Research Universities and Local Economic Development: Lessons from the History of the Johns Hopkins University

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Abstract: This paper examines the evolution of university practices and policies towards technology transfer at one American research university, the Johns Hopkins University. We consider the university's founding vision and organizational culture and subsequently the ways in which this influenced the university's stance towards patenting, entrepreneurial efforts on the part of faculty and industry-sponsored research. This historical perspective enriches our understanding of universities as complex organizations that may encounter difficulties accommodating expectation of increased industrial interaction. Our intention is to expand the debate of the role of the university in the regional system of innovation by considering a detailed example of one university that has not historically embraced industrial activity.

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I. Introduction

Research universities are often believed to be one of the conditions for successful local economic development (Miner et al 2001). The success stories of Silicon Valley and MIT, the Massachusetts Institute of Technology and Route 128, and the Research Triangle Area in North Carolina are well studied (c.f. Rogers and Larsen, 1984; Rosegrant and Lampe, 1985; Link 1996). Since the 1980s, despite the establishment of university technology transfer offices, incentives from federal and state governments and new industrial outreach efforts, most research universities have not yet been particularly successful at technology transfer and have not yet generated significant local economic development. While university knowledge spillovers are noted to be geographically localized many factors that affect the transmission of these spillovers[1]. Most importantly, a university's founding mission, institutional context and prior experiences with commercial activity influence interaction with industry and ultimately affect the ability of the university to impact its local environment and determine its role in the regional innovation system.[2] The examination of the counterfactual case where the local economy has not captured the benefits of proximity to a research university illuminates the complexity of this process.

We focus our investigation on an in-depth analysis of one university, the Johns Hopkins University, and examine the historical context of industrial interaction over the university's 125-year history. By any number of measures and independent assessments, Johns Hopkins University is one of the world's leading institutions of higher education and research.[3] The

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[1] Other factors may inhibit the absorption of university spillovers such as attributes of the region and its, industrial composition, characteristics of the labor force and social capital variables. In addition, the historical relationship of local industry with the institution may be instructive. These are not considered in this paper.

[2] Matkin (1990) in his analysis of the evolution of technology transfer and policies at the University of California, Stanford, Penn State and MIT probably comes closest to addressing the institutional issues that are addressed here.

[3] See, for example, the various rankings of American institution of higher education by US News and World Report and other outlets where Johns Hopkins is typically ranked in the top 15 overall and in the top 10 for its academic reputation.

academic achievements of its faculty are well known and documented.[4] Over its history, twenty-six individuals associated with the University have been awarded a Nobel Prize. In addition, Hopkins has historically received more U.S. government research and development support than any other American academic institution and its School of Medicine is the single largest recipient of research grants from the U.S. National Institutes of Health.[5] Yet, despite substantial academic achievements, Hopkins provides an example of a university that has had little direct effect on its regional economy in terms of benefits as measured by spin-off companies or university-industry cooperative relationships (Feldman, 1994; Terry 2001).

Performance along a variety of measure of technology transfer at Hopkins has lagged similar institutions. Table 1 presents data on the total research expenditures and measures of technology transfer such as the number of licenses to industry that are generating income, the amount of royalties received from those licenses and the number of start-ups formed (Feldman et al. 2001). In 1997, Hopkins had 103 licenses for intellectual property that were generating revenue while Harvard University had 232 and Columbia University had 201. Royalties generated per active license were also lower. It is difficult to quantify the long-run economic impact of university technology transfer; however we may compare current yields. Table 1 also presents an invention ratio, defined as the number of invention disclosures per $1 million in research spending at the university. Stanford, the University of Wisconsin, MIT and Columbia University had the highest ratio. Table 1 also presents the amount of royalty generated per active license and Hopkins again ranks low. In contrast to a cohort of similar institutions, Hopkins is considered a late entrant in post-Bayh Dole technology transfer since it did not have a dedicated professional technology transfer office until 1986 (Mowery and Ziedonis, 2001)[6].

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[4] This is especially true for the Johns Hopkins Medical Institutions encompassing the activities of the Hospital, the School of Medicine, the School of Hygiene and Public Health and the School of Nursing. See, among others, Harvey (1976), Harvey (1981) and Harvey et al. (1989) and the books and other material listed at http://ww2.med.jhu.edu/medarchives/biblio/aldidone.htm.

[5] Abramson et al. (1997: 93-95) and National Science Foundation/SRS, Survey of Research and Development Expenditures at Universities and Colleges, FY 1997.

[6] The Association of University Technology Managers (AUTM) reports that Hopkins formed an office of Technology Transfer in 1973 under the criteria that one-half full time equivalent (FTE) staff member was working

Johns Hopkins University institutionalized the norms of open science with a reluctance to allow commercial interests to influence faculty research agendas and an abhorrence to engage in activities that might involve proprietary restrictions on knowledge dissemination (Merton 1979). This paper begins by examining the founding mission of Hopkins and its early leadership's stance toward profit-making based on academic research. We examine the history of university policy towards patenting since patents provide intellectual property rights that may be transferred to existing firms or used in the formation of new start-ups. Attention then turns to the impact of funding sources and incentives to commercialize the result of academic research and the experience of actual technology transfer cases during the first hundred years of Hopkins' history. Finally, we examine the absence of successful role models of commercial activity along with the well publicized failure of early entrepreneurial attempts. The examples presented here are chosen to be representative of the university's technology transfer experiences. Most notably, we find no evidence of any direct commercial success until the mid-1980 and the routine assignment of patents by researchers to the university did not occur until the 1970s. Our motivation is that a historical perspective may enrich our understanding of universities as complex organizations and illustrate reasons why research universities limited interaction with commercial activity and thus had limited impact on the local economy.

II. The Founding Mission

Johns Hopkins University is a private university which was formed in 1876 from a $7,000,000.00 gift from Baltimore merchant and railroad magnate Johns Hopkins. This donation was the largest made to an education institution at the time and was greater than Harvard University's endowment, the largest in existence in this period. [7] It gave the Trustees a free hand

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in technology transfer. We use 1986 as more realistic date due to policy changes that allowed more aggressive incentives for faculty and the commitment of resources to support the activity.

[7] This endowment, however, was not as significant as might first be thought. Indeed, while its endowment might have seemed comparable to that of older colleges, Hopkins' annual revenues and property holdings were not. For example, the property of Harvard was at the time more than five million dollars, while that of Yale was thought to equal the university's endowment. Furthermore, the income-yielding funds of Harvard in 1875 were over three millions while those of Yale near a million and a half. At the same time, Hopkins' fund yielded revenues of slightly

to define a vision of a university primarily devoted to research and graduate training and free of any direct ecclesiastic and political control (Bruce, 1987: 336). Indeed, despite the fact that Hopkins and a majority of the trustees were members of the Society of Friends (Quakers), they were chosen by the founder partly on his belief that they would "be free from a desire to promote, in their official action, the special tenets of any denomination or the platform of any political party" (Gilman, 1898: 7). The group of twelve trustees included the President and the Chairman of the finance committee of the Baltimore and Ohio railroad in which a large portion of the endowment was invested, two U.S. Supreme Court justices, a clergyman with a law degree and a physician (Ryan, 1939: 17).[8]

The university opened primarily as a graduate school with six departments in the humanities and the sciences, including chemistry, physics, mathematics, geology/mineralogy and botany/zoology and classics. The Johns Hopkins University Press (first known as the Johns Hopkins Press), which is currently the oldest continuously operated university press in America, was added in 1878 as a way to disseminate the results of university research.[9]

The early history of Hopkins and its relationship to industry, local or otherwise, was strongly influenced by its first president, Daniel Coit Gilman. An admirer of the German university system, which emphasized specialized training and knowledge for its own sake, Gilman sought to create an institution that would encourage graduate research and the advancement of individual scholars. Gilman had previously been President at the University of California, but left over debates with the legislature about his vision for the university.[10] Gilman's vision was to create a new university that would differ significantly from both the practical orientation of technical and land grant colleges and from the American liberal arts tradition of broad based knowledge appreciation (Bowman, 1939; Bruce, 1987; Hawkins, 1960).

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less than $200,000. By comparison, Harvard received in 1874-1875 $168, 541.72 in tuition and $218,715.30 from property, the total of which was about twice the income of Hopkins (Gilman, 1906: 4-5).

[8] French (1946) is the most detailed history of the founding of the Johns Hopkins University.

[9] When Daniel Coit Gilman, first president of The Johns Hopkins University, inaugurated the Press, he stated his conviction that publishing, along with teaching and research, is a primary obligation of a great university.

[10] F. Franklin (1910, repr. 1973) and A. Flexner (1946)

"What are we aiming at?" Gilman asked, in his inaugural address, "The encouragement of research ...and the advancement of individual scholars, who by their excellence will advance the sciences they pursue and the society where they dwell."

Because of public pressure to play a more significant role in the local community, Gilman modified his original plan to focus on graduate education and included undergraduate teaching (Ryan, 1939). His inaugural address nonetheless mentioned the *freedom* to investigate and the *obligation* to teach (Gilman, 1898) and hiring decisions stressed scholarly achievements. The consensus is that Gilman was able to recruit talented faculty who achieved scholarly acclaim (Bruce, 1987; Harvey et al., 1989; Hawkins, 1960; Lucas, 1994; Ryan, 1939; Schmidt, 1986).

New divisions were added in later years. The Johns Hopkins School of Medicine (SOM) was organized in 1893 around a nucleus formed by William Osler (medicine), William H. Welch (pathology), Howard A. Kelly (gynecology and obstetrics) and William S. Halsted (surgery) and laid the foundation of modern clinical teaching (Harvey et. al. 1989). The School of Hygiene and Public Health (SHPH) was founded in 1916 as the first and largest of a series of national and international schools of the kind funded by the Rockefeller Foundation (Fee, 1987; French, 1946). Its double-labeling derived from the British notion of public health, which referred to the practical and administrative approach then in vogue in that country, while hygiene referred to the research-oriented German institutes model. Consistent with the Hopkins mission, however, the SHPH faculty would be more involved in laboratory experiments than public administration. A department of engineering was added in 1912 and was granted school status in 1919.

The mind-set of the original faculty was forcefully geared toward scientific research and many of them proved openly hostile to the practical application of their work. For instance, the first professor appointed at Hopkins, Basil L. Gildersleeve, a classicist and specialist of ancient Greek, openly declared in his Commemoration Day address of 1877 "that the word useful should be banished from the university vocabulary" (Hawkins, 1960: 304). It is hardly surprising that a classicist held this stance; however, a number of his colleagues in scientific fields also expressed similar sentiments. For instance, Hopkins first appointee in physics, Henry Rowland, stated that he would dedicate himself to the pursuit of a "substantial reputation" rather than "filthy lucre" (Rosenberg, 1990: 52). The shrill tone that he used in an address that he delivered in 1883 as Vice President of the American Association for the Advancement of Science also conveys his early mindset:

> "The proper course of one in my position is to consider what must be done to create a science of physics in this country, rather than to call telegraphs, electric lights, and such conveniences, by the name of science... When the average tone of the [scientific] society is low, when the highest honors are given to the mediocre, when third-class men are held up as examples, and when trifling inventions are magnified into scientific discoveries, then the influence of such societies is prejudicial (Rowland, 1902: 609)."

Perhaps the most radical stance toward industrial research was made by Ira Remsen, the university's first professor in chemistry and the second president of the institution (from 1901 until 1913). Remsen "deliberately maintained a posture of disdain for the practical applications of chemistry" (Rosenberg, 1990: 19), disparaged what he described as "practicalism" on many public occasions, steered his students towards teaching rather than industrial pursuits and refused any offers to consult to private industry as long as he occupied his university position. Furthermore, when one of his students suggested that private industries might support the university by paying for laboratories and cited German examples, Remsen responded that he "could think of no worse fate for the university than such an invasion" (Hawkins, 1960: 140).

During the early decades of the university some critics charged that the training Hopkins offered was too impractical to meet the needs of an increasingly industrial city and region (Yoe, 1989: 3). Early on, trustee Lewis N. Hopkins, nephew of the founder, expressed the opinion that "great discoveries always came from those who were devoting themselves to practical applications" (Hawkins, 1960: 305). In 1886, an assistant to the president of the Baltimore and Ohio railroad prepared a report on technical education that asked the following:

> "Why should not the Johns Hopkins University sustain a department for higher technical training in industrial pursuits?... The present tendency of the Johns Hopkins University management savors too much of the classic and metaphysical scholasticism of the Middle Ages... The Johns Hopkins University should be considered as a part of the Baltimore school system, and its crowning glory. To maintain this position it should afford instruction in applied as well as in pure science (Barnard, 1887: 82-83, quoted by Rosenberg, 1990: 209-210)."

Similarly, in 1887 one Colonel Thomas J. Scharf attacked the university for its failure "to come down out of the scholastic clouds" and establish practical and technological schools (quoted by French, 1946: 84, 166).

Gilman, however, remained faithful to his vision, which he had articulated in his inaugural address: "Remote utility is quite as worthy to be thought of as immediate advantage. Those ventures are not always the most sagacious that expect a return on the morrow. It sometimes pays to send our argosies across the seas, to make investments with an eye to slow but sure returns. So is it always in the promotion of science" (Gilman, 1898: 18). In later years, Gilman would justify his approach by invoking Faraday's motto: "There is nothing so prolific in utilities as abstractions" (Gilman, 1898: 117)[11] and would state that inventions such as the telegraph, the telephone, photography, the steam locomotive and electric lighting had not been the creation of industrial fabrics, of mercantile corporations or even of private enterprise, but of university researchers whose motive was not "acquisition of wealth, but the ascertainment of fundamental laws" (Lucas, 1994: 173).

Gilman's philosophy was consistent with what has come to be describes as the linear model of innovation, by which new knowledge breakthroughs originate more from remote research activities conducting by universities than by directly engaging in practical problems that originated with industry. Part of the early mindset of Hopkins faculty in terms of their view of commercial activity can certainly be traced back to what historian of technology David Hounshell (1996: 16) has referred to as the professionalization of science and its parallel plea for pure science, i.e. science pursued for its own sake rather than for profit – an activity which was sometimes referred to by proponents of pure research as "prostitute science". Similarly, the sociologist Robert Merton (1979) has also pointed out that academics were traditionally governed by the so-called norms of open-science and therefore strongly believed in the free dissemination of knowledge and opposed the idea of intellectual property. Indeed, beliefs similar to those of the early Hopkins faculty were expressed by a number of other American academics at the time (Matkin, 1990: 58-61).

[11] As he wrote in the preface of the reproduction of his address "The Benefits Which Society Derives from University": "When the following address was delivered, the comments which had been made upon the work of the University seemed to call for a new exposition of its principles and aims" (Gilman, 1898: 94).

III. University Patent Policies

Perhaps the first important Hopkins contribution to the commercial realm was the accidental discovery of saccharin by a visiting European postdoctoral fellow, Constantin Fahlberg, who worked with Ira Remsen. In his investigation into the reactions of a class of coal tar derivatives (toluene sulfamides), Fahlberg noticed one day in 1879 an unaccountable sweetness to his food that he ultimately traced back to some compound that was accidentally sputtered on his fingers and arms, despite the fact that he had washed them thoroughly. The two researchers jointly published the discovery in the *American Chemical Journal* in 1879 and in 1880 and in a German journal in 1879. Fahlberg saw the potential of low-cost sweetening agents whose production would be much more reliable than that of sugar cane crops while Remsen soon moved on to other projects. Fahlberg left Hopkins and academia altogether, moved first to New York City and then back to Germany where he obtained financial backing, went into business with a relative and eventually came up with a successful manufacturing process. Fahlberg marketed his product under the label *saccharin* from the Latin word saccharum for sugar. He filed for and was granted US and European patents on *Manufacture of Saccharine Compounds* and *Saccharine Compounds* in 1884 and 1885. Remsen was not listed as a co-inventor, although the patents referred to the jointly authored American articles.

It seems fair to say that the university's culture toward profit-making activities had no impact on Fahlberg, for he had already filed for patents on other products before his serendipitous discovery.[12] Fahlberg allegedly became wealthy with the industrial development of the new sweetening, but Remsen and the university never received, nor claimed, any royalty from the commercial venture (Field, 1993). Remsen is noted to have come to profoundly despise Fahlberg, but he never challenged his patents despite an offer from Merck & Company to do it on his behalf when his university was experiencing financial difficulties at the turn of the century.[13] As one student later recalled: “I urged Remsen to accept Merck and Company’s offer

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[12] For example, Fahlberg was granted US patents for “Improvement in processes for utilizing zinc sulphate” (1878), “Method of removing iron from ferroginous saline solutions” (1882) and “Recovery of plumbic dioxide from ferroginous solutions” (1882).

13 This has often been attributed to the fact that Fahlberg eventually claimed that the discovery was his alone,

to undertake the contest, but he refused, saying that he would not sully his hands with industry" (quoted by Field, 1993: 5). Remsen's subsequent appointment as President of Hopkins no doubt helped to reinforce the university's stated mission and perpetuate a culture in which commercializing research was not consistent with the academic culture.

The disdain of profit-making enterprise may not only be linked to the values of particular individuals that were of pivotal importance in Hopkins' history, but also to the general climate of opinion that characterized the Progressive Era at the turn of the century. Many faculty members in the economics department (Hawkins, 1960)[14] and the School of Hygiene and Public Health (Fee, 1987), helped define the progressive ideals of promoting expert and disinterested scientific planning and mitigating the ill effects of laissez-faire enterprise. In the early 1880's, Henry A. Rowland declared that scientific minds were "destined to govern the world in the future and to solve problems pertaining to politics and humanity as well as to inanimate nature" (quoted by Hawkins, 1960: 306). In later years, one graduate student would recall the spirit of these days as "a general desire to save democracy and change the world, a feeling that scholars were especially called to lead the people" (Hawkins, 1960: 307).

This university culture would in turn prevail while other institutions were experimenting with formal technology transfer mechanisms. For example, the Wisconsin Alumni Research Foundation was organized in 1925 around the patenting of vitamin A (Apple, 1989). Even though a similar opportunity was presented when vitamin D was discovered at the SPHH in 1922, Hopkins administrators remained hostile to patenting and formal technology transfer throughout this period.[15] As interest in intellectual property increased, a committee on external relations was formed at the SOM in the early 1930's to consider issues of conflicts of interest. It asked all members of the staff to be "punctilious" in informing the president of "such of their activities as involve relations to other institutions of instruction or research, or to commercial or

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leading to Remsen's comment in a letter to English chemist William Ramsey: "Fahlberg is a scoundrel. It nauseates me to hear my name mentioned in the same breath with him" (quoted by Field, 1993: 1).

14 Perhaps the most important figure in that respect was Richard T. Ely, founder of the American Economic Association, although Thorstein Veblen also spent some time at Hopkins.

15 Feldman and Desrochers (2001) is a more detailed account of the Hopkins' patent controversies.

industrial agencies, where the relations in any way involve the interest of the University.[16] A unanimous decision was made to the effect that the university should not own or control patents, but its members disagreed whether individual faculty should do so. As was expressed in a resolution adopted by the Advisory Board of the Medical Faculty in 1933.

> "The Advisory Board of the Medical Faculty considers it undesirable for any member of the Faculty or anyone connected with the School of Medicine to patent any invention or discovery that may affect the public health; but, in case any member thinks it desirable to secure a patent, he should bring the matter before the Advisory Board before so doing."[17]

This stance on intellectual property was soon to be tested by Einar Leifson, a young instructor in bacteriology. Leifson would launch a firm based on his research work and eventually resigned his position in 1937, partly as result of his frustration with Hopkins' administrators stance on this matter.[18] The firm he founded, Baltimore Biological Laboratory, proved successful and was acquired by Becton Dickinson in 1955. In 1948, the Hopkins Board of Trustees adopted a position on patent ownership that was supportive of the practice of the School of Medicine.[19]

The cost and complexity of effectively managing a patent portfolio certainly played a role in steering some university administrators away from patenting,[20] the fact remains that the culture of the academic research community at the time was, by and large, opposed to appropriating private gains from academic research. For example, Harvard did not change its policy of not filing for patents on medical inventions until 1975, about the same time that Hopkins reconsidered it patent policy (Matkin, 1990: 62).

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16 Committee on External Relations, Report to President Ames, 4/18/33. Available at the Johns Hopkins Medical Archive.

17 Excerpt from JHU's 1933 Advisory Board of the Medical Faculty Meeting, Chapter 7: Medical Patents. Available at the Johns Hopkins Medical School Archives.

18 The correspondence between Leifson and Hopkins' authorities can be found in the "Einar Leifson" folder at the Johns Hopkins Medical School Archives.

19 Johns Hopkins University Patent Policy adopted at meeting of the Board of Trustees, May 31, 1948, Chesney Medical Archives, folder Patent Policy 1947-1949.

20 See Matkin (1990: 56-80) for an account of other universities' early patent policies. In some cases, large investments in patents and start-up companies proved costly mistakes.

IV. Funding Sources

Another possible explanation for the stance towards formal technology transfer is that the main funding sources of academic research did not reward or even actually discouraged profit-making resulting from the research that they had supported. Private foundations, which until the Second World War supported the bulk of medical research, typically opposed patenting the results of the research that they had supported (Matkin, 1990: 61).

Following World War II, the age of massive federal government support of academic researchers pursuing paths deemed of national as well as scholarly interest there was little expectations of direct technology transfer. Actually, the direct result of this new source of funding was that "rather than focusing on the more immediate practical and applied R&D needs of private industry, academic research became more concerned with the basic and long-term applied research agendas of the federal agencies" (Abramson et al., 1997: 98) because the conduct of research through federal sponsorship became a source of prestige and autonomy within the academic profession.[21] Since a majority of academic research funds were now allocated through a system of peer-review evaluation guided by "best-science" principles, the new environment further reinforced differences between the two sectors' research cultures. As a result, "throughout [the post-war period] the transfer of technology from academic research institutions to industry was treated generally as an ancillary activity by most major research universities" who considered their primary contributions to the technological capabilities of American industry to be "well-trained graduates, published research results, and faculty consultants" (idem). A letter written to Hopkins' President Steven Mueller in 1981 illustrates the perspective of the local business community:

> I feel one of the basic premises should be that the University desires or is even obligated to foster a closer working relationship with industry in the interest (a) of

[21] Abramson et al. (1997: 371) point out, however, that despite this general shift in orientation, many institutions retained a commitment to industrial extension service and regional economic development even as they took on support of federal agency missions. Among these were many of the original land grant colleges, as well as other institutions such as the Georgia Institute of Technology, Rensselaer Polytechnic Institute, Pennsylvania State University and the University of Minnesota Mines Experimental Station.

> stimulating the development of business and industrial technology for the benefit of mankind in general; (b) of participating in the "re-industrializing" of America and (c) of improving the economic development climate in the immediate geographic area in which Johns Hopkins resides. As to (a) and (b), many of the strong links that used to exist between many universities and industries have been allowed to erode or disappear altogether under the dominance of government sponsored research at universities. The amount of industry sponsored research whether carried on internally or at universities has declined dramatically in the last several decades - a decline which has contributed greatly to our productivity malaise. As to c), Johns Hopkins has been or is perceived by many to have been aloof from the needs or wants or business and industry. It can be legitimately argued that ready and regular access to research and other facilities at The Hopkins would greatly enhance the opportunities to grow new business in this area.[22]

Certainly, an additional factor affecting technology transfer and the ability to generate spin-off firms is the area of technical expertise of faculty. Among academic disciplines, engineering is the most practically oriented and typically has extensive interaction with industry. While biomedical technology is currently an active area in university tech transfer, traditionally engineering schools had a more applied orientation that was amenable to commercial activity and perhaps most relevant to local economic development. We now consider the history of engineering at Hopkins.

V. Engineering Education and Research

A school of engineering was not part of the original vision for the university (Feldman and Desrochers 2002). At the turn-of-the-century the state of Maryland policy makers, Hopkins' home state jurisdiction, argued for engineering education to make up for deficiencies in the state system of higher education. For instance, despite all the distinction of its chemistry program, Hopkins graduates received few job offers from manufacturers in its early years (Bruce, 1988: 341). By the first decade of the twentieth century, some observers complained that as many as 300 young men annually left the state to attend northern institutes of technology, while others who might have wanted to pursue an engineering degree were held back because they could not

[22] Letter from John S. Lalley to Dr. Steve Muller, President, The Johns Hopkins University, January 19, 1981. Available at the Johns Hopkins Medical Archives, Box 5/R127I16, Folder "Industrial Liaison 1981".

afford to study outside the state of Maryland (French, 1946: 166). The state legislature provided $600,000 in 1912 to launch a technical engineering program to put a halt to this exodus and promote state industry.

From the outset, some Hopkins faculty insisted that this money be used to create a model for advanced study and research in engineering that would promote a less technically oriented curriculum and focus on graduate studies, thus distinguishing itself from other polytechnic schools (French, 1946). According to Yoe (1989: 5): “A few faculty members felt strongly that formal instruction in an essentially pragmatic field was inconsistent with the University’s role and ideals,” while others even suggested that the university use the state’s money to expand graduate study in the natural sciences.

The Department of Engineering opened in 1912 and became a School in 1919. It had, in its early decades, a strong Maryland component in terms of its student body, corporate support, links with local high schools and night courses for technical workers (French, 1946; Yoe, 1989). Despite this early orientation and success, engineering only achieve tenuous success at Hopkins. The post World War II years marked the beginning of a progressive dissociation between Hopkins’ engineering and practical concerns. The fate of Hopkins’ engineering in the post war era, however, cannot be understood without a brief introduction to the impact that federal (especially military) funding had on American engineering education at the time. According the historian of technology Eugene Ferguson (1992: 157-168), the advent of massive federal funding was accompanied by a rapid shift from practicalism to so-called engineering science. In essence, the new approach called for the elimination of courses having a high vocational and skill content and the creation of more theory-laden curriculum.

In many ways, Hopkins was a pioneer of the new approach. Early signs that the engineering science approach could be found in a 1944 report that recommended that much of the “handbook” material of specialized methods courses be dropped in favor of increased emphasis on basic science and engineering principles along with work in social studies, the humanities and oral and written expression. For example, “Heat Engines” was eventually replaced by the study of “Thermodynamics” and “Electrical Machinery” by “Circuit Analysis” (Yoe, 1989: 41). While suggestions in further reports to drop undergraduate education were not adopted, graduates of the School were soon awarded “Bachelor of Engineering Science” degrees

(Yoe, 1989: 41) and given a much less “hands-on” education than their predecessors. The graduate program was soon geared toward the training of university teachers and researchers, while the new hiring policy resulted in an increasing number of faculty with training in the sciences rather than engineering, in the process blurring the line between research engineer and research scientists.

In 1961, the School of Engineering changed its name to the School of Engineering Sciences, while older subdivisions merged or expanded the “science” aspect of their work. As the training given at the engineering school came increasingly to mimic the offering of the science departments of the university, engineering at Hopkins was merged with the rest of the Arts and Sciences faculty in 1966 to create the School of Arts and Science. Following the merger, the word “engineering” almost disappeared from campus (Yoe, 1989: 52).

The School of Engineering was recreated in 1979, in part to allow the university to rebuild its ties with industry (Yoe, 1989: 56). It can be argued, however, that engineering at Hopkins still bears to this day the imprint of the post WWII era. As then vice-provost for research Jared Cohon described it a decade ago (Levine, 1990), most faculty at the engineering school focused on relatively abstract questions and received the bulk of their funding from a handful of federal agencies such as the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the various branches of the Department of Defense (DOD) and very little funding from industry. Furthermore, as one faculty member pointed out to us in an interview, there is relatively little consulting to private industry done by Hopkins’ engineering professors. This is reflected, among other things, by the fact that while Hopkins as a whole always ranked among the best American universities in terms of total research expenditures, its percentage of industry sponsored research as a portion of total research expenditures still ranked the second to lowest among the top 20 universities in the 1990’s (Abramson et al., 1997).

V. Legacy of Past Technology Transfer Efforts at Hopkins

Despite its basic research orientation, Hopkins prides itself on the fact that past basic breakthroughs often led to useful commercial applications[23] For example, the drug heparin, used to prevent blood coagulation in the treatment of thrombosis and cardiac surgery, was discovered in a series of experiment between 1916 and 1918. Merbromin, discovered in 1919, and was later developed and marketed as mercurochrome by the Baltimore firm of Hynson, Westcott & Dunning. Similarly, some of the early work carried at the SHPH dealt with the causes of health problems related to epidemics, malnutrition and environmental toxins and led to discoveries that resulted in important commercial products. Among the most significant achievements of these days was the discovery of vitamin D in 1922 which proved useful in preventing rickets. Work conducted in the 1930s and 1940s which led to the discovery of how the polio virus spreads and invades the nervous system and which would eventually set the stage for an effective vaccine. These discoveries, however, typically brought no private benefits to academic researchers and the university.

In the few cases where a discovery or a technology seemed to hold significant commercial promise, more entrepreneurial faculty left academia to work full-time in the private sector. We have already briefly discussed the cases of Constantin Fahlberg and Einar Leifson, but they were by no means the only ones. For example, according to Fee (1987: 116), one of the most lucrative inventions of the early years of the SHPH occurred in the department of bacteriology at the initiative of a voluntary worker, Veader Leonard, who discovered the bactericidal action in the genito-urinary tract of a new disinfectant, hexylresorcinol, when it was given orally. During the 1920s, Sharp and Dome, a local pharmaceutical company,[24] gave the school $5,000 a year to continue this work under Leonard's direction, a sum which actually more than doubled the department's research budget. A research team confirmed the clinical usefulness of the product, which led to strong interest by pharmaceutical companies and the medical community. As a result of this commercial breakthrough, however, several younger faculty members involved in this research left to work directly for better salaries at Sharpe and

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[23] For a detailed list of Hopkins academic breakthroughs, see the following links: www.jhu.edu/news/news_info/research.html; hopkins.med.jhu.edu/BasicFacts/discovery.html; www.worldcare.com/e_consultations/consortium/johns_hopkins.html

[24] Sharpe and Dohme merged with Merck in 1953.

Dohme. On the other hand, accounts of the success related to MIT and Stanford stress the importance of the entrepreneurial mindset of many individuals on their faculty and the ability to combine industry consulting with academic work. For example, when MIT president Karl Compton ruled in the 1930s that professors could spend 20 percent of their time on outside consulting, he did it "to rein in their outside activities, not to encourage them" (Rosegrant and Lampe, 1985: 18). Evidence of the Stanford entrepreneurial spirit is provided by McCormack (1998:1) who points out that "Stanford's previous dean of engineering, Bill Kays, said that if an engineering faculty member wasn't consulting with industry, "he wasn't sure if he should be on the faculty." A different scenario recently unfolded at the Applied Physics Laboratory,[25] when the laboratory's top expert in radio frequency electronics left in its first spin-off company (Schafer, 1999).

Success in generating successful spin-off companies is not an easy undertaking and requires repeated attempts and learning by trail and error. Hopkins did not generate many spin-off firms and when the earliest were not successful it reinforced the idea that commercial activity was not an appropriate activity for the university. The first significant firm based on Hopkins' research, was the Rowland Telegraphic Company (RTC) which was formed in 1898. As noted earlier, Rowland was Hopkins' first appointee in Physics and his distinguished academic career led to, among other honors, election to the National Academy of Sciences, the Royal Society and the French Academy of Sciences. In the late 1880s, a routine medical examination for an

[25] The Applied Physics Laboratory (APL) was started in 1942 in a D.C. suburb by a group of scientists and engineers under the sponsorship of the Office of Scientific Research and Development who were trying to improve the effectiveness of Allied anti-aircraft shells through the development of a very small radar radio tube. Unlike many other defense laboratories led by universities that were disbanded at the end of the war, the APL thrived because of its expertise in guided missiles to defend naval ships against air attacks. Because of its strong link with Hopkins (many of the early participants at APL were Hopkins graduates and Luke Hopkins, a member of JHU's board of trustees, undertook to be personally responsible for APL during the war years), the Navy asked the university to continue to be responsible for APL which in 1948 became a permanent division of the university. While the addition of APL to Hopkins was significant in monetary terms (its payroll was comparable to that of the entire university), it never shared Hopkins' commitment to the free-flow of knowledge. Indeed, while Hopkins's administrators prohibited "closed" research in any of its academic division throughout the history of the institution, APL was

insurance policy revealed that Rowland had diabetes, an incurable illness at the time, and he was told that he had at most 10 or 15 years to live. As a result, he soon engaged in more applied work in telegraphy and hydroelectric power, which led to both inventions and consulting activities. As he wrote in his diary: "The certainty of my death in a few years entirely changed my life and I worked for money for wife and children as I never expected to" (quoted by May, 1995, n.p.).

In the mid-1890's, working at the university's state-of the art Physical Laboratory, Rowland invented an improved multiplex telegraph. His innovation, simply put, was a method of rapid automatic telegraphy by the use of powerful alternating currents. Hopkins' Presidents Gilman and then Remsen supported Professor Rowland, not only morally, but also financially. The Physical Laboratory was freely placed at his disposal during the entire course of his work in developing his invention, and he was allowed the greatest latitude as to the disposition of his own time with relation to this special work (Anonymous, 1902: 540).

Rowland also benefited from the support of wealthy Baltimore businessmen who financed the creation of the Rowland Telegraphic Company. Yet despite Rowland's brilliance and the practical experience that his partners brought to the venture, the RTC story illustrates the difficulties in turning an academic laboratory invention into a commercially successful product. As the company president put it in his annual report of 1907 (Rowland Telegraphic Company, 1907: 1):

> "The Rowland Telegraphic Company, seven years ago, undertook to develop a commercial machine to embody an original invention. There were no precedents to follow. The questions presented were new in mechanics and electricity; the laboratory could only afford artificial wires but not the varying conditions of the real telegraph line. We were, more than we realized, feeling our way in the beginning, but we found that Rowland had grasped... the real needs for a new telegraph system. This fact opened up to us the widest experimental use of telegraph wires ever accorded to a new invention. The work thus went forward with the combined advantage of laboratory and field experience. It grew upon our hands into an undertaking far greater than we had foreseen. We soon found that it was not enough to demonstrate the working principles of Professor Rowland's invention, and that only a fully commercial machine would (or could) prove the availability of the invention in commercial use; and that alone after commercial trial upon circuits of

always allowed to engage in classified, or secret, work. Klingaman (1993) is a popular history of APL.

> varying environment and length, and for a long enough period and thoroughly enough to show its durability and regularity and the ability of the employees to manage it."

The transition from the laboratory from the field proved especially difficult. According to the same source, it was necessary to perfect the function of each part of the machine, to standardize all the components, to make special tools and jigs and to ensure that all similar parts were exactly alike. Furthermore, the integration of the machine in existing systems meant dealing with a diversity of telegraph wires, the complex phases of handling traffic, the difficulties met in changing the character of the operator. The owners and personnel of the RTC also discovered that a new invention had to be shown universally applicable before it was introduced at all. As the company president reported: "This elaborate work was wholly unexpected. It led to repeated remodeling, but progressive successes always justified the continuance of our work" (idem). The RTC went out of business in 1910 and had no discernable impact on Baltimore's economy.

A somewhat more significant early century Hopkins' contribution to the commercial realm was the patenting of silica gel in 1919 by chemistry professor Walter A. Patrick, who had found it useful for the adsorption of vapors and gases in gas mask canisters. (One could argue, however, that this was actually more the discovery of a new use, for silica gel had been known as early as 1640, but had remained a curiosity until its adsorbent properties were found useful during World War I.) Dr. Patrick reached an agreement with what is now Grace Davison, a Maryland-based chemical company, to further develop the substance. Again, however, the transition from the laboratory to the commercial world was a long and arduous one. Davison first began selling silica gel in 1923 and began building its K-1 silica gel plant in Curtis Bay (Maryland) in 1927 but it was not until World War II that silica gel received wide acclaim.[26] Once more, however, much development work had been needed to develop the original academic breakthrough and new applications had to be found for the product before it became a commercial success.

Remsen's attitude toward saccharin, the administration's stance towards Leifson, the long

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[26] From the history of the Grace Davison company, http://www.gracedavison.com/about/history.htm.

gestation period before practical uses were found for Silica Gel and the lack of success of the RTC might have left some imprint on Hopkins organizational culture during its first decades, but were probably forgotten in the post World War II years when massive governmental funding had increasingly removed academic research from commercial concern. Some individuals nonetheless then tried to market their discoveries and inventions. The most significant event in that respect, however, proved to be a spectacular and embarrassing failure, the intrauterine contraceptive device (IUD) *Dalkon Shield* (DS).[27] Although the university was not directly involved with the product and the subsequent court cases, the episode created a reluctance to explore the commercial realm.

The Hopkins faculty involved in the development of this device was Hugh Davis, an obstetrician and gynecologist at Hopkins Medical School and director of Hopkins' Family Planning Clinic. Davis was one of many physicians who began experimenting with new models of IUDs in the 1960s and eventually came up with a closed ring device that he called the "Incon Ring". In 1968, he teamed up with electrical engineer and inventor Irwin Lerner and his attorney Robert E. Cohn to market his product. Lerner quickly improved on Davis' innovation by adding lateral spikes, a central membrane, and a multifilament "tail" to it. These adaptations were intended to decrease the expulsion rate of the apparatus, increase its surface area (which Lerner and Davis believed an important factor in the effectiveness of an IUD), and make it easier for doctors to check its position in the uterus. The new device was labeled *"Dalkon Shield"* and was patented under Lerner's name. According to then Hopkins legal council, Davis had offered his invention to the dean of the JHMI, who, however, declined the offer.[28] As a result, the Dalkon Shield lost its intellectual property connection to Hopkins. Davis began testing the DS at Johns Hopkins Family Planning Clinic in 1968 and performed a study involving 640 women whose results were published in the American Journal of Obstetrics and Gynecology.

The partners in Lerner Laboratories eventually formed the Dalkon Corporation[29] to

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[27] The early history of the DS has been told, usually in dramatic terms, in many outlets. See Mintz (1985), Perry and Dawson (1985), Sobol (1991), Grant (1992), Hicks (1994) and Hawkins (1997).

28 Personal interview with Frederick T. DeKuyper, December 2000.

29 The corporation was owned 55 percent by Lerner, 35 percent by Davis and 10 percent by Cohn.

market their device, which hit the market in January 1971 after A. H. Robins, a large and well-respected Richmond (VA) drug company,[30] purchased the DS from the Dalkon Corporation in June 1970. Davis and Lerner accepted positions as consultants to the company. Davis, in the meantime, had boosted his product by appearing in a 1970 Senate hearings where he made a strong case against oral contraceptive and by promoting his product as the "superior modern contraceptive" in both professional and lay publications.[31] However, important problems related to the use of the DS soon emerged and eventually led to legal battles that culminated in A.H. Robbins' petition for bankruptcy in 1985.[32] The *Dalkon Shield* case has since then been portrayed in numerous instances as "a story of corporate greed and callous disregard for the reproductive health and emotional well-being of women" (Hicks, 1994: vii), while women who experienced negative side-effects and complications were typically labeled "survivors" (idem) despite the fact that the literature on the topic, while long on cases of "bleeding, pain, inflamed and perforated uteri, spontaneous abortions, infertility, sterility, birth defects in offspring" and "psychosocial damages" such as "strained or failed personal relationships" (idem, vii and 2) is rather short on actual cases of fatal illnesses directly attributable to the DS.[33] Indeed, one can find reviews of the studies that indicted the DS that labeled them "inconclusive" and gave credence to A.H. Robbins's defense that blamed most of the complications experienced by women not so much to the DS, but to other factors such as promiscuity, poor hygiene and incorrect use of the product by physicians (Kronmal et al., 1991; Mumford and Kessel, 1992). Whatever the merits of the Dalkon Shield case and despite the fact that Hopkins was never involved in liability suits, this episode proved to be a public relation embarrassment for the

[30] Some of the most well-known products of A.H. Robins are Chapstick and the cough syrup Robitussin.

[31] There were more than 70 other IUD alternatives available in the early 1970's.

[32] Actually, through reorganization proceeding, Robins' managers and shareholders were able to eliminate all individual and corporate liability for injuries related to the DS. The firm was acquired by the American Home Products Corporation which paid $2.3 billion to a trust that was responsible for settling or defending, and paying the claims of injured women (Sobol, 1991).

33 Most claimant organizations in the DS case mention the number of 20 "documented deaths" attributable to the DS. The total number of women who used the DS IUD between 1971 and 1974 is generally estimated to be around 4 millions (Hicks, 1994).

university and, according to Hopkins legal council at the time, made Hopkins' administrators weary of similar ventures for a long time.

VI. Conclusions

American research universities have long been recognized as important actors in technological change and economic development and as a source of basic knowledge, technical solutions and skilled workers for American industry (Nelson and Rosenberg, 1992; Abramson et al., 1997). The university's relationship with firms and the traditional mechanisms by which academic knowledge was transferred to industry - such as publishing, consulting and the hiring of students and faculty by the private sector - have in recent decades been supplemented by more formal policies and arrangements such as sponsoring university research, licensing university intellectual property in the forms of patents, and promoting the formation of spin-off firms by providing incubators, equity investments and incentives to faculty. Much of this activity is done in the hope of generating increased regional development and capturing the benefits from proximity to the university. While knowledge spillovers from universities exhibit a strong geographic localization there are many factors that affect the transmission and absorption of these spillovers (Feldman 1999 reviews this literature). This paper has explored the institutional context of universities including the university's founding mission, the expectation regarding patenting and the ownership of intellectual property, the types of funding sources and their expectations regarding what constitutes appropriate activity and the success or lack of success of institutional experiences, degree of risk aversion and commitment to change.

There are several reasons why we find that Hopkins has not generated highly visible economic benefit for the local area. One of the most important in our opinion is that it was never one of the university's objectives. Consequently there was a general lack of incentives and encouragement for commercial activity that might have potentially benefited the local area. This mission and academic culture institutionalized the norms of open science and stand in sharp contrast to the economic extension orientation of the Morrell Act land grant institutions or the decidedly more commercial orientation of MIT or the economic development mission put forward by Leland Stanford. Another possible reason which was not examined in detail in this paper is that the type of basic work conducted at Hopkins was less amenable to direct technology transfer than the work conducted at institutions with a much stronger engineering curriculum, such as Stanford and MIT. But it is difficult to attribute causality in this exercise as universities with a more practical orientation will develop programs and expertise to satisfy their institutional mission.

When industrial activities occurred through the initiative of individuals or through personal circumstances, there is no evidence of success. This appears to have only reinforced the norm that this more applied commercial work was not an activity suitable for the university.

History and institutional context matter. Link (1998) concludes that the development of North Carolina's Research Triangle Park was the result of deliberate public policies that began in the 1920 and took fifty years to realize tangible economic benefit in terms of job growth and enterprise development. Understanding historical context, early failures and false starts are an instructive though unfortunately overlooked heuristic that provides perspective on current activity and performance.

While there are clear indications that change is underway as a result of increased support of technology transfer activities, the legacy of the past remains. As current vice-provost for research Theodore Poehler – a man who has spent more than 50 years in various divisions of the institution – put it in a recent interview, commercializing research "just wasn't something people did. Hopkins was a place where you would come to be an academic person and do research, and that's that. Most people here today are still here for that reason" (Cavanaugh Simpson, 2001: 16). A decade ago, the ophthalmology professor Robert Massof characterized the attitude of his colleagues toward the business world in the following way: "Academics tend to think that money from business is tainted, that dealing with business is a form of prostitution" (quoted by Levine, 1990: 26). Jared Cohon, then vice provost for research, echoed this sentiment: "There's just been a different kind of culture here. I can't explain why it happened that way, but I accept it as real. We've always been a basic research, individual-investigator, federally-funded institution, the kind of place that emphasizes the creation of knowledge for its own sake" (idem).

The new role of universities as engines of local economic development (Feller 1990) or magic beanstalks of invention and research (Miner et al 2001) places new demands on universities and raises question about the role of research universities in advanced economies. Although not the emphasis of this paper, the history presented indicates some of the problems inherent in the new role prescribed for universities. Others have raised the concern that universities are being asked to deviate from an historically successful role in the U.S. system of innovation and that commercial influences may destroy the norms of open science that have promoted the national interest (Nelson 2000; Slaughter 2001). These same concerns may be raised at the regional level. Universities certainly add more to their local economies than the metrics of technology transfer capture. And there are certainly many different models of how universities interact with and enrich their local economies than the well-known examples portray.

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Table 1: Differences in the Ratios of University Technology Transfer Activities: 1997

University	Total Research Expenditures	Adjusted Royalties Received	Licenses Generating Royalties	Start-ups Formed	Invention Rate	Royalty per License
UC System	$1,586,533,000	$612,800,000	528	13	4.51	$116,061
Johns Hopkins	$ 942,439,696	$ 4,686,519	103	3	2.43	$ 45,500
MIT	$ 713,600.,000	$ 19,860,549	255	17	5.04	$ 77,885
Washington Research Foundation	$ 528,602,441	$ 11,478,605	142	25	5.30	$ 80,835
Michigan	$ 458,500,000	$ 1,708,939	83	6	3.66	$ 20,590
Stanford	$ 391,141,224	$ 34,014,090	272	15	6.34	$125,052
Wisconsin Alumni Research Foundation	$ 379,600,000	$ 17,172,808	133	2	5.24	$129,119
Harvard	$ 366,710,262	$ 13,402,273	232	1	3.25	$ 57,768
UNC-Chapel Hill	$ 263,517,405	$ 1,665,909	61	2	3.57	$ 27,310
Columbia	$ 244,100,000	$ 46,105,192	201	4	6.02	$229,379

Source: Feldman et al (2001). Data from the 1997 AUTM annual report and Chronicle of Higher Education articles.