Engine or Infrastructure?
The University Role in Economic Development

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Introduction

While a growing number of academics are interested in technological change, the innovation process, organizational transformation, and economic development, few have considered the role of the university in this context. Surprisingly, the literature lacks an adequate conceptual understanding of the role of the research university in contemporary capitalism. This gap is significant since, as numerous scholars have noted, capitalism is changing. A recent article in The Economist characterized the university as a "knowledge factory." As observers increasingly note, knowledge has replaced natural resources and labor-intensive industry as a primary source of wealth creation and economic growth (Drucker 1993; Nonaka and Takeuchi 1995; Florida 1995; Romer 1993, 1995 ; Leonard-Barton 1995). In this new economy, knowledge and ideas are a critical component of economic advantage, with intellectual capital (Stewart 1997; Edvinsson and Malone 1997) being a pivotal resource. Taken in the context of this broader economic transformation, it stands to reason that the university's role is becoming increasingly important as an economic and social institution.

What is the role of universities in knowledge-based capitalism? Should we be surprised that universities are increasingly involved in areas of direct relevance to industry? Answers to these questions require a better theoretical understanding than we now have. This chapter draws f rom the previous chapters in this book, from survey research I have conducted on with Wesley Cohen on university-industry research centers and from other sources to layout the underpinnings of a better conceptual understanding or theory of the university's role in knowledge-based capitalism. It also deals with the tensions that new role is generating, and reconsiders the notion of the university as an "engine" of economic development. While I do not expect to fill the wide theoretical gap, I do hope to place the debate in a richer conceptual context.

First, I want to emphasize that the university is embedded and enmeshed in the knowledge economy in many complicated ways both direct and indirect, both formal and informal, that are not yet clearly articulated, identified or understood. Second, I want to offer a new way of thinking about what the university does. Drawing from joint work with Wesley Cohen, I emphasize the notion that universities act to optimize eminence and highlight the tensions between the quest for eminence and the pursuit of research support from industry. Furthermore, I am led to conclude that the university functions less as a direct engine of economic development, but that its role is quite subtle and nuanced taking on a function which is even more important: that of an enabling infrastructure for technological and economic development.

Toward a Theory of the University

Conceptual foundations for understanding the role of the university are weak. The most important work includes that of Robert Merton (1973), the more recent work of Partha Dasgupta and Paul David (1987, 1994), and Nathan Rosenberg and Richard Nelson (1994); from an historical perspective there is the work of David Noble (1977) warning of corporate manipulation, Stuart Leslie's work (1987, 1990, 1993) on Stanford and MIT during the era of "cold war science," Henry Etzkowitz (1988, 1989, 1990) notion of the entrepreneurial university, and the work of Roger Geiger (1986, 1993) and Laurence Veysey (1965) on the historical development of the research university.

Robert Merton (1973) argued that academic science should be an open project. While this view has often been understood as a normative prescription, Merton's own justification was

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grounded in efficiency. Firms are motivated to undertake scientific and technical advance by their quest for profit and intellectual property. Academic science has its own motivations that are centered on the efficient creation of knowledge and advance of scientific frontiers. The quest to discover and publish early creates a productive competition; information is quickly disseminated quickly, as openness leads researchers to write their results on the "blackboard of science" promptly.

Building upon Merton's view, Dasgupta and David (1987, 1994) have presented an economic argument for keeping university and industry research separate. Academic science is a quest for fundamental discovery; industry research focuses on profit motives and proprietary access. They argue that any intermingling of these functions would have negative social welfare implications, hence only a strong separation will optimize resource allocation and social welfare. Other economists, such as Edwin Mansfield (1991) and Adam Jaffe (1990) ,have probed the relationships between university and industrial R&D and the effects of those relationships.

In contrast, Nathan Rosenberg (1982) has argued that the divide between science and technology is difficult or impossible to discern. Applied work often begets fundamental work and vice versa. Rosenberg and Richard Nelson (1994) trace the ways in which university science contributes to technical advance in industry, and the ways in which technical advance in industry contributes to fundamental understanding. While such large-scale theories help illuminate the interaction of science and technology generally, they tell us little about the specific role of the university. How do the individual and organizational incentives of the university affect collaboration with industry and the government?

Two theories examine the university more specifically. One, associated with David Noble (1977) can be referred to as the "corporate manipulation" thesis. essentially arguing that corporations interfere with the normal pursuit of academic science and seek to control relevant universiity research for their own ends. A second theory, espoused by Henry Etzkowitz (1988,

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1990), Roger Geiger (1986, 1993) and Slaughter and Leslie (1997), is that of "academic entrepreneurism." These scholars argue that university faculty members and administrators act as entrepreneurs, cultivating opportunities for federal and industry funding to advance their own agandas. Despite these important advances in our understanding of the role of the university in capitalism, they fail to fully grasp the objective function of the university, the intricate and complex ways in which the university is embedded within economy and society, and full nature of the tensions thereby generated.

Let me quickly outline what some elements of a better theory of the university might do. Like any good theory, it would begin by identifying what a university does and what it attempts to optimize. We find that the university is an institution that generates and disseminates knowledge. It competes with other institutions, and the nature of this competition is around eminence, which the university seeks to optimize along with reputation and prestige. In this regard, the university engages in a productive competition for highly regarded faculty, who attract outstanding graduate students, with the university's increased reputation in turn attract leading undergraduates, and so on. The pursuit of eminence is reflected in contributions to new knowledge, typically embodied in academic publications. Universities, however, like all social and economic institutions require funding to pursue their objectives. This gives rise to a fundamental tension which underscores the nature and history of interactions and relationships between the university and industry --a tension between the pursuit of eminence and the need for funding support. Today's debate over university-industry relations is the most current manifestation of this underlying tension.

Let me elaborate this argument in terms of three points. First, the university is fundamentally engaged in knowledge production or knowledge creation, but the nature of that production has changed over time. In general, we have seen a shift in emphasis at universities from knowledge transfer in the 19th century, with an emphasis on training students who then go out into the world, to research and knowledge creation in the mid- and late-20th century. Furthermore, this shift in university activities was related to the evolution of science-based industry in the late 19th and 20th centuries, in particular the rise of the industrial R&D laboratory (Hounshell 1996; Servos 1994). Today the life sciences and molecular biology best represent the contemporary profile of science-based industry (Blumenthal et al. 1986a, 1986b). The growing emphasis on the role of knowledge in production has focused attention on the important contribution that universities might make to industry. In an era of knowledge-based capitalism, the capacity to combine diverse approaches to research makes the research university a particularly good place to pursue knowledge creation. Today's research university has the advantage of being able to cultivate and incubate a wide range of research approaches and strategies that are potentially relevant to industrial R&D and commercial technology.

Second, the university is becoming much more important as an economic and social institution than it ever has before. The reason for this is basic. The shift from industrial capitalism to knowledge-based capitalism makes the university ever more critical as a provider of critical resources such as talent, knowledge, and innovation. The university, however, is embedded and enmeshed in this system of knowledge-based capitalism in subtle, nuanced and complicated ways we must better understand if we are to fully comprehend the broader processes of innovation, value creation, and economic growth. And, given this, the university is a very useful laboratory for understanding the broader dimensions of knowledge-based capitalism and of regional and national development.

Third, universities act to optimize eminence, prestige and reputation: The pursuit of external research support from industry and other sources essentially involves balancing new financial support against eminence. Generally speaking, attracting corporate funds does not hinder the quest for eminence, but industry funds may at times come with too many restrictions: control over publishing, or excessive secrecy. Furthermore, strategies for attaining eminence have changed over time. In some periods, eminence dictated a focus on teaching; at other times it has advocated work to enrich our stock of knowledge. There are tensions embedded across the entire historical evolution of university-industry interactions; so, it should come as little surprise that they are evident today in issues involving the "skewing" of academic research from basic toward applied research or in growing concerns about the increased "secrecy" of academic research as discussed in Chapter 11. The initial wave of industrial support of and involvelment in academic research appeared at the turn of the century in conjunction with the rise of industrial R&D. Chemistry and engineering departments at the time were host to a deep struggle between faculty who wanted to pursue applied, industry-oriented research, and other faculty who wanted to study anything so long as it was basic research. This tension ran particularly deep at MIT (see Servos 1980). Departments that became dependent on industry funds lost eminence as prestigious faculty members moved away. One goal of post-war government funding for university research (Brooks 1993) was to counteract this negative impact of industrial support by creating `steeples of excellence.'

University-Industry Research Centers in the United States

To shed some additional light on this general argument, let me now turn to empirical evidence provided in a detailed Carnegie Mellon survey study of what we have called university-industry research centers (see Cohen, Florida and Goe 1994). The study indicates that university-industry ties in the United States are quite extensive, identifying 1056 university-industry research centers as of 1990. Moreover, the magnitude of spending by these joint research centers is substantial: a total of $4.12 billion in 1990 with $2.9 billion spent directly on R&D. For comaptrison sake, this is more than double the National Science Foundation's $1.3 billion of support for all academic R&D in 1990 and almost one-fifth of all government expenditures in science and engineering. Between 1970 and 1990, it should also be pointed out, the share of industry funding of academic R&D more than doubled, rising from 2.6 to 6.9%.

These university-industry research centers involve not only a lot of money, but also a large number of faculty and students. They include, according to the CMU survey, roughly 12,000 university faculty members, 22,300 doctoral-level researchers (15% of total), and 16,800 graduate students. These people do not necessarily work for university-industry research centers full-time. Indeed, one advantage these centers enjoy is their ability to leverage resources, including faculty time.

Another indicator of deepening university-industry ties in the United States is academic patenting. In 1974, 177 patents were awarded to the top 100 research universities. In 1984, this number increased to 408; in 1994, it jumped dramatically to 1486 (Cohen et al. 1998: 182). In 1997, the 158 universities in the survey conducted by the Association of University Technology Managers applied for more than 6,000 patents. Universities granted roughly 3,000 licenses based on these patents to industry in 1998, generating roughly $500 million in royalty income, up from 1,000 in 1991. Furthermore, a growing number of university's such as Carnegie Mellon and the University of Texas at Austin have become directly involved in the incubation of spinoff companies, sometimes with great success as in the case of Carnegie Mellon and Lycos. And, as Josh Lerner has discussed in Chapter 15, a growing number of universities have sought to develop ties to venture capital funds, encourage venture capitalists to open offices, and in some controversial case, such as Boston University' and Seragen, to make direct venture investments themselves.

Academic Entrepreuriism? University Initiative and Federal Science Policy

A growing theme in the debate over university-industry ties revolves around the concept of academic entrepreneuriism. This view stands in some contrast to the notion that universities are more or less unwitting pawns of corporate manipulation. The question becomes: To what extent do universities actively cultivate and forge ties to industry?

The findings of the CMU survey of university-industry research centers indicate that universities, rather than industry, were the prime movers in the drive to develop closer academic-industrial ties. This contradicts the corporate manipulation thesis and tends to support the argument advanced by Henry Etzkowitz that "entrepreneurism" has permeated U.S. universities. The findings of the CMU survey clearly indicate that main initiative for university-industry research centers originated with universities. More than two-thirds (73%) of university-industry research centers in the CMU survey report that the main impetus for their establishment came from the entrepreneurial efforts of university faculty and administration. For comparison sake, it is useful to note that just 11% of centers reported tat the main impetus for their establishment came from industry.

This university initiative did not occur in a vacuum,: It was in many respects prompted and conditioned by shifts in federal science and technology policy. Here it is important to point our that more than half of all funding for university-industry research centers comes from government. Of the university-industry research centers that participated in the CMU survey, 86% received government support, 71% were established based on government support, and 40% reported they could not continue without this support (Cohen, Florida and Goe, 1994)..

Three specific policies conditioned the move among universities toward university-industry research centers. First, the Economic Recovery Tax Act of 1981 extended industrial R&D tax breaks to support research at universities. Second, the Patent and Trademark Act of 1980, otherwise known as the Bayh-Dole Act, permitted universities to take patent and other intellectual property rights on products of federally funded research. This allowed universities both to take patent rights and to assign or license those rights to others, frequently industrial corporations. Third, government agencies began funding a relatively small number of research centers such as the NSF Engineering Research Centers and Science and Technology Centers both of which required industry participation, creating the perception that government resources would in the future be tied to joint university-industry research initiatives.

The push for linkages to industry had its roots in a combination of perceived declining government research funds in the 1970s and in the debate over U.S. competitiveness in the 1980s. A number of university leaders, including Derek Bok (1982), then President of Harvard University, posed the university as a potentially potent and under-used weapon in the battle for global industrial competitiveness. The National Science Foundation promoted joint centers as a way of encouraging closer ties between universities and industries and improving the transfer of academic research to industry. Although less than a hundred centers were originally funded under various NSF programs, these initiatives encouraged universities to seek closer research ties to private industry, by creating the perception that future competitions for federal funds would require demonstrated links to industry, thus prompting more and more universities to establish such centers, sometimes with their own funds. Universities, for example, provide 18% of the total support for the centers in the CMU survey, much of it coming in the form of cash support.

The Reaction from Industry

Industry's views of growing university-industry research ties are decidedly mixed. A first approximation comes from the findings of the CMU survey. A significant portion university-industry research center funding, $800 million, comes from industry, representing 70% of industry's total contribution to academic research, and 1.5% of industry's own R&D budget. This funding takes the form of grants, dues, equipment, and even some endowed chairs.

A richer perspective comes from our interviews with corporate leaders. Almost every company we interviewed thinks that universities are doing what they do very well. Cutting-edge academic research is superb, and students are being well educated. What companies are concerned about is the move into applied research that university industry research centers represent. This concern has three causes. First, students are the most important product that universities produce, and industry is worried that a focus on profit will hurt the education function. Second, industry now feels that it can get better research results out of one-on-one interactions with professors. University-industry research centers offer the advantage of strong government support, allowing firms to leverage their investments; but overhead in research centers is often high, and the results often not directly relevant to the interests of the participating company. Faced with increasing pressure to achieve results, company research divisions are resorting to smaller contracts with individual faculty members which last several years. This ensures them faculty commitment, a counterpart with aptitude for the business culture, and a check on overhead costs. One vice-president for research summarized industry's feelings about university-industry research centers: "The university takes this money, then guts the relationship." Third, firms are concerned with university wrangling over intellectual property rights. They are particularly concerned with the time delays this may cause. They are also concerned that even though they fund research upfront , they are forced into unfavorable negotiations over intellectual property when something of value emerges. Furthermore, some companies are concerned that the centers they support will share vital information with their competitors. Because several firms normally participate in a single research center, faculty members may inadvertently make public vital information. For industry, this risk of information leakage is significant.

Implications for the Research University

What do closer ties to industry mean for the university and its traditional missions of research and teaching? Where are the tensions manifesting themselves? This is a question that is on the minds of many inside the university as well as in government. Closer ties between university and industry clearly pose important implications for the research university. For universities, the key issue has to do with the tradeoff between the quest for eminence and the pursuit of funding support from industry. The CMU survey indicates that industry is still capable of affecting the direction of research agendas, their policies on information disclosure and publication, and, perhaps most troubling, the amount of communication within the center itself. Of the centers surveyed, 65% indicated that industry exerts a "moderate to strong influence" over the direction of their research. Furthermore, it is important to distinguish between two distinct issues facing research universities. The first can be referred to as the "skewing problem"--the alleged shift in research effort from basic to applied research. The second is the "secrecy problem" and involves the rise in restrictions on publication of research findings.

Many contend that growing ties to industry tend to skew or shift the academic research agenda from basic toward applied research. The evidence here is mixed. David Blumenthal and others (1996) found that industry-supported research in biotechnology tended to be "short term." Surveys by Diane Rahm (1994) and Robert Morgan (1993, 1994) found some empirical association between greater faculty involvement with industry and more applied research. The findings from the CMU survey indicate that centers tend to choose how closely to be involved with industry and how to apportion their research mission between basic and applied work. The CMU survey found that the research direction of centers is associated with the extent to which they expressly take on the mission of improving industrial products and processes, Centers which view this mission as important devote 29 percent of their R&D activities to basic research, while centers which do not consider this mission important devote 61 percent of their R&D activities to basic research (Cohen, Florida and Goe 1994). While this evidence is interesting, it remains unclear whether or not industry funding is causing academics to shift their research agendas. In fact, the National Science Board data show the composition of academic R&D between basic and applied research has remained relatively stable since 1980 at about 66 percent though this down from 77 percent in the early 1970s (Brooks and Randazzese 1998).

. Complicating the matter, the findings of the CMU study of university-industry research centers appear to indicate that such centers are able to achieve significant gains in industrially relevant technology. The CMU study finds that centers can and do choose the extent to which they want to focus on basic versus applied research. Furthermore, the CMU study and the related research of Cohen and his collaborators (Cohen et al 1996; Cohen, Florida et al.1998) clearly shows that the process of knowledge or technology transfer from university to industry occurs through multiple channels, such as, publications, students, informal discussions, consulting relationships, intellectual property, spin-off companies and so on (also Faulkner and Senker 1995). Policies and programs that seek to tie university and industry through more formal systems for technology transfer and commercialization appear to strengthen some channels, while weakening others. This is particularly true of technology transfer agreements, which include disclosure restrictions. The same study however finds that these channels often operate together in synergistic ways. In this regard, it may be a mistake to attempt to alter the system in ways we do not yet fully understand.

A larger and more pressing issue appears to revolve around growing "secrecy" in academic research. Most commentators have posed this as an ethical issue, suggesting that increased secrecy contradicts the norm of open dissemination of scientific knowledge. The real problem is not simply this normative and ethical challenge, but academic secrecy it may threaten the efficient advance of scientific frontiers. One dimension of this issue revolves around the nature and extent of so-called disclosure restrictions, that is restrictions on what can be published and when it can be submitted for publication. Here again, the findings of the CMU survey are illustrative. Over half of the centers in the CMU survey said that industry could force a delay in publication, and over a third reported that industry could have information deleted from papers prior to publication. Even though some have argued that these delays are for relatively short time periods, and the information which is deleted tends to be of marginal value, the issue of disclosure restrictions opens up a veritable Pandora's box. Blumental and his collaborators (1997) report that 82 percent of companies they surveyed that support academic research in the life sciences require academic researchers to keep information confidential to allow for filing a patent application, and that 47 percent of firms report that their agreements with universities occasionally require academic institutions to keep results confidential for longer than is necessary to file a patent. The study concludes that participation with industry in the commercialization of research is "associated with both delays in publication and refusal to share research results upon request." (Blumethal et al. 1997). Furthermore, a survey of more than one thousand technology managers and faculty at the top 100 R&D performing universities in the United States by Rahm (1993) found that 39% of technology managers reported that firms place restriction on information sharing by faculty, and that 79% of them and 53% of faculty members reported that firms had asked for research findings to be delayed or kept from publication. A1996 article in The Wall Street Journal (King 1996) reported that a major drug company suppressed findings (disallowing publication of research it had funded in a major scientific journal after that article had been accepted) of sponsored research at the University of California San Francisco, when the research found that cheaper drugs made by other manufacturers were therapeutically effective substitutes for its drug, Synthroid, which dominates the $600 million market for drugs to control hypothyroidism. While prestigious universities with strong federal funding are often able to avoid the deleterious impact of industry investment, less prestigious research universities are not (Randazzese 1996). Furthermore, as Mowery et al. point out in Chapter 11, there is concern that growing secrecy in biotechnology research tools and techniques may be holding back advances in that field.

There are also growing concerns both among university faculty and industry that US universities may have become "overzealous" in the pursuit of revenues from technology transfer. There is mounting concern over the practice and policies of technology transfer offices and university intellectual property staffs in particular. Industry is increasingly nervous about disclosure restrictions and intellectual property policies at universities and particularly the increase legal wrangling that occurs. They are concerned both about legal wrangling over intellectual property and the time delays it may cause, a noted earlier. This perception of overzealousness on the part university technology transfer operations may in fact be damaging the relationship between the university and industry. It also appears to be provoking some negative reactions on at least some parts of faculties. While such a negative reaction is not pervasive yet, it continue to bubble under the surface as a general sentiment, voiced variously as "why are we doing this, what does it mean, why are we compromising ourselves." Among university faculty in the United States, it is safe to say that there is a bit of aversion to technology transfer offices specifically.

A related tension revolves around the impact of increasing internal university funding of university-industry research centers on university finances. According to Irwin Feller (Chapter 3), the most rapidly increasing source of academic research funding comes from the university itself.

While federal funds are holding constant or increasing slightly and industrial funds for research are increasing somewhat, the fastest growing segment of research funds are internal funds. Universities increasingly believe, according to Feller, that they need to make investments in internal research capabilities, by funding center and laboratories for example, in order to compete for federal funds down the road. The need for internal funding is an important motivator for university technology transfer efforts. The revenue from these efforts is discretionary funds which can be invested in new activities such as closer research ties to industry which it is hoped will someday lead to greater revenue streams in the form of larger federal grants. Carnegie Mellon, for example, generated more than $20 million from its initial equity stake in Lycos, which it is using among other things to finance endowed chairs in computer science and the construction of a new building for computer science and multimedia research. It is the quest for these sorts of discretionary funds which are growing (in some case rapidly) at the margin which motivates increased university interest in revenues from technology transfer.

Finally, closer ties to industry are helping to bring about a change in the personnel at research universities. Whereas universities used to comprise only faculty and students, university-industry research centers are creating a new faction within the university, the research scientist. These research scientists work primarily on sponsored research and outside of the realm of graduate education. They consider themselves a different group, and some universities have created new career tracks for them. This means that research scientists have personal and institutional goals that differ from those of faculty and students. And these divergent goals may create distortions when universities make important decisions affecting their trade-off between eminence and cash flow. Interestingly, as the interests of research scientists become better represented, a university's eminence may suffer.

University-Industry Relations in Japan

Japan is also moving to a knowledge economy, and university and industry are working more closely together as well. In fact, as the chapters in this volume indicate, university-industry ties in Japan are much more extensive than most U.S. scholars, analysts, and policymakers have typically thought. Furthermore, as the chapters in this volume document, the nature of university-industry ties in Japan differs considerably from those in the United States. The simplest way of saying this is that university ties in Japan are considerably less formal than such ties in the United States, and depend on an informal network structure of relationships as opposed to formal contractual relationships.

University-industry ties in Japan are quite extensive as previous chapters amply demonstrate. As Odagiri documents in Chapter 10, there were 1448 joint research projects between university and industry in Japan in 1994, involving 89 universities and 883 firms. As Pechter and Kakinuma in Chapter 4 show, nearly half (46%) of all publications emanating from an industrial corporation in Japan in 1996 had a university co-author, up from 23% in 1981. As Kneller (Chapter 12) and Yoshihara and Tamai (Chapter 13) demonstrate, Japanese patent statistics sorely understate the role of university research in patentable innovations in Japan. Chapter 13 shows that Japan's Patent Agency and Monbusho reported only 129 university patent applications in 1994, less than one percent of all patent applications. Furthermore, as that Chapter documents,, while the Japan Patent Office reported only two patent filings by University of Tokyo faculty in 1994, a survey by the university's Department of Engineering reported that there were as many as 150 inventions made by faculty members, suggesting that 148 of these academic inventions were filed by the private sector rather than the by university faculty members. A study of Japanese patent applications in genetic engineering cited by Kneller in Chapter 16 found that half of the approximately 600 patent applications in that field listed a Japanese university scientist as co-inventor.

Further insight into the nature of university-industry ties in Japan is provided by the comparative results of the international survey of industrial R&D in the United States and Japan conducted by Cohen, Goto , et al. (1998). This study indicates that Japanese universities may well play a greater role in contributing to Japanese industrial R&D than that of U.S. universities in that nation's R&D. According to the results of their survey, 52% of Japanese firms (compared to 33% of U.S. firms) report that research by universities and government research institutes (which they term "public research") suggests new R&D projects. They also found that 50% of Japanese firms (compared to 40% of U.S. firms) report that research by universities and government research institutes contributes to R&D project completion. These findings lead them to conclude that: "The magnitude and pervasiveness of these trends o the role of public research in suggesting new R&D projects or contributing to project completion suggests that the flow of information from public research is substantially greeter in Japan than the U.S." (Cohen, Goto et al .1998: 10).

Taken as a whole, the chapters in this volume on university-industry ties in Japan provide the outlines of a broad model of how the process of technology transfer from university to industry works in that nation. The defining principle of this model is the mobilization of knowledge through informal but well-articulated networks. In its simple (and most over-simplified) form ,the model works like this. .In return for intellectual property emanating from academic laboratories, industry tends to compensate the academic inventors in the form of donations. The use of donations as the preferred form of industrial support is a product of Japanese law, which since the Second World War prohibited direct industrial support of university research. Faculty members use these donations conduct research work in their laboratories. When the research leads to something of relevance to industry, that research is informally transferred to industrial partners who patent the discovery. These same industrial sponsors also tend to hire the graduate students from the university laboratory. In this way, the system tends to create a productive cycle. Large R&D intensive firms sponsor academic research of direct relevance to them through donations, which in turn support relevant academic research. The results of the research are transferred to those sponsors via intellectual property ownership and transfers of human capital. More donations come in, more research get done, more graduate students are trained, more patents go to the firms supporting the research, more graduate students get hired by those same firms, and so on. It is important to point out that this informal system appears to be an effective way of cross-pollinating the channels for technology transfer, in that it involves the transfer of formal codified knowledge along with human capital (in the form of graduate students familiar with the technology).

Rethinking the University's Role in Economic Development

I now turn to a key issue: the role of the university in economic development. Here, in particular, I want to suggest that the conventional metaphor of the university as an "engine" of regional economic development is misapplied. The university's economic role is much more complicated, subtle, nuanced and complex than such mechanistic thinking allows. Instead of thinking of the university as an engine of economic development, it is more appropriate to conceptualize it as a pivotal component of an underlying infrastructure for innovation on which the system of knowledge-based capitalism draws.

The role of the university in economic development has captured the fancy of business leaders, policymakers, and academics as they have looked at the examples of technology-based regions like Silicon Valley and the Route 128 region surrounding Boston and Cambridge. They have concluded that the university has played a fundamental role in developing the technological innovations and technologies that power those regional economic models. A theory of sorts has been handed down based mainly on anecdotes and so-called success stories of the university as "engine" of regional economic development. This view is similar in many respects to the now widely criticized "linear model of innovation" which rests on the assumption that there is a linear pathway from university science and research, to commercial innovation, and onto regional development in the form of ever-expanding networks and genealogies of newly formed companies. This model is in turn reflected in a wide variety of university-based and publicly supported technology transfer programs which aim to increase the output of university "products" that are of value to industry.

There are self-evident reasons to question that view. It is quite clear that Silicon Valley or the Cambridge/Boston regions are not the only places with excellent universities working in areas of potential commercial importance. One way to begin to structure the problem is to think of the relationship between the university and the economy as composing a simple two-dimensional system, in which the university transmits a signal, which the regional economic environment must absorb. Increasing the volume of the signal need not result in effective transmission or absorption if the region's transmitters, so to speak, are not turned on or are functioning ineffectively. In short, the university appears to be a necessary but insufficient condition for regional technological and economic development. To borrow a phrase from the work of my CMU colleague, Wesley Cohen and Daniel Levinthal (1990) what appears to matter here--and what is to often neglected in policy circles--is what we might call "regional absorptive capacity," the ability of a region to absorb the science, innovation, and technologies which universities generate. Another way of saying this is that regions need to capture the "spillovers" of the technologies and innovations they generate.

In Chapter 18, Michael Fogarty and Amit Sinha examine the flow of intellectual property (in this case patents) from universities to other universities and to firms around the nation. They identify a simple but illuminating pattern: a significant outward flow of intellectual property from universities in older industrial regions such as Detroit and Cleveland to high-technology regions such as the Boston/Cambridge region, the California Bay Area, and the greater New York metropolitan area. Their work suggests that even if the ability to generate new ideas and new knowledge is going on in many places, it is those places that have the ability to use and absorb those ideas, which are able to turn them into economic wealth.

This brings us to the most critical contribution of the university to economic development; and this lies in the domain of talent. As is increasingly noted, talent is the key resource of the knowledge economy. As a factor of production, it has a number of critical features. First, talent is highly mobile. Second, the distribution of talent in scientific and technical fields is highly skewed. Finally, the labor market for knowledge workers is different than the general labor market: Smart people do not necessarily respond to monetary incentives alone; they want to be around other smart people. In this regard, talent tends to attract talent, which is why universities tend to compete to attract the best talent, so called academic stars, and that they do so by leveraging the reputations of the talent they already have, for example by highlighting the number of Nobel prize winners on their faculty.

The university plays a magnetic role in the attraction of talent--a classic increasing returns phenomenon. The fact is that good people attract other good people, and places with lots of good people attract firms who want access to talent creating a self-reinforcing cycle of growth. According to Dr. Uenohara of NEC, one of the most significant corporate impacts of NEC's Research Institute in Princeton was that it helped the firm to attract better talent in Japan--having a basic research faculty with Nobel Prize caliber talent was a important factor in attracting bachelor's level engineers. The need to attract talent is also one of the key reasons why firms organize their internal research units in ways that emulate university research laboratories, with investigator autonomy, the ability to publish, hold seminars, invite visitors and so on. A key role of the university in the knowledge economy then is as a collector of talent - a growth pole which attracts eminent scientists and engineers who attract graduate students, who in turn create spinoff companies, and eventually encourage other companies to locate nearby.

Furthermore, it is important to recognize the dynamic nature of this system for attracting talent. Over time, any university or growth region will constantly re-populated with new talent. Leading universities constantly replenish their stock of talent, with professors and graduate students moving in and out. In short, universities—and, I would postulate, the labor market for knowledge workers more broadly--are distinguished by high degrees of "churning." It is not simply capturing any given stock at any given moment that matters: What matters is the ability to attract and replenish that stock. This is particularly true in advanced scientific and technical fields, where "learned skills" (e.g. engineering degrees) tend to depreciate rather quickly. So, growth regions benefit from this dynamic process of talent creation and attraction.

This has important implications for public policy. Consider the fact that virtually all public policy in this area, whether it is national, state, or local, has been organized as a giant "technology push experiment." The basic logic goes like this: if the university can just push more innovations out the door, those innovations will somehow magically turn into economic growth. Avoiding a lengthy critique of the naive assumptions made here about the "localized" nature of spillovers, it can simply be said that the process for turning academic research into companies that create regional growth is long and complex.

The key then is to move away from the limited concept of the university as an engine of economic development, and begin to view the university as a complicated institutional underpinning of regional and national growth. If nations and regions are really serious about building the capability to survive and prosper in the knowledge economy and in the era of talent, they will have to do much more than simply enhance the ability of the university to transfer and commercialize technology. They will have to act on this infrastructure both inside and surrounding the university in ways that make places more attractive to and conducive to talent. And, it is here--in the attraction if talent--that national and regional policymakers have a great deal to learn from the universities, who have been doing just this--creating organizational and institutional environments conducive to knowledge workers--for a very long time.

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