exchange as of April 2004, although five had changed their name but remained essentially the same company. Another 44 of the 181 firms had been acquired or merged with another firm, some having done so two or three times since the IPO. Some mergers or acquisitions took the company private. Although it was difficult to tell without further supplemental analysis, some of the acquisitions stemmed from company financial distress (i.e., company was failing but remained attractive to a buyer). Thirty-six other firms were delisted from a major exchange, typically NASDAQ, and now trade as penny stocks in the over-the-counter market or pink sheets. Firms trading within these contexts are typically financial distressed and high-risk investments. Only five companies clearly had failed and were no longer in business.

Using the 96 companies that are still trading on a major exchange in their original form (i.e., had not been acquired or merged), post-IPO firm performance was investigated. Although there are a variety of ways to assess firm performance (e.g., product sales, return on investment, profits), stock price was chosen given its role as a proxy for firm success and its importance to university equity practices.

The 96 companies had an average stock-price close of $19.62 at the end of the first day of trading. The stock price held at least even to that level 35 percent of the time up through Dec. 31, 2003, and more than twice its opening price (a 100-percent return) an average of 13 percent of that same period. A 100-percent return would be considered a strong return even for the oldest IPOs in the dataset.

Table 2 breaks out these results by the top five industries represented.

Table 2
Post-IPO Financial Performance

Measure of Performance	Pharma (*n*=32)	Biotech (*n*=19)	Medical Devices (*n*=10)	Computer Hardware/ Software (*n*=13)	Research and Testing (*n*=10)
Stock price close of day one	$20.19 ($50.72)	$19.2 ($28.89)	$16.91 ($18.09)	$14.52 ($7.63)	$19.82 ($13.11)
Percent time stock traded above day 1 close through 12/31/03	42% (31%)	40% (32%)	36% (35%)	32% (35%)	24% (19%)
Percent time stock traded two times above day 1 close through 12/31/03	13% (20%)	19% (22%)	14% (21%)	12% (23%)	10% (15%)
Change in stock price between 1/02/01 and 12/31/03	-51%	-50%	-53%	-39%	-46%
Change in NASDAQ Composite Index 1/02/01 to 12/31/03	-13%				
Change in Amex Biotechnology Index 1/02/01 to 12/31/03	-17%				

Note: *Numbers shown without parentheses are averages. Numbers in parentheses are standard deviations.*

As can be seen, there was variability in performance by industry. Pharmaceuticals, biotechnology, and research and testing closed the first day of trading on average around $20 per share. Medical devices and computer hardware/software closed on average around $5 less. However, the

spread in close prices differed substantially with pharmaceuticals showing the greatest range in performance (standard deviation of $50.72). Computer hardware/software showed the least variability ($7.63 standard deviation). In terms of performance over time, pharmaceuticals and biotechnology had, on average, the longest sustained performance, with biotechnology offering the strongest returns in terms of stock appreciation (i.e., traded more than twice the close price at day one 19 percent of the time). Once again, though, there was considerable variability in performance across industries with research and testing showing the smallest variability among IPO firms over time. All of the other industries showed a consistently higher spread in stock performance over time.

As it regards the top three most high-performing IPO openings, Intrabiotics (University of California-Los Angeles license, pharmaceutical company), Akamai Technologies (Massachusetts Institute of Technology license, Internet company), and Sequenom (Boston University and Johns Hopkins licenses, biotechnology company) all closed the first day of trading at more than $100 with Intrabiotics closing at $292.49. All of the firms had described their technologies in glowing terms and some had reported product sales, although none of the companies were profitable at the time. Akamai and Intrabiotics grew stronger in the first few months of trading before a steady fall off, while Sequenom began a long slide that started on day two of trading and later became involved in a class-action suit against the company for alleged IPO improprieties.

In terms of companies that enjoyed the strongest sustained performance, the top three included Bone Care (University of Wisconsin license, pharmaceutical company), Affymetrix (University of California-Berkeley and Stanford licenses, biotechnology company), and Broad Com (University of New Mexico license, computer hardware company). All three companies sustained a 100-percent increase over the close price of day one for between 60 percent and 80 percent of the time through Dec. 31, 2003, and all three traded on that date 200 percent to 300 percent above the day-one close price. Although two of the three companies were not profitable at the time of the IPO (Broad Com being the exception), all had promising products and/or late-stage clinical trials nearing completion at the time of the IPO.

The majority of the companies in the dataset have not enjoyed the level of success described above. As Table 2 shows, the collective companies performed much more poorly than the NASDAQ Composite Index or the Amex Biotechnology Index. The life-sciences firms in the dataset have done especially poorly over the last three years. This finding provides further evidence of the high-risk nature of licensing primarily basic technologies from universities as well as the especially long product-development times required.

Considering that the issue of taking stock equity in firms is a significant one for technology transfer professionals, an exploratory investigation of its effects on post-IPO performance also was pursued. Some have suggested that universities that hold equity in a company may signal the marketplace that the institution is committed to the company's success,[11] a practice that, in turn, might stimulate greater investment in the company and a stock-appreciation benefit. To test this premise, the post-IPO stock price of companies in which universities held equity was compared with the post-IPO stock price of companies in which there was no university-held equity. One-year stock price differences between the two groups of companies that went public during 1996 and 1999 (a total of 67 companies) were explored. Choosing this period largely eliminated the economic slowdown that began in late 2000. Results indicated no significant differences between those companies with university-equity positions and those without them ($p=0.69$).

Discussion and Implications for Practice

Much was revealed in this first study of IPO companies that went public based in full or in part on a university-licensed technology. The specific issues of licensing locally vs. at a distance, licensing exclusivity, conflicts of interest, and stock-equity practices are discussed in light of the study results.

Local vs. National Licensing

A key finding of this study was that licensing activity is bifurcated. Universities are actively engaged in efforts to stimulate local and regional economic development while also seeking national opportunities. However, not all universities are located in regions friendly to new ventures such as the West Coast and Northeast. State governments nevertheless expect much from their research universities in terms of business incubation and university-industry partnerships. The results of this study provide evidence of the challenge in delivery, suggesting the need for greater state efforts at building environments friendly to start-ups. Such state efforts could include helping to attract venture-capital firms, allowing a portion of public university endowment resources for new-venture investment, and creating tax-structure incentives. Furthermore, universities might engage in greater partnering with other universities in their area in order to pool resources and/or leverage complementary competencies. Roundtable discussions at AUTM conferences led by universities located in states with strong in-state impact (see Table 1) would likely stimulate other useful ideas for fostering local economic development.

Licensing Exclusively

A second important finding of this study was that firms that obtained an exclusive license appeared to gain a small to moderate advantage with respect to reaching the IPO stage. However, absent carefully drafted contractual language, an exclusive license agreement may result in a university's technology being developed less quickly or within only limited fields of use. As such, vigilance in including milestone-achievement expectations in a license agreement is critical. Only some universities in this study appear to have done so, a finding in alignment with recent research.[12] Enforcing and/or proving breaches, however, is challenging, reinforced by a federal government that has almost never exercised its march-in rights to a federally financed technology. Thus, upfront attention to educating licensee companies on university public-trust responsibilities, insistence on explicit contract language, and company transparency related to the inspection of financial accounts and site-visit flexibility is important.

Conflicts of Interest

A noted finding of this study was that, in approximately one-third of the IPO firms, faculty inventors held an organizational position. However, because the role of faculty was unclear in many other IPO documents, this number is possibly higher. On the one hand, this finding is encouraging because faculty involvement in licensee companies can be of critical importance to technology development. On the other hand, serving in a company managerial role is often enormously time consuming and a practice likely to exceed the typical university one-day-per-week consulting rules. Thus, advancing new policy ideas to allow for such activity in a way that does not undermine the core missions of the institution would be useful. For example, policies that allow leaves of absence or that support commercial work during sabbaticals help legitimize such activities. Recognition for faculty patenting and licensing activity in promotion and tenure processes would also be beneficial. However, care should be exercised in balancing competing work demands.

The other conflict-of-interest-issue finding from this study was that careful protection of faculty publication rights without undue industry hindrance is not universally evident. Although further research is needed, there did appear to be much variance in how diligent universities were with this issue. A common rule of thumb on the rights of a company to delay publication to investigate possible proprietary opportunities is thirty to sixty days.[13] While these numbers appeared in some of the documents, they were absent in other ones. Furthermore, one-quarter of the documents that did reference publication rights appeared to give de facto veto power to the firm. Although it is possible that there are supplemental documents covering these issues more specifically that did not appear in the IPO documents, the finding is nevertheless troubling. Technology transfer professionals would be wise to borrow examples of good practice from colleagues around the country to include in their documents.

Stock-Equity Practices

The issue of stock-equity practices was a core focus of this study. As was described, companies in which universities hold equity are more likely to reach the IPO stage. However, such companies do not appear to derive post-IPO benefits from such relationships. Although more research is necessary, the results suggest certain implications. First, because accepting equity in lieu of upfront fees does make it more attractive to a young technology firm to license a technology, the continued selective use of this practice is wise. However, much more fundamental to the firm's success is its business plan, the competitiveness of the industry, the realistic time to product sales, and the company's ability to raise money. Technology transfer professionals may wish to investigate carefully these fundamental issues and should consider rejecting a licensing deal if a company's shortcomings warrant such a decision.

Second, care in structuring the equity deal is important. Some of the institutions in the IPO dataset with a long history of accepting equity provided great clarity in their equity terms and showed nuanced insight into the implications of potential later company acquisitions and mergers as well as stock-dilution possibilities. Furthermore, careful consideration of how involved a faculty member will be in conducting and presenting company-financed research in the future should also be weighed when deciding whether they should be allowed to own stock and under what circumstances.

Finally, assuming that equity will inevitably lead to substantial downstream payoffs can be speculative at best. Although the firms in this dataset, especially in biotechnology and pharmaceuticals, tended to have higher stock performances, some of which could be classified as blockbuster, there were as many huge failures as there were moderate successes. Timing the sale of stock is also critical. For example, universities holding stock in IPO companies with promising products but few sales and that are multiple years from profitability are more likely to experience an early stock-price gain at best followed by a long slide. As such, universities would be wise to consider either an early stock-sale exit or plan on holding the stock long term in the hopes of realizing the benefits of stock appreciation at some later point. Universities holding stock in IPO companies closer to profitability and that have a promising product, and when applicable, later-stage clinical trials, appear more likely to experience largely continual and longer-term upward stock-price appreciation after the IPO. As such, in these cases, it would be wise not to liquidate early. Holding a stock portfolio longer term, however, runs the risk of a stock-price decline due to many factors, including an economic slowdown such as occurred in late 2000.

While the equity implications described above are considerable, it is equally important to remember that, of the 181 IPOs studied, one-quarter of them had been acquired or merged and, thus, were not included in the post-IPO stock-price analysis. As an exit strategy, an acquisition or merger can be equally or more beneficial to stockholders than an IPO. Thus, universities would be wise to investigate the potential for a licensee to be acquired or merged and to be sure to consider this possibility when drafting contract language.

Conclusion

This study was the first to investigate the impact of university technology transfer licensing practices on downstream company performance, namely with IPOs. The insights offered regarding the university role in state and national economic growth, the current status and financial health of the IPO companies, the impact of licensing exclusivity, the potential conflict-of-interest issues, and the use of equity as a strategic facilitator should help inform practice and policy. More in-depth analyses of stock-price performance among university-affiliated IPOs, especially those following an acquisition, would also be useful for aiding practitioners in making decisions related to their stock-equity practices. In addition, further detailed analyses of university start-ups and IPO companies built upon university-based technologies could provide technology transfer officers with meaningful decision-making tools for the valuation of technologies and negotiation of licenses.

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Technology Licensing to Nontraditional Partners: Nonprofit Health Product Development Organizations for Better Global Health

Charles Gardner, Ph.D., and Cathy Garner, Ph.D.

Abstract

Commercialization of technologies arising from university research depends on the ability of technology managers to find and contract with appropriate development partners. New health-science technologies require substantial investment to bring them to the market. When such technologies appear to have limited commercial markets, it is often difficult for technology managers to find any licensee willing to invest research and development dollars in the technology. Developments in the area of *neglected diseases* may open up new opportunities for licensing. Over the past decade, The Rockefeller Foundation and other donors have provided social venture capital to launch a number of nonprofit "companies" that have now collectively raised more than $1 billion from philanthropic and government donors to support product development. These public-private partnerships (PPPs) support development of drugs, vaccines, and diagnostics to address diseases that predominantly afflict the poor, such as HIV/AIDS, tuberculosis, and malaria. Today, there are nearly a dozen such PPPs following business models, managing portfolios of candidate products (often in-licensed from academia), negotiating in-kind support from the private sector, or engaging industry through contract research and development, and using intellectual property in creative ways to harness private sector know-how while ensuring affordability and access. Academic research institutions have many functions,

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including educating the next generation of scientists, advancing and sharing knowledge, and, perhaps, even improving the world. Any technology manager who ever imagined there might be priorities beyond income generation should consider these nontraditional partners.

The Problem of Neglected Diseases

For diseases for which no market or only a small market exists,[1] investments in drug, vaccine, or diagnostics development may be difficult to recover. Private-sector pharmaceutical and biotechnology companies that wish to remain responsible to their shareholders cannot justify such upfront and high-risk investment. For this reason, in global health parlance, such diseases have come to be called *neglected diseases.*[2]

Neglected diseases primarily affect people in developing countries. Public research institutions in the industrialized world traditionally have not viewed these diseases as either a priority or as a major threat to their populations, and research-based companies do not pursue promising compounds or vaccines for these illnesses because of inadequate projected returns on investment.[3] Recent developments in bioterrorism and the rapid spread of SARS may have begun to change this situation for some neglected diseases.[4]

Developing countries themselves traditionally have not given high priority to investing their limited resources in health research. The lowest income countries have neither the scientific capability nor the manufacturing infrastructure to undertake self-provision.

Likewise, international development aid usually is focused on immediate health-service delivery and the provision of basic health care. While such initiatives are vital, the development of new treatments for neglected diseases is vital to address the high levels of morbidity that can inhibit individual and community advancement. New tools are needed to combat HIV/AIDS, tuberculosis (TB), and malaria, in particular.

This market failure results in 90 percent of the world's health research and development being directed toward solving the health problems of only 10 percent of the world's population (the wealthiest). This is often referred to as the *10-90 gap*, a glaring inequity that has mobilized philanthropic foundations and governments over the past decades. The Rockefeller Foundation was an early leader in this field.

The Rockefeller Foundation's Contribution to Health Equity

The Rockefeller Foundation's health-equity strategy derives from its broader mission to enrich and sustain the lives and livelihoods of poor and excluded people throughout the world. Tremendous advances in medicine have made it possible for all people to live longer, healthier lives. But the benefits of these advances are not distributed evenly. Poor people—in both poor and rich countries—are sicker and die younger. The Rockefeller Foundation's goal is to reduce avoidable and unfair differences in the health status of populations.

Throughout most of its ninety-year history, The Rockefeller Foundation focused on infectious disease research. By the mid-1990s, however, this area had attracted many donors. At the same time, many diseases remained for which no prevention measures existed (e.g., vaccines and microbicides to prevent HIV). Few new products were in the pipeline to treat malaria and TB. What products there were seemed unlikely to reach the people who most needed them, and the microbes themselves were rapidly evolving resistance to the best medicines.

These considerations influenced The Rockefeller Foundation's decision in the 1990s to shift further downstream and focus on product development. The Rockefeller Foundation also was motivated by the 10-90 gap. In an era of promising technological advances, emerging and re-emerging infectious diseases, and rising microbial resistance, empty pipelines for the poor were and are unacceptable.

To address the daunting gap between health technology haves and have-nots, The Rockefeller Foundation's new strategy was to seed the creation of a number of nonprofit public-private partnerships (PPPs) that take an entrepreneurial approach to developing products and making them accessible to poor people in developing countries. From the beginning, it was clear that this strategy was a necessary, but still insufficient, approach to improving global health equity. Other efforts within The Rockefeller Foundation, and by other donors and partners, would need to address access and capacity building.

The Rockefeller Foundation has supported the initial development of the International AIDS Vaccine Initiative, Medicines for Malaria Venture, Global Alliance for TB Drug Development, International Partnership for Microbicides, and Pediatric Dengue Vaccine Initiative. The Rockefeller

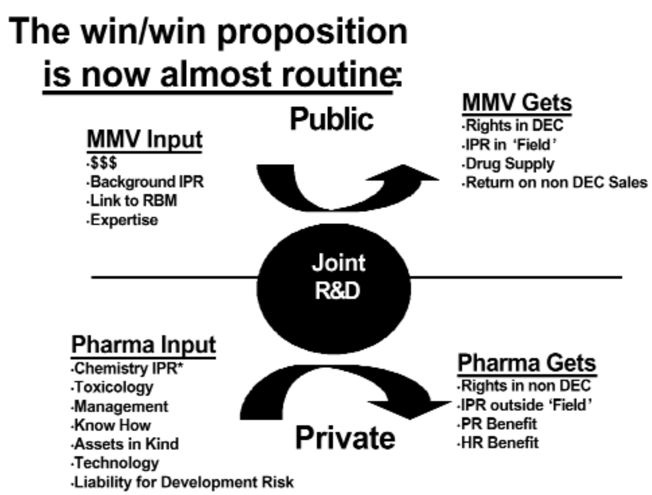
Foundation also launched two new organizations that focus on crosscutting issues: the Initiative on Public-Private Partnerships for Health and The Centre for the Management of Intellectual Property in Health Research and Development (MIHR).

The overall goal has been to expand existing product-development pipelines and accelerate the development of safe, effective, affordable, and accessible products that will reduce the burden of neglected diseases afflicting the poor. For most of these organizations, core funding now comes from other philanthropies and government donors.

To date, the five PPPs listed above have raised more than $500 million from government and philanthropic donors. The Bill & Melinda Gates Foundation and several European development agencies have been their greatest champions. Direct and in-kind support from industry is also significant.

Other product development PPPs have been created as well, including the Aeras Global TB Vaccine Foundation, Malaria Vaccine Initiative, Drugs for Neglected Diseases Initiative, and the Foundation for Innovative New Diagnostics. The field as a whole has attracted more than $1.1 billion from a variety of donors.[5]

These PPPs orchestrate a delicate balance of contributions and outputs that can be illustrated in the figure below provided by the Medicines for Malaria Venture, a product-development PPP based in Geneva, Switzerland.



The Medicines for Malaria Venture, representing the public sector, invests cash and provides background intellectual property that it has sourced, as well as expertise, and links to multilateral efforts such as Roll Back Malaria. In return, it retains all rights for the drug's use in developing countries, intellectual property rights in the field of malaria, and royalties on the drug sold in nondeveloping countries. Its ultimate goal is to develop affordable new antimalarial drugs to overcome growing drug resistance in disease-endemic countries.

The private sector (pharmaceutical companies) contribute their specialist drug-development expertise to the partnership and bear liability for risks in development. As part of the return for these inputs and risks, the company retains the right to sell the drug in developed countries and intellectual property rights for fields of use beyond malaria. In addition, the company is likely to gain a positive public image from such work as well as greater commitment and retention of its work force. In an ideal partnership, both sides win and deliver much-needed medicines to people in developing countries, an outcome that neither party could have achieved without the other.

PPPs as Potential Licensees for University Intellectual Property

All of the PPPs have licensed some technologies from universities into their development portfolios, yet many technology managers still may not be aware of these organizations. One additional challenge is that PPPs, with a focus on social good, are not able to provide major royalty or equity deals. But because most of the technologies they seek to develop have little commercial potential, there are few (if any) opportunity costs to any university that enters into a licensing arrangement of this kind.

Universities have a mission for public good that must be balanced against their need to see an economic return from licensing their intellectual property. The PPPs provide a route to ensure the development of technologies that might otherwise be consigned to the laboratory shelf, with the added advantage that such technologies may begin to make a difference in health outcomes for the world's poorest people—1.2 billion of whom live on less than $1 per day. The following case studies illustrate the potential for university licensing to product development PPPs and other similar organizations.[6]

Combating Chagas' Disease

Researchers at Yale University and the University of Washington developed a class of antifungal compounds called azoles that are useful in eradicating the parasite *Trypanosoma cruzi. T. cruzi* is the etiologic agent of Chagas' disease, which is commonly found in 21 Central and South American countries.

Problem

While the azole antifungal compounds potentially could address a large market in industrialized countries as a commercial product to treat fungal infections, the application for Chagas' disease addresses one of the world's neglected diseases. Chagas' disease disproportionately afflicts the poorest in Latin America, as the parasite lives in the mud floors of homes. Approximately 16 million to 18 million people in Latin America are currently afflicted with Chagas' disease, and 50,000 of those afflicted die every year. At present there is neither a vaccine nor a drug recommended to prevent Chagas' disease. Treatment is possible only in the early stages of the disease; once the disease has moved into its chronic stage, the only option is to manage the symptoms. Until housing improvements are made, those who live in mud, adobe, and thatched homes (the poorest) are most at risk.

Solution

The university licensors located and approached the Institute for One World Health in San Francisco to develop these compounds for the benefit of lower income populations of South and Central America. The licensing agreement created a dual-market opportunity in which the universities are also able to partner with pharmaceutical companies to develop antifungal agents for markets in industrialized countries. One World Health acts as a virtual pharmaceutical company and specializes in teaching and implementing good manufacturing practices and clinical-trial methodologies in developing country markets.

Monitoring HIV in Remote Areas

Researchers from Massachusetts General Hospital working in collaboration with scientists at another institution have invented a portable device that can monitor immune-cell levels. Finding an inexpensive and practical way to diagnose and monitor HIV infection in remote locations has been one of the biggest scientific challenges to emerge from the global AIDS crisis.

Problem

The device is in the prototype stage and requires further funding for development of a handheld device that a relatively untrained person could use in the field to test HIV-infected patients in minutes. Traditional funding sources, such as the National Institutes of Health, do not typically fund commercialization efforts. Working with a commercial partner might jeopardize the goal of providing this device to people in resource-poor countries.

A charitable foundation was interested in funding this project and obtained from Massachusetts General Hospital a nonexclusive license limited to a territory including only selected resource-poor countries. However, the terms of this nonexclusive license granted rights to use the technology for defined commercial applications as well as the right to sublicense, without the approval of, or notice to, the licensor.

A new invention was developed with funding provided by the charitable foundation, and Massachusetts General Hospital began to market it to conventional businesses. However, prospective licensees objected to the licensor's inability to grant an exclusive license for commercial use of the technology. In other words, the nonexclusive license that had been granted to the funding organization was threatening the possibility of also concluding a commercial deal.

Solution

The technology transfer officers at Massachusetts General Hospital negotiated an amendment to the license agreement with the charitable funding organization whereby the organization agreed that it would assign its nonexclusive commercial license to a Massachusetts General Hospital licensee provided that the licensee agreed to accommodate the charitable objectives of the funding organization in resource-poor countries within a reasonable length of time. This was a solution that the prospective licensee could accept. The use of such a clause ensures that the inventors can attain the original goals and that commercial returns outside the field of HIV can also be gained.

Seeking New Approaches to TB Treatment

Researchers at Harvard University have developed an aerosol technology that significantly advances the science of pulmonary drug delivery and shows particular promise in the field of TB. This invention may overcome certain drawbacks of existing TB therapies.

Problem

Although drugs do exist for the treatment of TB, key limitations of these treatments include duration of treatment, side effects, and difficulties of drug administration, all of which contribute to the problem of emerging drug resistance. TB infects more people today than at any other time in human history and claims about 2 million lives each year.

Solution

As part of a course offered by Harvard's engineering school, a nonprofit corporation called MEND (MEdicine in NeeD) was formed and has obtained an option to the aerosol technology from Harvard. MEND plans to leverage its intellectual property position and the technical know-how of its founders to attract individual donations, foundation money, and federal awards to support its development programs. Because the proprietary technology that MEND has optioned will have applications beyond TB, MEND may explore strategic public-private partnerships to secure additional investment, support, and/or resources.

Can Such Strategies Deliver?

It is too early to gauge the ultimate success of the PPP model. The model will be judged to be successful if and when a new product is proven safe and effective—a product that would not otherwise have been developed through the traditional risk-capital model pursued in major pharmaceutical companies. However, some interesting interim output indicators are available.

First and foremost, the product-development PPPs have attracted substantial investment from a wide variety of donors. They also have acquired significant portfolios of candidate products and have expanded significantly global pipelines of candidate products for their respective diseases.[7] Further, analyses indicate that products can be developed faster via the PPP model and at a lower total cost than expected based on industry norms.[8] In industry, development cycles for drugs and vaccines are longer than any of these organizations have yet existed, but there are some hopeful signs from some of the partnerships that have been longer established.

Malaria Treatment: Medicines for Malaria Venture

One child dies every three minutes from malaria today, and the parasite is rapidly developing resistance to frontline drugs. Multidrug combinations can be used to combat and prevent such drug resistance, but such treatments are usually more expensive than treatments using a single drug. Chlorproguanil-dapsone-artesunate, or Lapdap, is a fixed-ratio, oral, three-drug combination used to treat uncomplicated *Plasmodium falciparum*, the parasite that causes the the most dangerous form of malaria. It is the brainchild of Bill Watkins, Ph.D., at Wellcome Trust Laboratory in Nairobi and Professor Peter Winstanley at the University of Liverpool in the United Kingdom. The drug, approved in July 2003, has been brought to market by a PPP involving Wellcome Trust, GlaxoSmithKline, the World Health Organization, the Department for International Development in the United Kingdom, Liverpool University School of Tropical Medicine, the London School of Hygiene and Tropical Medicine, and African researchers. Governments can purchase Lapdap for about five cents per course of treatment for a child (compared to ten cents per treatment for chloroquine and forty cents to ninety cents per child using artemisinin-based combination therapy).[9] Lapdap will be commercialized by Medicines for Malaria Venture.

Designing a Better, Faster Treatment for TB: The Global Alliance for TB Drug Development

Because research and development efforts for new TB drugs came to a virtual standstill after the 1960s, TB treatment relies on drugs that are up to fifty years old. Given the shortcomings of such drugs, the international treatment standard imposes a six- to nine-month course of treatment and requires health professionals to observe patients taking their medications for the majority of the treatment course. This lengthy, complex regimen makes compliance difficult for patients and places enormous burdens on health-care workers and systems. Moreover, the rise of drug resistance and the convergence of the TB and HIV epidemics increase the urgency for development of better, faster acting therapeutics for TB. Global TB control targets—particularly the Millennium Development Goal of halting and reversing TB by 2015—are now in jeopardy. The goal of the Global Alliance for TB Drug Development, based in New York, is to develop new drugs that reduce the course of treatment to two months or less, overcome drug-resistant strains, and effectively treat latent TB. Since its creation in 2000, the TB Alliance has acquired and now manages a portfolio of ten candidate TB drugs, half of which originated from university-based research. Present plans are to have a lead drug candidate in human testing within the year.

These examples show that universities can play a vital role in the identification of potential new drug candidates and in their ongoing development to ensure that such products can be made available for those most in need. Most of the product-development PPPs have clear intellectual property policies which reserve certain rights for the poor—be that differential pricing of products or conditions of access for specific groups of countries.[10]

Technology Managers for Global Health

Technology managers have heavy caseloads, and technology licensing offices have strong networks of existing potential licensees. Therefore, information about the PPPs and their roles needs to be easily accessible. This need, together with the awareness of major global health problems, prompted the establishment of a AUTM Special Interest Group—Technology Managers for Global Health—which met for the first time in 2004.[11]

This group of volunteers has begun to gather a tool kit of ideal licensing practices in this field, based on real experiences, and to develop a catalogue of organizations that focus on neglected diseases. As it becomes more established, TMGH will continue to attract more members and develop new approaches, best practices, and strategies to put consideration of licensing options for global health on the map for technology management offices in the industrialized world.[12,13]

The formation of TMGH within AUTM has been supported by MIHR,

which was established by The Rockefeller Foundation in the fall of 2002 as a not-for-profit global organization (headquartered in the United Kingdom), "in the belief that improved management of intellectual property by the public sector is one way to achieve the goal of improving availability of health products needed in developing countries by the poor."[14] MIHR's focus is four-fold. It is

- building capacity in publicly funded research institutions in developing countries so that they can enter into sound public-private partnerships of their own—partnerships that may promote global health through the development of locally appropriate technologies linked to low-cost local manufacture,
- working with AUTM and other organizations to help technology management offices in industrialized countries understand how their institutional policies and practices can have a positive impact on global health,
- conducting research on intellectual property management practices and sharing best practices that are relevant to both developed and developing countries through *Handbook of Best Practices for Management of Intellectual Property in Health Research and Development*[15] and through its participation in various global fora, and
- seeking to develop information-management tools that can assist those with technologies that could make a difference to global health.

Conclusion

The new nontraditional partners for technology managers to consider are PPPs in at least three senses: (1) they apply business models in pursuit of public health goals; (2) they receive support from governments, philanthropic institutions and individuals, and industry; and (3) at the level of individual projects, they often catalyze and support true public-private R&D partnerships (such as university-industry agreements).

These nontraditional partners assemble and manage portfolios of candidate products to increase their chances of success in finding some that will be safe and effective. They apply business-management practices to speed the development of products for neglected diseases through preclinical and clinical testing, manufacture, and distribution. And they chart new waters in the creative use of intellectual property to engage private and public sector know-how in the R&D process and ensure that their products are ultimately affordable and accessible to the poor.

These organizations are potential licensors of university-based technologies and can make certain that product development is directed toward those most in need. When a faculty member at an institution has a lead that may have applications for global health, the institution's technology managers have at least two options: (1) if the technology appears to have a commercial market, the technology manager may consider nonexclusive dual-market licenses that would allow the product to be developed by a PPP for use in developing countries for specific neglected disease indications while a profit-oriented licensee pursues financial gain in commercial markets or (2) if the technology has no commercial market at all, then product development PPPs may be the only available option to keep that technology off the shelf and in development to make the world a better place.

According to the Initiative on Public-Private Partnerships for Health, there may now be as many as 25 product development PPPs. Only those that are global, autonomous, and that take a portfolio approach to product development are listed below.[16]

- Program for Appropriate Technology in Health
  http://www.path.org
- International AIDS Vaccine Initiative
  http://www.iavi.org
- Medicines for Malaria Venture
  http://www.mmv.org
- Malaria Vaccine Initiative
  http://www.malariavaccine.org
- Global Alliance for TB Drug Development
  http://www.tballiance.org
- Aeras Global TB Vaccine Foundation
  http://aeras.org
- International Partnership for Microbicides
  http://www.ipm-microbicides.org
- Pediatric Dengue Vaccine Initiative
  http://www.pdvi.org
- Foundation for Innovative New Diagnostics
  http://www.finddiagnostics.org

- Institute for One World Health
  http://www.oneworldhealth.org
- Drugs for Neglected Diseases Initiative
  http://www.dndi.org

To learn more about MIHR, visit the web site at http://www.mihr.org.

Notes

1. Where a small market exists, the term *orphan disease* may be more common. *Neglected diseases* are typified by their occurrence amongst larger numbers of people who cannot afford treatment even if a product is developed, and who, therefore, tend to have little voice in the global marketplace.
2. Medecins Sans Frontieres Access to Essential Medicines and the Drugs for Neglected Diseases Working Group. *Fatal Imbalance—The Crisis in Research and Development for Neglected Diseases.* Geneva: 2001.
3. Ibid.
4. Note the emergence of specific programs to address issues of smallpox, Ebola, and Anthrax, for example. Under the Bioshield Initiative, research has increased from $53 million to $1.6 billion and includes genomic sequencing of bacteria and protozoan pathogens. The recognition that bioterrorism has no boundaries draws increased attention to disease wherever it occurs.
5. A. Sander and R. Widdus, "The Emerging Landscape of Public-Private Partnerships for Product Development." A report prepared for a workshop on Combating Diseases Associated with Poverty: Financing Strategies for Product Development and the Potential Role of Public-Private Partnerships, London, April 2004.
6. The examples given here come from examples collected by H. Foskett, Harvard University; R. Menapace; and S. Shah Basu, Massachusetts General Hospital and displayed at the AUTM Annual Conference, San Antonio, March 2004.
7. Boston Consulting Group, "Interim Evaluation of Harnessing the New Sciences, Final Report," prepared for The Rockefeller Foundation, Nov. 24, 2003.

8. Towse et al., OHE Consulting, "Estimates of the Medium-Term Resource Needs for Development of Pharmaceuticals for Neglected Diseases." Paper presented to IPPPH Workshop, London, April 2004. Table 7 demonstrated for a number of PPPs that the out-of-pocket costs would be less than half the estimate for a traditional pharmaceutical company as estimated by Di Masi *(Journal of Health Economics)*.
9. Source: *Malaria Facts and Figures*, Medicins Sans Frontieres.
10. See, for example, http://www.mmv.org and http://www.iavi.org.
11. TMGH was established following a Gordon Conference on technology transfer in 2003.
12. M. C. Freire, "Technology Transfer's Next Frontier: Global Health as a New Bottom Line," *Journal of the Association of University Technology Managers* 14(2002): 1–5.
13. L. Nelsen, "The Role of Universities in Assuring Access in Developing Countries," *Yale Journal of Health Policy, Law, and Ethics* 3(2003): 302–308.
14. See http://www.mihr.org.
15. Centre for Management of Intellectual Property in Health Research and Development, *Handbook of Best Practices for Management of Intellectual Property in Health Research and Development*, ed. R. Mahoney (Oxford, England: MIHR).
16. Visit http://www.ippph.org's partnership database for a complete listing of product development PPPs.

Measuring the Impact of University Technology Transfer: A Guide to Methodologies, Data Needs, and Sources

Robert A. Lowe, Ph.D., and Suzanne K. Quick, Ph.D.

Abstract

This paper discusses measures that capture the impact of university technology transfer activities on a university's local and regional economies *(economic impact)*. Such assessments are of increasing interest to policymakers, researchers, and technology transfer professionals, yet there have been few published discussions of the merits of various measures. The bottom line is that no single measure can capture the many aspects of technology transfer; rather, any assessment of the impact of technology transfer on local and regional economies must be discussed with regard to several measures. Two constructs are offered for assessing the impact of university technology transfer on local and regional economies: direct vs. indirect impacts and benchmarking analysis against a proper counterfactual. This paper also discusses, as an example, a project at the University of California that aims to develop an information infrastructure that can be used in the future to provide data to support the types of assessments discussed in this paper.

Introduction

The modern university plays an integral role in local, regional, and national economies, and the nature of that role has increasingly come under close scrutiny.[1] The evolution of universities in the last two decades has been particularly evident in the growth of university technology transfer activities, that is, patenting and licensing operations designed to move inventions out of university laboratories and into development, and, ultimately, commercialization. With the growing size and scope of university-industry relations

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and technology transfer activities, policymakers, members of the news media, university officials, and academic scholars have paid considerable attention to economic impact in the years following passage of the Bayh-Dole Act.

While one could consider economic impact in terms of impact on a national economy,[2] those people who are interested in university technology transfer often raise questions regarding the impact of universities on the local and regional economy. Consequently, local and regional economies are the focus of this paper, and economic impact is defined as the specific outcomes resulting from technology transfer activities that lead to increased wealth and prosperity for the region in which the university is located. This definition is consistent with previous publications in this area.[3, 4, 5]

Specifically, two questions are commonly asked:

- How much impact does university technology transfer have on the local and regional economy?
- How has this impact changed over time in scope, size, and type?

In spite of the importance of these issues for the technology transfer profession, a search for prior published studies analyzing and debating measures of the economic impact of technology transfer yielded surprisingly few results. A number of annual reports from various universities were reviewed to identify common themes in how technology transfer offices discuss their economic impact. Of critical note is an excellent review, albeit unpublished, of the state of the art in measuring the economic impact of university technology transfer by Ashley Stevens.[6]

Kramer, et al., defines the economic impact from commercialized products as follows: "Postcommercialization, the economic impact can be considered to be associated with the sales revenue generated by such products. Postcommercialization economic impact can be estimated through the royalty revenues generated by licenses to university technologies."[4]

In Stevens' review in the same year, he notes similar methodology as state of the art.[6] Pressman and colleagues,[3] as well as Kramer and colleagues,[4] and others have examined an important aspect: *preproduction investment* at their respective institutions, as detailed later in this paper. It is striking that the methods and approaches in Stevens' review[6] and those described by Pressman, et al.,[3] continue to be the state of the art in 2004. However, each of these papers recognizes that technology transfer contributes to local and regional economies in a variety of ways not proportionately associated with royalties generated. That is, economic impact is more than a multiplier of royalties generated.

This paper reviews a range of methodologies that researchers can use to assess the economic impact of university technology transfer. The purpose of this paper is twofold. First, there is value in codifying in a published format the many avenues through which technology transfer impacts a university's local and regional economy. In discussing each, this paper contributes to the collective dialogue of what might be kept in mind as universities and policy analysts conduct economic impact analyses. Second, the authors intend to spur creative thinking regarding data-collection strategies and methods to get at these issues. As an example, this paper describes a project at the University of California that was undertaken to assure data would be available to support different types of economic-impact assessment. No one measure will capture the many aspects of technology transfer. Presenting multiple analyses together provides a more holistic and more nearly accurate approach to understanding the overall economic impact of technology transfer.

There are two conceptual considerations that are critical to assessments of economic impact. First, it is important to distinguish between direct and indirect impacts. Direct impacts—such as students entering the labor force or the number of patents issued—are intended, direct consequences of university activity. Indirect impacts are akin to externalities. These outcomes are unintended but result from some university activity nonetheless. An example of an indirect impact is knowledge dissemination that occurs outside of, but concurrent with, formal technology transfer contracts. This latter category, while more difficult to quantify, addresses important technology transfer impacts not captured in more standard measures.

Second, any analysis of technology transfer activities requires carefully choosing a counterfactual simulation against which to benchmark the analysis. In other words, it is important to consider what would have occurred had the university not been involved in a given aspect of technology transfer activity. Why is this important? Every university licensing transaction can be defined as an investment of limited resources—financial, human capital, and otherwise—among a choice of alternative investments for the resources. As a simplistic example, a licensing officer may choose to work on assisting one start-up this month or choose to spend her time executing a number of material transfer agreements during the same period. The *counterfactual method* of examining economic impact forces a more thorough benefit-cost analysis by asking, for example, What did licensing to a particular firm accomplish with the university resources used that would not have been accomplished with other alternatives (licensing to a different firm or type of firm or, perhaps, not licensing at all but allowing the technology to be published openly)? In other words, the counterfactual method better determines the true cost of resources used to license an invention by examining the opportunity cost or second-best use of these resources.

The counterfactual method also illustrates that proper answers to these types of questions are not based on counts of firms started, total licensing revenue, or number of employees working on university technologies without additional context.

The paper is structured as follows. The next section places the economic impact of technology transfer in the context of broader university missions. The third section, "Measures of Economic Impact," lists a series of methods that help assess the economic impact of university technology transfer. The fourth section, "The StartUpView Project," describes a representative project at the University of California to develop data infrastructure and processes to perform some of the economic impact analyses described in the third section. Finally, the last section concludes.

Economic Impact Analysis and the Broader Mission of the University

This paper focuses on using measures of economic impact to assess the benefits of university technology transfer activity. It is recognized, however, that universities are chartered with other missions, such as educating students and enhancing society's general knowledge base. Indeed, this point speaks to the lack of consensus regarding a methodology for assessing overall impact of academic institutions in general. Many would argue (and with a good deal of merit), that traditional economic analyses are not appropriate to use in assessing the broader goals of the higher-education system. For example, one cannot simply write down a production function for the university, given inputs such as labor and capital, because many of the university's outputs are both difficult to measure and cannot be fully quantified in a meaningful way.

Technology transfer offices support these broader educational, research, and public-service missions of the university. As a result, economic impact is merely one factor in assessing the overall impact of a technology transfer office, albeit a factor that is widely discussed. Hence, the methodologies and data discussed below focus on economic impacts and are not complete examinations of the overall impact of the modern university on society.

Measures of Economic Impact

This section provides a synthesis of methods and measures that can be used to capture various aspects of the economic impact of university technology transfer. Several of the measures have considerable overlap and are not mutually exclusive. Thus, they cannot be added together to capture one bottom-line impact amount.

As mentioned in the introduction, there are few published studies that discuss specific methods for measuring the economic impact of technology transfer. However, there are numerous university annual reports that reference one or more of the measures presented in this section. Individual studies are cited as examples of various methods, but many of the methods are synthesized across a number of annual reports, and, in some cases, citing any one or even a few reports would not be appropriate. It is also important to recognize that no one method is right or wrong, but one needs the vantage point of examining economic impact from a number of different angles to build a more complete analysis. This synthesis is based, in part, on the authors' experiences with efforts to assess economic impacts of the University of California and other universities, as well as a review of technology transfer office annual reports and related publications.

Employment Impact

Many previous studies focus on employment impact as the most direct consequence of technology transfer activities. Employment impact is typically defined as an aggregate estimate of all jobs created by or related to technology transfer activities. The final sums can be calculated as either population counts (total number of persons employed) or dollar amounts (such as population times average salaries).

Added employment stems from several sources related to university licensing. First, jobs created by new firms (founded on university-patented technologies) are a major source of added employment. Second, university licenses to established firms create jobs in the industrial scientific community to further develop and commercialize the licensed technology. Technology transfer offices and related administrative groups, of course, also add employment in the region.

There is a secondary level of employment growth attributed to jobs created to supply university licensees with goods and services. For example, a pharmaceutical development firm founded on a university invention may need local suppliers to provide chemicals to the firm and additional development services. This may lead to a new chemical supply company being founded locally or an existing chemicals company deciding to open a local office or increase the size of an already existing local office. This secondary level also includes added jobs in service sectors, such as restaurants, housing construction, and the like, that result from employment growth in the region. These jobs are difficult to measure directly and to attribute to technology transfer activities. To measure the secondary level of impact, a multiplier relating the number of new jobs created (under the primary level) and an associated number of suppliers and retailers is needed.

The challenge is to estimate the overall number of jobs created for a given invention. In an ideal world, periodic surveys would be conducted. However, the expectation that this method will be used is often unrealistic, although start-up companies provide an opportunity to gather more well-defined employment data and gathering such data can be required as part of the annual reporting of milestones included in license agreements. Another approach is to make assumptions regarding the number of jobs per royalty dollar received, with adjustments for industry and other factors.[7] To be sure, such an assessment provides only rough estimates of the impact of university technology transfer, but it still provides more useful data than do simple counts.

A challenge in examining job creation is to separate added employment growth due to technology transfer activities from employment substitution. A licensor may assign an employee to work on developing the licensed technology while leaving other projects unfinished. Similarly, only net change in jobs can be measured. However, an important, but often overlooked, counterfactual are those jobs that would have otherwise moved but were retained locally by economic growth.[6] This process does not lead to directly observable job creation in the absolute growth in the number of jobs, but it does imply an important economic impact because employers would not assign employees to a new project (that is, a licensed technology) unless that project had a higher expected net benefit to the firm.

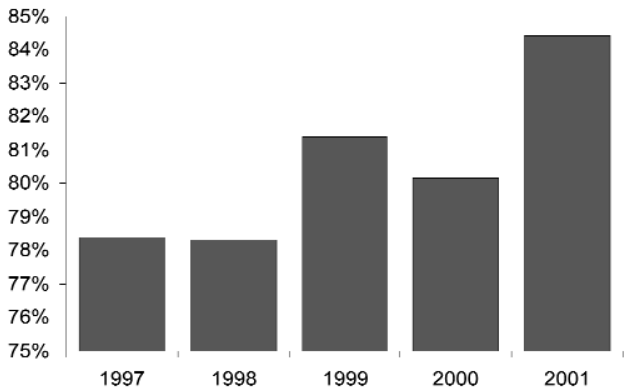
New Firm Development

One of the most visible outputs of university technology transfer practices is the number of new firms founded with university inventions as their platform technology. The majority of annual reports that were reviewed on university technology transfer equate new firm development with economic impact. These studies are motivated by the recognition that university-based start-ups, particularly founded by faculty and graduate students, bring considerable resources such as new employment and human capital to the region.

Such analysis is predicated on a belief in the localized nature of university start-ups. This belief is well-founded. In California, a number of university start-ups are located in technological hotbeds near major research universities, such as San Diego, San Francisco and the East Bay, and, of course, Silicon Valley. None of this is surprising, and this observation alone does not provide sufficient evidence to support the belief that university start-ups are inherently localized; a number of other market and institutional factors could easily explain these founding patterns. However, there also are technology sectors in Irvine, Santa Barbara, and Davis where start-ups from those respective University of California campuses have been founded. As illustrated in Figure 1, the *AUTM Licensing Survey™* data indicate that more than 75 percent of start-ups are founded in the same state as their licensing university. The latter evidence is stronger, but clearly much more work is needed to understand that rate and the nature of start-ups that locate near their respective universities.

Previous assessments of the economic impact of start-ups include raw counts of firms founded, patents licensed by start-ups, employees hired by new firms (discussed above), and investment capital attracted to the region via new firms (discussed below). Assessments of new firm creation face challenges similar to those faced by measures of added employment. Given a firm founded on technology licensed from a university, it is difficult to

Figure 1
Share of Start-ups Founded in Same State/Province as Licensing University, U.S. and Canada



claim that technology transfer operations were the critical catalyst simply because it is difficult without more detailed data to disprove the counterfactual: that a technology would not have been ultimately commercialized in the absence of a technology transfer office assisting a start-up firm. It is only by assumption that the activities of a technology transfer office are considered critical to founding a firm. While this caveat should not deter analysis, it suggests that any results should be treated with caution.

At least two methods of analysis would provide information regarding this issue. First, detailed case studies are appropriate to establish individual cases in which a technology might not have been licensed without the involvement of the university.[8] Secondly, broader comparisons might be made by examining patterns of start-ups licensing. Examining whether and when start-ups licensed technologies that failed to interest larger companies and determining whether and when established firms failed to commercialize the technology and terminated their license will be useful for this type of assessment. Specifically, one can utilize data included in secrecy agreements and terminated licenses to evaluate cases in which commercialization of a technology appears unlikely without additional effort by the inventor and the technology transfer office.

Investment Initiation

A third recognized area of economic impact is the amount of financial capital that is attracted to the region to develop university technologies. The title of this section is investment initiation because the goal is to capture data regarding financial investment that is induced by technology transfer activities.

Preproduction Investment

A study by Pressman, et al.,[3] at the Massachusetts Institute of Technology (MIT) noted that an important area of economic impact, particularly with respect to start-up firms, is the considerable investment capital needed to develop university inventions. This point is particularly salient for the present discussion because many inventions are in a very early development stage at the time of licensing.[9] The MIT methodology complements the analyses discussed in the previous subsection, which primarily measure final outcomes but underestimate the true investment devoted to developing and commercializing university inventions.[3]

Pressman, et al., estimate the preproduction investment, or financial investments, made to further develop licensed technologies up to the point of product commercialization.[3] Data on preproduction investment were obtained through written and phone surveys of licensees as well as financial statements from a sample of licensees. The sample was stratified to captured licensees in both biotechnology and the physical sciences.

To estimate the overall investment brought about by MIT licenses, the survey results of total investment per license were used to estimate the investment per year that the license was active under assumption of a uniform distribution for those years. That is, a $4-million investment on a license that has been active for four years is estimated to be a $1-million annual investment. This figure is then multiplied by the total number of active license years for all comparable (same technology class and licensing terms[10]) MIT licenses. The authors conclude that every dollar in licensing revenue is associated with $24 of induced investment. The challenge for technology transfer offices analyzing the economic impact of operations is to make the case that such investment is localized thanks, in part, to the process of technology transfer. That is, an important counterfactual that enters this analysis is: How much of the induced investment would not have been local if the university technology transfer office was not involved?

University Reinvestment

University reinvestment describes the extent to which university licensees contribute back to the university as a result of previous licensing relationships. These monies are potentially quite important in meeting the broader missions of the university. For example, such funds may be designated to support further research related to the licensed technology, or, if there are no restrictions on their use, may be allocated to academic areas that traditionally do not receive substantial funding. Moreover, university reinvestment captures a component of the return on investment for funding the activities of a licensing office.

The scope of university reinvestment by start-ups is clearly reflected in the experience of Calimetrics, a company founded in 1994 to develop optical data storage technology licensed from UC Berkeley. In its early years, the company recognized the need for further development of the technology and drew upon the substantial intellectual resources available in the local area. Calimetrics initially negotiated research agreements with and hired researchers from local institutions, including Stanford, UC Berkeley, and Lawrence Berkeley Labs.[11]

Calimetrics' continued relationship with the university community represents a common practice among university start-ups. A recent report from the University of California at Irvine indicates that companies founded on UC Irvine technologies not only generated more than $5.2 million in royalty income for the university but also contributed $13.5 million in research funding over time.[12]

While these experiences illustrate that start-ups do continue to reinvest in local universities, it is also important to note that, as these firms prosper and evolve, they may well seek additional collaborations with universities outside their local area. In Calimetrics' case, as the firm's development projects progressed, substantial funding was secured through a National Institute of Standards and Technology ATP Award in which Calimentrics chose to collaborate with researchers at Georgia Tech and the University of Arizona. As one of Calimetrics' founders explained: "When you're first starting out, you're dependent on the local roots of the company, but once we got the technology to a certain level, our aspirations for suppliers became global, and we scoured the world for individuals with world-class expertise in this industry."

Measures of university reinvestment can be obtained from donation, gift, and research-grant data collected at foundation offices, contracts and grants offices, and campus accounting offices. Additionally, hiring of graduate students offers another measure of indirect reinvestment; these data may be collected from specific university departments that maintain records on graduate placement.

Regional Spillovers and Knowledge Flows

Several academic studies have focused on regional *spillovers*, or the process of university knowledge disseminating through the surrounding area. These spillovers best represent the concept of indirect impact referred to earlier in this paper. Knowledge resulting from both university research and related development may benefit other companies in the region, even if they were not part of the original sponsored research or license agreement.

Knowledge spillovers have been captured in several studies as joint publications between university faculty and local companies' scientists[13] and patent cross-citations.[14] These analyses are interested in understanding in general how geographically localized to the campus the flow of knowledge out of the university actually is. Knowledge flows may be local, it is believed, due to the need for close contact between the university inventor and company scientists when that knowledge is particularly tacit.[15]

Analysis in this area often examines the geographic distance between the university and the location of assignees for patents citing a given university patent. While an imperfect or *noisy* measure, patent citations do represent some proportion of the knowledge flows between university scientists and firms working in related areas. In addition, examining the identity and location of firms citing university patents, or corporate scientists publishing journal articles that cite university journal articles, offers a sense of real or potential collaborative ties between local firms and the university.

Such analysis strongly predicts the likelihood of a technology being licensed or not, as well as what type of firm will license the technology: inventor-founded start-up, a start-up with no inventor involvement, or an established firm.[8]

Data for this type of research may be obtained from public sources, such as journal citation indices and patent databases, or can be acquired directly from companies. Little additional data collection for these types of studies may be necessary on the part of the university. Moreover, while much academic research has focused on this issue, there are shortcomings that the university may be able to address. The mechanisms of knowledge transfer, whether through licensing, consulting, hiring graduate students, etc., have yet to be fully explored. A technology transfer office can offer supplemental data and case studies or interviews with licensees. Hence, the university may contribute to this effort by collecting data on which faculty and graduate students are formally linked to companies. Firms founded by faculty and students, as mentioned above, provide one possible data set. Additionally, consulting relationships, corporate funding for research, and graduate work-study and fellowships indicate another set of relationships that, when linked to research and products by funding companies, can be used to describe the mechanisms of knowledge transfer from university researchers to the public.

The StartUpView Project

In recognition of the importance of start-ups in understanding the impact of technology transfer efforts of a university, in 1999 the systemwide Office of Technology Transfer at the nine-campus University of California undertook a two-year effort to build a database of the University of California's licensee start-ups, develop query applications so that these data may be accessed, and institute a process to continue collecting data on start-up licensees. Although the university now draws heavily on the data maintained within this database to document the scope and pattern of university start-up activity, prior to the initiation of the StartUpView project, the university had never tracked its start-up activity and was unable to identify the contribution made by this significant aspect of its technology transfer program. This section offers the StartUpView project as one illustration of infrastructure and data systems to facilitate several of the types of economic impact analysis described earlier in the paper.

StartUpView is a database that captures the history and ongoing operations of licensee firms founded on University of California technology. The database includes information on the founders (names, contact information, and whether they were a named inventor on intellectual property related to the licensed technology), the company location (miles from a University of California campus, address), technology (invention, company's general line of business, and products, where available), and company performance (sales, employee count).

Much of this information is available publicly, although some data were obtained directly from the company or from patent and licensing records. Because there is confidential information included in the database, access to certain data fields in StartUpView is restricted, whereas information in other fields is made available to a broad audience.

Data collection for such a system presents two challenges: collecting retrospective data and creating a robust process for capturing data going forward. To identify previous start-ups, licensing officers were first interviewed to create a list of companies. This list was then checked by calling each company or, in some cases, inventors (for companies that no longer existed) to verify the status (start-up or not) at the time of licensing and to categorize whether the University of California technology was the platform technology upon which the company was founded (or merely ancillary to the decision to found a firm). Once the licensee start-ups were identified, additional research was conducted to collect information about the firm's location, performance, technologies, and ongoing relationship with the university. A partial list of the data included in the StartUpView project, plus an example of data, is displayed in Figure 2.

Finally, an annual process was established to ensure that consistent, accurate data would be collected going forward. The process included codifying both procedures and data sources for each data field in the database. Because some data can be collected at the time of signing a license agreement with a start-up, licensing officers became an ongoing, critical source of information for the database. This task included extending and customizing current technology transfer office database systems, as well as establishing carefully detailed training documents for future employees to follow in collecting data on characteristics and performance of start-up firms. With this database in place, the University of California is in a far better position to enable the types of analyses discussed in the earlier sections of this paper.

Figure 2

Sample of Data Maintained in StartUpView

Data Category	Field Name	Sample Data
Company ownership history	Common Name	Berkeley Tek Company
	Parent Name	PQRS Technologies, Inc
	Founding Name	Berkeley Tek Company
	Other Names	BTKI
	Founding Year	1994
	Ending Year	N/A
	Current Ownership Status	Acquired
	Acquisition/Merger Date	1/12/2004
License information	Agreement Number	1995-01
	Campus	Berkeley
	Ownership (Public/Private)	PR
	UC Equity (ever)	YES
	UC Equity (current)	NO
	Equity Description	Initial equity: 100 voting shares; exercised in 2002
Technology Area	Standard Industrial Classification	2834
	Keywords	Pharmaceuticals
	Business Description	...
University Relationships	Inventor Founder?	YES
	Other Relationships with UC	Sponsored research contract 1999-101
	Non-UC Licensors	NA
Location	Address	55 Main Street Hayward CA 95000 US
	Founding City	Hayward
	Founding State	CA
	Distance from UC	22
	URL	N/A
Performance	1996 Revenue	$0.00
	1997 Revenue	$100,000.00
	1998 Revenue	$821,500.00
	1999 Revenue	$1,032,000.00
	2000 Revenue	$1,500,425.00
	1996 Employment	4
	1997 Employment	4
	1998 Employment	6
	1999 Employment	14
	2000 Employment	16

Concluding Comments

The intent of this paper is to broaden the current thinking about the economic impact of university technology transfer by providing a variety of approaches for addressing this subject. No one measure of economic impact is right or wrong, and no single approach will adequately capture the multiple ways in which local and regional economies are influenced by technology transfer activity. Each of the approaches discussed in this paper has merit, and only through presenting multiple analyses together will the field develop a more holistic and nearly accurate understanding of the overall impact that technology transfer has on economic development.

The paper notes that there have been very few published studies of the economic impact of technology transfer. Why is this so? One explanation is that such assessments have been limited by the availability of data. Data availability shapes the research question; as a result, policy analysis and academic research on technology transfer often have focused on the data supplied to the analysts by universities. Historically, few universities have systematically maintained the infrastructure needed to fuel a full range of meaningful analyses of economic impact. Royalty-focused methods often are seen as the only practical estimates, because royalty data are the only data readily available to carry out such assessments.

Universities do have a significant role to play in providing the tools for policymakers and researchers to analyze and understand the economic impact of higher education in general and technology transfer in particular. With this in mind, the authors structured this paper to encourage the development of data collections and measures that can be used by a wide variety of researchers interested in studying the economic impact and operations of university technology transfer. This paper describes the creation of a University of California database related to start-up activity as one concrete example of the processes and systems that can be put in place to provide essential information for economic impact analyses. It is the authors' hope that this will motivate the collection of quality data by many academic institutions that can be used for analyses. While this article by no means offers a comprehensive assessment of all salient considerations, it opens dialogue on this important subject.

Acknowledgement: This paper is based upon the results of a larger project funded by the Industry-University Cooperative Research Program at the University of California.

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