Demand vs. Supply Driven Innovations: US and Swedish Experiences in Academic Entrepreneurship *

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Abstract: Measured by per-capita publication measures, Sweden is an academic powerhouse. Hence, its inability to commercialize on these accomplishments is a puzzle. This paper attributes this failure to the top-down nature of Swedish policies aimed at commercializing these innovations as well as an academic environment that discourages academics from actively participating in the commercialization of their ideas. This sits in stark contrast to the US institutional setting that is characterized by competition between universities for research funds and research personnel, which in turn has led to significant academic freedoms to interact with industry, particularly by founding new firms. We conclude that the technocratic, supply-driven nature of attempts to exploit academic output in Sweden has been markedly less successful than the demand-driven market institutions in the US.

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1. Introduction

Measured by per-capita publication measures, Sweden is an academic powerhouse. Hence, its inability to commercialize university research results is a puzzle. An important clue to this puzzle comes from a growing body of evidence that the role of academics in commercializing their discoveries is critical. This paper compares the different incentive structures that academic researchers face in the United States and Sweden and demonstrates that in Sweden academics face strong disincentives to take the time away from their academic pursuits to facilitate knowledge transfer to the commercial sector.

Recent surveys of Technology Licensing Offices in US universities have revealed an important clue: commercialization of university ideas generally requires the continuing involvement of academic inventors. In the US, the competitive nature of the university environment along with legislation such as the Bayh-Dole Act has caused universities to adopt policies to encourage the continuing involvement of academic researchers, thus facilitating the transfer of ideas to the private sector.

The Swedish experience is quite different and somewhat confused. On the one hand, the Swedish government has invested lavishly in university research that has, in turn, produced impressive *academic* results. At the same time, it has enacted a rich set of policies to facilitate the transfer of these results to the commercial sector. Unfortunately, this effort has largely failed to create incentives for academics to remain involved in the commercialization of their ideas. Not only have academics historically faced limited potential upside gains to entrepreneurial ventures due to a restrictive commercial environment, but the policies have not succeeded in limiting the downside risks vis-à-vis inventor’s academic careers. A key problem has been the failure to provide universities with incentives to encourage academics' commercial activities.

It should be understood that we are not recommending, in what follows, that Swedish universities should treat American arrangements as a role model, especially insofar as

that model implies the suppression of some traditional academic norms. Rather, we invoke the American experience for the insights that it may provide for Sweden's limited achievements in transferring technology from its universities into various sectors of the economy. We also believe that there are many similarities between the Swedish university system and those of continental Europe, inasmuch as their universities are essentially parts of larger national bureaucracies and therefore compete with one another to only a rather modest degree. We suggest, then, that the conclusions that we draw from our analysis may also be applicable in a larger European context.

The paper proceeds as follows. In section 2, we provide an assessment of the Swedish experience in commercializing results of academic research. In section 3, we discuss the American experience and the importance of academic involvement. Section 4 discusses Swedish policies aimed at technology transfer. Section 5 explores the impact of university policies on the supply of commercially relevant ideas. Section 6 concludes.

2. Commercialization of Academic R&D – An Assessment of the Swedish Experience

The data that directly relates to the transfer of technology from Academe to the private sector in Sweden is sparse and difficult to interpret. However, it is fair to conclude that transfer, when it does occur, does not lead to the establishment of dynamic, fast growing technology-based firms. In fact, such firms are rare in Sweden in general. In a comprehensive review of 60 firms founded between 1965 and 1974 and based on new technology, Utterback and Reitberger (1982) found that total employment in these firms in 1980 was 4,640 domestically and 970 abroad. To help calibrate this number, note that domestic employment from these firms was only one half of one percent of total employment. Rickne and Jacobsson (1996) update the study by following 53 of these firms through 1992 and find that the employment in these firms *decreased* to 3,400 domestically.[1] Rickne and Jacobsson (1999) study *all* new technology-based firms

[1]Seven firms were excluded due to liquidation or because they no longer fitted the original selection criteria. The original criteria for selection was that they should be 100% Swedish owned, have a

founded in Sweden between 1975 and 1993 (and still in existence in 1993). The 1,284 firms that meet these criteria employed only 19,488 people, and only three of them had more than 200 employees with none more than 300. As a comparison to the US, and granting the far greater size of the US economy, one may mention that Sun Microsystems alone, founded in 1982, has in excess of 25,000 employees, i.e., more than the sum by 1993 of all the new technology-based firms founded since 1975 in Sweden.

A subset of this phenomenon is reflected in the few studies that have focused on technology-based firms founded by university faculty. Olofsson and Wahlbin (1993) find that of the 569 firms founded between 1974 and 1989, 60 percent remain very small with total annual sales below SEK 2 million, and most are part-time consulting firms. This trend may be changing. For the 427 firms known to have been founded after 1980, 30 percent have total sales exceeding 5 million. However, direct employment and production effects of the activities of these firms are small: Total sales of all the firms were SEK 3 billion and the firms employed only 3,500 workers.

The slow-growth phenomenon may be even more pronounced in university spin-offs than commercial spin-offs. Lindholm Dahlstrand (1997a, 1997b) specifically addresses the issue of how new technology based firms with their roots in universities perform relative to firms with a different origin. This is done by identifying all spin-off firms in the Utterback and Reitberger (1982) sample and by including all spin-offs from the Chalmers Institute of Technology in Gothenburg. She finds that university spin-offs consistently grow much more slowly than other spin-off firms.

The point of this section was to demonstrate not only that the influence of new firms on the Swedish economy has been meager in recent years, but also to make a more subtle point: any assessment of the expected return of a new venture is likely to be low. There

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minimum of 20 employees, a turnover of at least SEK 5 million in 1980 and manufacture a product of their own design.

are no anecdotes in Sweden, such as Sun, which will influence potential entrepreneurs' decision making process.

3. The American Experience and the Importance of Academic Involvement

Although start-up firms and academic entrepreneurship are important mechanisms in commercializing university ideas, they are not the only ones. Unfortunately, comparison of the Swedish experience in commercializing university ideas to that of the US is confounded by the nature of the data. The unit of observation in Swedish studies is the firm, or spin-off. However, in studies of the US experience the unit of observation is the *invention*. There is also generally data concerning the method by which the invention was commercialized, if at all. The reason for this difference foreshadows some of the conclusions of this study. The US data has been collected in various efforts (see below) from university technology licensing offices (TLOs). American universities have an incentive to operate TLOs as they own the ideas that are developed within their walls and are potentially remunerated when these ideas are exploited commercially. University faculty members are required to complete invention reports periodically and the TLO assesses their potential commercial value. The TLO then negotiates technology transfer agreements with firms seeking to commercialize the technology. In Sweden, property rights for innovations lie entirely with the inventor. Without an incentive to facilitate the transfer, central records of each innovation are unavailable. This is unfortunate, as the concern of economists is not whether new firms are being formed, but rather whether university ideas are being commercialized and hence improving welfare. The US data provides a more complete picture in which to assess this question.

This point cannot be overemphasized. In the Swedish studies, the criteria for entering the study is whether or not the firm was founded by university based faculty. However, in the US there are numerous cases where university ideas were commercialized by methods other than the foundation of new firms (see Shane, forthcoming; Jensen and Thursby, forthcoming; Goldfarb, 2001b).

An overriding fact that has significant bearing on our conclusions is the following: *most university inventions require continuous involvement of the inventor to be successfully commercialized***.** In the US, ideas reach TLOs in primitive states and much critical knowledge is often tacit. In one survey, Jensen and Thursby (forthcoming) find that at least 71 percent of the inventions require further involvement by the academic researcher if they are to be successfully commercialized. 48 percent of the ideas are in proof of concept stage, 29 percent have a prototype available on a lab scale and for only 8 percent is manufacturing feasibility known. This presents a potential difficulty in commercialization of university ideas. The incentive structure of academics does not encourage commercialization activity. If anything, such activity is generally discouraged as it diverts effort from more fundamental research endeavors (Goldfarb 2001a). Hence, successful technology transfer requires the creation of incentives and the weakening of disincentives for the academic to direct effort towards commercialization activities (Goldfarb 2001b). The incentive structure does not necessarily take the form of these academics founding new firms, rather, there are basically three possible mechanisms of further involvement in the project and three possible mechanisms of inventor compensation. They are generally used in some combination.

The form of inventor involvement most preferred by academics is research grants whereby the researcher continues research in her lab that is relevant to the commercial endeavor. This arrangement allows the researcher to hedge the downside risk of lost academic opportunity inherent in putting forth effort towards the new venture. Generally there are special provisions that allow the sponsor to extract rents from the potential results stemming from sponsored research. The second form is consulting arrangements whereby the researcher either spends a limited amount of time working for the firm and/or takes up a position of one of the firm’s boards. Finally, the academic may found a new firm.

The first form of academic remuneration is wages. This mechanism provides the weakest incentives to the academic to further the commercialization of the invention, as rewards are not tied to the outcome of the venture. Two alternatives are more successful to this end: a. providing some sort of performance based payment structure, such as licensing royalties, or b. equity compensation. Jensen and Thursby, demonstrate theoretically that equity will elicit more researcher effort than the other methods.

Although our understanding of when and in which combinations each of these mechanisms is chosen is incomplete, there are some clues. Shane (forthcoming) finds that when patent protection is weak, TLOs are more likely to license inventions to the inventor. Generally, this involves licensing the invention to a new startup, or in the language of the Swedish studies, to a university spin-off. This result suggests that when knowledge is tacit and property rights are weak, the best means to provide incentives to the academic researcher is via equity, which is a more powerful incentive in a young, small company. Because of the primitive nature of the technology when these firms are founded, the risk is considerable. Di Gregorio and Shane (2000) find that universities are more likely to produce spin-offs if they are willing to make equity investments in new firms in lieu of royalty agreements. This solves two problems. On one hand it shifts some risk from the new firm to the university, as some royalty payments are often required before any revenues are produced and second, it attenuates some of the problems new firms face with liquidity constraints.

The point of the previous discussion is by no means to downplay the role of academic entrepreneurship. On the contrary, academic entrepreneurship is often the most effective means to facilitate the technology transfer. It is important to understand, however, that it is not necessarily the best in all circumstances.

There is great variation within the US university system as to what extent the above mechanisms are available and used. It is likely that the broader the menu of options is in any given case, the more probable that an invention will reach its full commercial value. The Federal government has actively pursued policies aimed at facilitating this

commercialization. Most importantly, the Bayh-Dole Act in 1980 allowed universities to appropriate the property rights to an invention resulting from university research that was financed by federal grants. This Act was later expanded by public law 98-620. The fact that property rights were awarded to the universities rather than the inventor gave strong incentives to universities to set up their own offices of technology transfer that have become instrumental in negotiating the appropriate mechanism for commercialization. This US policy can be characterized as one that gave universities incentives to respond to a commercial opportunity, but did not dictate or even suggest what the best response to this opportunity was. The Act fostered and continues to foster much experimentation in the university policies how to best exploit this windfall of intellectual property. This is a "bottom up" approach.

The bottom up approach reaches well beyond government policy. The structure of the American university system is favorable towards such institutional experimentation and competitive forces have led universities to adopt policies that encourage commercialization of ideas. For example, American universities compete intensely for financial support to push out the envelope of research frontiers in disciplines that have come to produce useful knowledge. In recent years this has most notably been the case in microelectronics, computer science and molecular biology. This competition for funds has encouraged universities to accept grants from industry that restrict access to results stemming from the sponsored research, even though this is a policy that directly conflicts with well-established academic norms. An additional important dimension of American academic competition is reflected in a high degree of mobility on the part of faculty as universities compete for talent and prestige. As the commercial value of faculty inventions and services has become apparent, the demand for those services, especially those of highly reputable scholars, has increased. In response, universities have adopted policies needed to keep or attract these scientists. These policies include more liberal leave of absence and consulting privileges that generally allow the academic to pursue his commercial opportunities, while keeping his position as a faculty member intact (Kenney, 1986). Although there are potential benefits to such

policies for the university, there are also obvious costs. It is unlikely that such policies would have been adopted in a non-competitive system (Rosenberg, 2000).

4. The Swedish System for Technology Transfer

The Swedish system for technology transfer has been much more directed. Bureaucratic attempts to directly establish university policy have been the mainstay of Swedish efforts to facilitate academic entrepreneurship or other ways of technology transfer. As we shall see, these policies have largely ignored the importance of setting up incentives for universities and academics to pursue the commercialization of ideas originating in academe.

On the surface, incentives for faculty appear very strong: a 1949 law guaranteeing academic freedom also placed property rights emanating from their research entirely in the hands of faculty members (*lärarundantaget*). However, the outcome has been more complex. A consequence of full faculty ownership of property rights has been that the universities themselves have had little incentive to become involved in technology transfer to the commercial sector. In fact, as emphasized by Etzkowitz, Asplund and Nordman (2000) it has often been in the interest of universities to discourage contacts between faculty members and industry, since rigid civil servant pay schedules and other constraints have made it very difficult for them to retain highly valued personnel who have established personal ties with industry. Procedures for academic leave have not been adjusted to make it easier for professors to take temporary leave to organize firms in the manner that has become widespread in the US (see also Stankiewicz, 1986, p. 90).

Under these circumstances, Swedish academics are more likely to confine their external involvement to consulting activities, since to proceed further may force them to take a binary decision to leave the university, and few are prepared to do that (Etzkowitz *et al*., 2000). In a system that discourages faculty involvement with industry beyond consulting and where the property rights rest with the researcher, there is a lower

likelihood that the potential commercial benefits of academic research will be reaped. This is precisely because the downside risk of failure of the venture is increased as the researcher's faculty position is not ensured and the upside potential of the venture, as reflected by the low rates of growth of small firms, is not high. Hence, as emphasized by Vedin (1993), if the owner of the property rights shows little interest in exploitation, very little is likely to happen. This is also found by Etzkowitz *et al*. (2000), who conclude that "since most professors have little interest in commercializing their rights, or naively presume that discovery should somehow automatically produce rewards, relatively little use was made of these rights."

When property rights rest solely with the individual researcher, there is no "profit sharing" with his/her department. This has probably given rise to anti-entrepreneurial peer pressure at Swedish universities. Informal interviews as well as a recent government report on the collaboration between university and industry (SOU 1996:70, pp. 158–59) point to the existence of such pressure.

Several scholars studying the Swedish university/industry interface emphasize that, analogous to what Zucker, Darby and Brewer (1998), Audretsch and Stephan (1996) and Siegel, Waldman and Link (1999) have found for the US, personal contacts are essential (e.g., Uhlin *et al*., 1992 and Etzkowitz *et al*., 2000). It is clear, however, that these contacts have been mainly with large firms, and it has turned out that the large firms have preferred that these contacts remain informal in nature. In particular, the large firms have been very unwilling, or unable, to offer high-powered incentives to academics with whom they cooperate and, as a result, these academics tend to remain consultants. At times, consultancy is a very effective method of technology transfer. However, as evidence suggests, it is much more difficult to provide high-powered incentives to encourage academic involvement in the commercialization of their ideas when consulting is the only tool. This is, of course, yet another reflection of the Swedish large-firm model of high tech innovation (Granstrand and Alänge, 1995; Lindholm Dahlstrand, 1997a).

Henrekson and Rosenberg (2001) point out that the Swedish government has attempted to address the failures described above for the last quarter century. The policies used have included an extension of the universities' mandate in 1975 to communicate to the surrounding society results emanating from university research, and how they can be applied. This objective was eventually interpreted to imply collaboration between universities and private industry. This was formalized in 1998 (SOU 1998:128, pp. 153–154) where universities "are exhorted to be open to influences from the outside world, disseminate information about their teaching and research activities outside academia, and to facilitate for the surrounding society to gain access to relevant information about research results. Each university is also obligated to draw up and implement its own path for collaboration with the surrounding society. This plan has to be submitted for approval to the Ministry of Education" (p. 11).

This collaboration has taken many forms: commissioned research projects, industry consulting, doctoral studies hosted in industrial labs, salaries paid by industry, research institutes and other organizations run jointly by universities and industry, university employed contact secretaries who act as mediators between university and small and medium size businesses.

The success of these policies is mixed. Currently, industry-funded research has reached 2/3 of US levels, approximately 5 percent. University personnel are allowed to consult one day a week and often do. In contrast, the contact secretary program is generally regarded as a failure (Olofsson and Stymne, 1995). This is not surprising, as not only do they operate in a restricted environment; it is also unclear what incentives they have to facilitate the commercialization of university ideas. In contrast, American TLOs generally receive 15 percent of gross revenues generated through licensing or other mechanisms.

The Swedish government has also set up institutions designed to facilitate knowledge transfer and development. The government and private industry have financed 30 independent research institutes, which are geared towards specific industries (e.g.,

forestry, corrosion, fiber optics et cetera). About 2,000 researchers are affiliated with these institutes, although few of them hold Ph.D.'s. For example, NUTEK, the Swedish National Board for Industrial and Technical Development, universities, and private firms have established several "competence centers" since 1992. These facilities conducted about 500 man-years of research in 1996 with involvement of roughly 150 firms. This form of organization is growing, yet considering the need for faculty involvement in technology transfer, it is unclear how these organizations facilitate the necessary effort. There are very few, if any, serious evaluations of the results obtained by these organizations (Lundström *et al.*, 1998).

In addition, since 1994 seven broker institutions called Technology Bridging Foundations (*Teknikbrostiftelser)* have been established in major university regions. Their task has been to mediate commercialization of R&D from universities, SMEs and individual inventors by facilitating the patenting process, matching up VC funding etc. In addition, four foundations, such as the Foundation for Knowledge and Competence Development, have been established which, among other things, are intended to provide a bridge between the university and industry. Although it is too early to evaluate the performance of these institutions, they will have several hurdles to overcome. In mediating commercialization, the Technology Bridging Foundations seem designed to accept responsibilities that in the US lie in the hands of university TLOs. Since Swedish universities do not gain from this commercialization, it is fair to assume that resistance to such activities by administrators and other faculty will continue. In addition, an important part of the process that TLOs execute is the active solicitation of faculty invention reports. The bridging institutions are unlikely to have similar informational advantages.

The central difference between Swedish attempts at facilitating commercialization and the American experience is that in Sweden mechanisms are *designed from above*, while in the US they are encouraged to *evolve from below* and the intervention of policy has been largely to find ways to create incentives for such commercialization.

The above analysis has focused on the mechanisms best suited to facilitate the exploitation of university ideas and it also explored the rigid Swedish system so as to demonstrate that these mechanisms are often unavailable. However, it would be disingenuous to suggest that the reasons discussed above are the sole suspects for the lack of academic entrepreneurship. Sweden's private equity markets, underdeveloped until recently, has made it difficult to direct resources to commercialization efforts, its heavy taxation of entrepreneurial income dampens incentives to become an entrepreneur and its restrictive labor laws arguably are more harmful to small employers. These issues are discussed at length in Henrekson and Rosenberg (2000, 2001). During the last decade, Sweden has enacted several policies that have lowered the taxation of entrepreneurial income, relaxed some labor law restrictions and liberalized capital markets. Perhaps because of these policies, Sweden enjoyed an IPO renaissance in its stock market in the latter half of the 1990s. Furthermore, Di Gregorio and Shane (2000) find that the geographic proximity of VC funds is not a contributor to university start-ups, suggesting that if private equity markets are working at all, then good ideas will get funded. That said, Sweden's private equity market, even today, operates in a more restrictive environment than the US (Henrekson and Rosenberg, 2000, 2001).

5. The Supply of Ideas

Of more direct interest to this study because of its direct relevance to R&D policy, it is useful to explore to what extent the lack of academic entrepreneurship might be due to a low supply of university ideas.

It is straightforward to establish that there is extensive support for academic research in Sweden. R&D conducted in the university sector, as a share of GDP, is consistently the highest in Sweden when compared to the US and other OECD countries.[2] An extremely large share of R&D conducted by persons holding a Ph. D. is carried out in the

[2] As used here the term universities also includes colleges.

university sector in Sweden – in 1993 the total volume of R&D conducted by Ph. D.'s in Sweden amounted to 9,650 man years, and 52 percent (5,000 man years) of this volume was carried out at universities (SOU 1996:70, p. 32).[3,4] This generous concentration of resources has led to a comparable contribution to academic knowledge. In terms of publications (in recognized professional journals) per billion US dollars of GDP, Sweden was second only to Israel in 1995 in terms of publications relative to the size of the economy, while the US ranked 20th at less than half the Swedish level (National Science Board, 1997). Sweden has also consistently ranked very high in the biology-based disciplines, including especially clinical medicine and biomedical research (*European Science and Technology Scoreboard, 1999*, pp. 34–35). But, the fact that Sweden is producing academically valuable output does *not* indicate that Sweden is producing commercially valuable knowledge. One might suspect that a better-oiled university-industry interface will increase the production of commercially valuable ideas.

Attempting to establish whether or not commercial influences are strong enough to affect the direction of academic work (as opposed, for example, to influencing the sharing of information among colleagues) is a difficult proposition. There is a small literature attempting to shed light on this question, and the results are mixed. On one hand, Mansfield (1995) finds that university researchers who receive research grants from industry report that "problems they worked on in their academic research frequently or predominantly developed out of their industrial consulting – and in many cases, the cited academic researchers' government-funded work stemmed from ideas and problems they encountered in industrial consulting". Over 1/2 reported that the direction of their work and choice of topics was influenced by potential sponsors or users of their research output. This evidence suggests these researchers are producing knowledge that has higher *commercial* value than if they had lacked industry connections. Brooks and Randazzese's (1998) brief survey of evidence suggests that if

[3] It is approximately 6 percentage points higher when measured as a share of labor input rather than as a share of expenditure - see OECD, *Basic Science and Technology Statistics on diskette, 1997.*
[4] According to the same source 76 percent of total R&D at universities was in technology, natural sciences, biomedicine and agricultural sciences.

there is an effect, it is quite weak. We note that this implies that any affect on academic output does not correlate very well with its traditional measures, publications and citations. That is, by virtue of their connections with industry, there is little evidence to support the claim that university researchers are producing output of less *academic* value. Other evidence supports this conclusion. Goldfarb (2001a) finds that researchers supported from a very applied government program do not produce output that is less cited than those who do not.

Di Gregorio and Shane (2000) find that universities that receive research funds from industry are more likely to produce more startups. However, the effect, if it exists at all, is very weak. This suggests that the type of research being sponsored in research grants is not likely to lead to inventions that are best commercialized in new start-ups. Henderson, Jaffe and Trajtenberg (1998) find that the mean importance of university patents declined between 1965 and 1988, a time when commercial influence on academic research has been increasing. However, Thursby and Thursby (2000) suggest that universities have also exhibited an increased propensity to patent marginal inventions, which would suggest that Henderson *et al*. (1998) are finding a shift in university patenting policies rather than a shift in the overall portfolio.

The evidence of how the perception of entrepreneurial opportunity affects the choice of research decisions is limited to anecdotes. Kenney (1986) finds several examples of academic research being directed towards commercial goals when the principal investigator has a financial interest in a certain direction of research. However, these examples all pertain to research undertaken *after* a venture had begun and when the primary investigator had an equity stake in the sponsoring company. One might hypothesize that once researchers observe colleagues engaged in commercial activities, they might intensify their search for commercially valuable ideas themselves. Di Gregorio and Shane (2000) report a skewed distribution of start-up activities in a few universities, especially those located in areas with much entrepreneurial activity. This fact would support such a hypothesis. However, at present, it is not possible to determine whether this effect, if it exists, is small or large. This ignorance makes it

difficult to assess if the supply of ideas of potential commercial value in Sweden is retarded by simple comparison of incentive structures. Nevertheless, it is *unlikely* that Swedish university personnel have strong incentives to produce commercially valuable knowledge.

In contrast to the Swedish system, American universities are highly decentralized and intensely competitive. The decentralization implies that American universities retain a high degree of autonomy, thus pursuing opportunities for solving their own problems and for building upon their own unique strengths and aspirations. Competition takes place along several dimensions: (1) competition for students among universities (including competition between private and state institutions), and at the graduate level among professors for the best students; (2) competition among universities for the best professors in a cultural and economic context where the mobility of professors is very high; (3) competition among professors for research support, which provides released time from teaching and access to research assistants, equipment and other requisite materials. A university that can offer high quality teaching in fields for which there is a strong demand in labor markets can also charge higher tuition fees, which also leads to higher revenues.

As a result of the decentralization and the competition that takes place at so many levels, the US university system has become more responsive to the economic needs of society. In order to justify high tuition fees, students expect a high degree of relevance of the offered curricula. Likewise, professors who are dependent upon research grants in order to be able to pursue a successful research career, are more likely to adjust their research interests to fields that have a high current or expected future economic value (Rosenberg, 2000).

Because of the decentralization and the competition among universities for professors who are visibly productive, the American system tends to result in greater salary dispersion, where salary differences are likely to reflect the economic relevance of the professor's field of specialization as well as his/her higher achievements as a researcher

and teacher. Generally, professors active in research prefer to teach at the graduate level, where course content is closer to research at the frontier of the discipline and where students may come to play crucial roles in advancing those frontiers. Rosenberg (2000) presents evidence showing how rapidly entirely new fields as well as major breakthroughs in established fields have been introduced into the curricula at leading US universities over the years. In the US, therefore, universities can, to a considerable degree, be regarded as endogenous institutions that tend to be characterized by an impressive capability, as well as a strong incentive, to adjust to changes in the outside environment.

In these respects the Swedish and, for that matter, the corresponding systems in most other European countries differ substantially from the American university system. Traditionally, European professors have, by and large, been civil servants working within the public sector, which implies that a high degree of national uniformity has been imposed on pay schedules, rules for promotion and recruitment and other working conditions. Essentially, this is still the case also in Sweden, although it should be noted that greater flexibility in terms of pay schedules has been introduced during the 1990s. Nevertheless, the Swedish system differs from the American system in a number of important respects that are likely to impact unfavorably on the inclination to introduce changes in curricula and research orientation in order to accommodate the changing needs of the economy.

First, there is a greater separation of teaching and research. The bulk of undergraduate teaching at Swedish universities is carried out by lecturers who do not do research. This is likely to slow down the pace at which important new research findings are integrated into the curricula. If there are strong complementarities between teaching and research, teaching is likely to benefit when research-oriented faculty delivers it. Also, research is probably better when it is carried out in association with advanced students in an intellectual environment that encourages and rewards informed criticism.

Second, in contrast to the US, the Swedish university system is highly centralized. The central government is the body that grants charters to universities, and in practice it also decides on the rules of admission and the size of a university (through budgetary allocations), as well as the size of specific *fields* of study. Due to this strong influence from the central government there is also much less leeway for individual institutions to allow remuneration to track an individual professor's research and teaching performances more closely and to vary the level of remuneration according to the economic value of the professor's field of specialization. Moreover, greater centralization also makes it more difficult for individual universities to adjust the allocation of its research budget across fields in response to changing demand outside the university.

One way of illustrating this lesser ability to adjust to changing needs is given by the comparison by Jacobsson, Sjöberg and Wahlström (2000) of the number of degrees awarded at the B. Sc. and M. Sc. levels in electrical/electronic engineering and computer science in Sweden and the US, relative to active-age population in the 1977–95 period. For a very long time there was an excess demand for engineers within this specialization in Sweden. Still, the university system was slow to respond to this increased demand through an expansion in teaching. In the US, on the other hand, the number of degrees awarded tripled from 1977 to 1986, while the Swedish expansion did not take off until the number of degrees awarded had already peaked and begun to decrease in the US "market driven" system. When the number of B. Sc. degrees began to decrease, the US experienced a dramatic upgrading, with a large increase in the number of M. Sc. and Ph. D. degrees awarded (National Science Board, 1997).

The point, then, is not that the Swedish system of higher education simply failed to respond to a huge increase in the demand for trained personnel in the burgeoning fields of microelectronics and computer science. Rather, the point is that the response did occur, but it occurred, from a purely economic point of view, much too slowly. In considering universities in their specific role as suppliers of trained personnel in appropriate fields of study, timing is a crucial consideration. In competitive world

markets, large economic rents are commonly available to those firms (and those countries) that can respond most quickly to economic opportunities opened up by new technologies or new disciplines. But late arrivals are most likely to find that the large financial rewards have already been captured as competitive forces have driven prices down to much lower levels.

Third, in Sweden and other European countries, university degree requirements are typically formulated as a fixed program rather than a flexible accumulation of requirements and credits as in the US. In such a system it is therefore more difficult to make changes than in the American case. Etzkowitz *et al.* (2000) present evidence from their interviews that it is very difficult to change courses quickly and to introduce new fields in the old Swedish universities.

The above discussion demonstrates that Swedish universities are quite insular. It is likely that this ivory-tower effect transcends the educational objective to the research objective as well.

6. Conclusions

Sweden is a country putting a great deal of resources into R&D; R&D spending relative to GDP has been the highest in the world for more than a decade. The country also hosts several world-leading firms with a high R&D intensity, it holds a world class position in terms of publication rates in leading academic journals, and its government invests massively in the building of organizations to bridge the gap between university research and industry. At the same time, Sweden has a dismal record in transferring ideas generated in the university sector to the private sector when compared to the US.

This study attributes this difference to the distinct policies pursued by Sweden and the United States. The Swedish government has pursued a portfolio of policies aimed at directing funds at entrepreneurial ideas in general, and specifically at academic research output. These policies have been largely ineffective due to a lack of incentives for

academic researchers to become involved in the commercialization of their ideas. This, in turn, has likely dampened the incentives for academics to pursue commercially relevant areas of research and/or exploit commercially relevant applications of generic knowledge. The environment created by the Swedes sits in stark contrast to that in the US. In the US, the emergence of the flexibility needed to exploit commercially valuable research output is due to the relative *lack* of regulation as well as the intensive competititon for both research funds by researchers, and research talent by universities. In particular, academics in the US are relatively free to respond to market incentives for the commercialization of their ideas. By contrast, in Sweden, researchers risk being *penalized* for attempting to commercialize their ideas.

More generally, our analysis suggests that a policy aimed at encouraging science-based entrepreneurship should recognize that universities have the ability to restrict the pursuit by their faculty of entrepreneurial opportunities, and policies directing them to encourage such activities are likely to fail if they are unlikely to gain from such pursuits.

Having said this, even if the goal of a policy is to facilitate the commercialization of academic ideas, one cannot draw the conclusion that, based on US experience, property rights should be handed over to the university. Awarding property rights to universities works in the US because universities are largely autonomous, competitive institutions. In Sweden, however, universities are state-owned bureaucracies. Further study is needed to determine if, after adopting this policy, university bureaucrats would face strong enough incentives to develop offices similar to US Technology Licensing Offices.

With this in mind, we suggest retaining the system where property rights reside with the individual researcher. Noting that this policy has been less than successful in the past we recommend enhancing incentives for commercialization. This could be accomplished by strengthening the relationship between the amount of government funding and the success of a university in terms of research output and

commercialization of its research, its ranking in terms of student achievements and the number of applicants per study slot and so forth. The goal of such a policy would be to encourage the evolution of arrangements for voluntary profit sharing between universities, departments, researchers, venture capitalists and outside entrepreneurs.

Thus, universities may be induced to compete for faculty by offering high-quality patenting services, facilities et cetera, and in return they will be able to appropriate part of the proceeds in accordance with mutually beneficial contractual agreements.

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