Forthcoming in the *Journal of Technology Transfer*

Designing Efficient Institutions for Science-Based Entrepreneurship: Lesson from the US and Sweden*

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October 27, 2000

Abstract: The recent 'scientification' of commercial technology has brought the interface between universities and industry into sharp focus. In particular, academic entrepreneurship, i.e., the variety of ways in which academics take direct part in the commercialization of research, is widely discussed. The purpose of this paper is to suggest a framework for identifying the strategic individual decisions involved when educational choice is translated into science-based entrepreneurship. Identifying these decisions also allows us to hypothesize what incentive structures should be crucial. Our suggested framework is informally tested by an in-depth examination of the experiences of Sweden and the US. Despite large levels of R&D spending and comprehensive government support schemes, science-based entrepreneurship has been far less important in Sweden compared to the US. Our analysis points to weaknesses in the Swedish incentive structure in key respects: the rate of return to human capital investment, incentives to become an entrepreneur and to expand existing businesses, and insufficient incentives within the university system to adjust curricula and research budgets to outside demand. Several policy measures during the 1990s have reduced the weaknesses in the Swedish incentive structure. The current emergence of a more vibrant entrepreneurial culture in Sweden in some areas is consistent with these changes. Our analysis suggests that a policy aimed at encouraging science-based entrepreneurship should focus on strengthening individual incentives for human capital investment and entrepreneurial behavior both within universities and in business.

JEL Classification: J24, O31, O32, O57.

Keywords: Academic entrepreneurship, Innovation, R&D, Spin-off firms, Technology transfer, University-industry relations, Universities and business formation.

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* Financial support from Jan Wallanders och Tom Hedelius Stiftelse is gratefully acknowledged. We are grateful for excellent research assistance from Per Thulin and Brent Goldfarb.

1. Introduction

Nowadays, science-based entrepreneurship looms large in the public policy arena. This is quite natural given the recent 'scientification' of technology; in particular, the most rapidly growing and wealth-creating industries such as biotechnology, computers and telecommunications are progressively more science based. But why does such entrepreneurship flourish in some countries, especially the United States, while there seems to be so much less of it in other countries? The purpose of this paper is to attempt to identify some key institutional factors that are crucial determinants of science-based entrepreneurship. Particular attention will be paid to one important subset of science-based entrepreneurship, namely, academic entrepreneurship, This involves the variety of ways in which academics go beyond the production of potentially useful knowledge and take some sort of leadership role in ensuring successful commercialization.[1]

In the following section we outline a simple informal model of the strategic individual decisions involved when educational choice is translated into science-based entrepreneurship. Identifying these decisions also allows us to examine which incentive structures are likely to be crucial in promoting science-based entrepreneurship.

The remainder of this paper constitutes an informal test of our proposed theory. This test consists of an in-depth comparison of science-based entrepreneurship and the relevant incentive structures in the US and Sweden. Section 3 presents a brief comparison of the performance of the Swedish and US economies with particular emphasis on the high-tech sector and new technology-based firms. As shown in section 4, the two countries share a common organizational feature: the bulk of frontier research is done in teaching universities. In Section 5, we examine the government support schemes and other bridging arrangements between universities and industry in Sweden and the US. From this examination, it is clear that the relatively low level of science-based entrepreneurship in Sweden cannot be explained by the absence of government support. Sections 6 through 9 contain in-depth examinations of the relevant incentive structures in Sweden and the US. We identify four key areas in this respect: (1) human capital formation, incentives to (2) become an entrepreneur, (3) expand existing entrepreneurial ventures and (4) the incentives within the university system to adjust the lines of study and the allocation of research budgets to the demand in the private sector and to facilitate for faculty to bridge the gap between academia and the industrial sector. Section 10 contains a brief analysis of the recent entrepreneurial revival in some sectors of the Swedish economy, and whether this revival is consistent with our hypothesis. Section 11 concludes.

2. From Educational Choice to Science-Based Entrepreneurship

In order to create a large scientific base that in turn gets translated into a great deal of science-based commercial activity a number of crucial steps are involved. The ones likely to be most important are outlined in *Figure 1*.

[1] See Slaughter and Leslie (1997) for a comprehensive examination of the phenomenon in question.

Figure 1 From Educational Choice to Science-Based Entrepreneurship.

Enclosed

The first strategic choice facing an individual takes place in high school when the young individual decides whether to enter the labor market or to proceed to the university.[2] Given that the individual enrolls at the university, there is a choice between science and technology-based disciplines and other areas, notably the social sciences. At the point of graduation the natural science graduate can again choose between employment and graduate studies with the aim of getting a Ph. D. After having received a Ph. D. there is yet another choice, this time between a university career and employment.

Keeping in mind that we focus on the emergence of science-based entrepreneurial ventures such ventures are highly dependent on academically trained and motivated individuals. When talking about academic entrepreneurship, one primarily thinks about university faculty taking an active entrepreneurial and ownership role in these ventures. However, focusing exclusively on this connection is not justified. In addition to university faculty, there are several other important sources for recruiting people to science-based entrepreneurship: From the pool of individuals with either a graduate or an undergraduate exam, and from individuals with that educational background working in other firms.

From Figure 1 it is evident that there are a number of important links that have to function efficiently in order to create an environment where science-based entrepreneurship flourishes. First, the incentives to invest in human capital at the university level (1a, 1b, 1c). Second, the incentives to become involved in science-based entrepreneurial ventures both for university faculty and for nonfaculty with a natural-science training (2a, 2b, 2c, 2d, 2e). Third, the incentives within the university system; to adjust the lines of study to demand in the private sector, to facilitate the transfer from academia to the entrepreneurial sector. This third factor can be expected to have complex repercussions throughout the entire decision tree depicted in Figure 1. Most directly, it will influence the propensity of faculty to get involved in entrepreneurial ventures (2a), but it will also affect students' educational choice (1b, 1c, 3a).

Below we will examine whether the incentives hypothesized to be important for science-based entrepreneurship can indeed be claimed to be of importance. We test our informal model by an in-depth examination of the impact of science-based entrepreneurship in Sweden and the US, but before we assess the pertinent incentive structures we briefly compare economic performance, as well as the input side, i.e., resources going into R&D and government resources spent on arrangements with the purpose of bridging the gap between academia and the commercial sector.

[2] One may argue that crucial decisions have been taken even before that, when the student decides whether to focus on natural sciences and technology in high school.

3. Economic Performance

Both Sweden and the US emerged from World War II with strong economies, relative to almost all other industrialized countries. No doubt, the US was, in many respects, the technological leader, but by the late 1960s Sweden was not far behind. Given the relatively high income levels of the two countries at the time, both the catching-up effect and the tendency towards income convergence among countries[3] would lead us to expect a low Swedish growth rate relative to the OECD average in subsequent periods. *Table 1* indeed shows that Sweden grew slowly relative to the OECD from 1970 to 1998. However, this is not so for the US. From 1970 up to 1998 the US growth rate was comparable to the OECD average, and if the comparison is limited to the period 1990–98, US performance was markedly superior to the OECD average.

Table 1 The Growth Rate of GDP and GDP Per Capita in Sweden, the US and the OECD excluding the US for Different Periods, 1970–98 (%).

	1970–98		1980–98		1990–98	
	GDP	GDP per capita	GDP	GDP per capita	GDP	GDP per capita
Sweden	1.7	1.3	1.6	1.2	1.0	0.6
the US	2.8	1.8	2.8	1.8	3.0	2.0
OECD excl. the US	2.7	1.9	2.3	1.6	1.8	1.0

Source: OECD, *National Accounts 1960–1997 Vol. 1*, 1999; OECD, *Main Economic Indicators*, February 2000.

Employment adjusted for population growth rose by approximately 27 percent in the US between 1970 and 1998, while it decreased by 8 percent in Sweden during the same period.[4] The share of high-tech output and employment is considerably higher in the US than in Sweden, averaging approximately 3 percentage points higher over the period 1970-1996. Although the high-tech share in Sweden did increase from 11 to 19 percent between 1990 and 1996, virtually all of this increase can be attributed to one telecomms firm (Ericsson) and one pharmaceutical firm (Astra).[5]

The view that the increased high-tech production in Sweden is driven by a strong development in a few large firms is supported by complementary evidence showing a low growth rate among new technology-based firms (Utterback and Reitberger, 1982; Rickne and Jacobsson, 1996). Rickne and Jacobsson (1999) study all new technology-based firms founded between 1975 and 1993 (and still in existence in 1993) in Sweden. The employees of the new technology-based firms represented 0.9 percent of manufacturing employment in the selected industries and 6.2 percent of employment in

[3] Convergence implies a reduction in the variance of income across countries. Convergence does not necessarily imply catching up, since a decreased variance may occur even if the other countries do not approach the income level of the technologically leading country (Barro and Sala-i-Martin, 1995).
[4] *Source*: OECD, *Economic Outlook*, December 1998 (data on disk), OECD, *National Accounts 1960–1997*, 1999
[5] The pattern is similar if we look at high-tech exports. Since the mid 1980s the US high-tech export share has been approximately 37 percent. Sweden's share was at about half the US level until the late 1980s. During the 1990s the Swedish high-tech export share has increased to 27 percent in 1996, which is roughly the average level in the OECD excluding the US.

manufacturing-related services in 1993. In total they accounted for 2.2 percent of employment in the industries they belonged to (either manufacturing or manufacturing-related services). Thus, their share of total employment is very small and, perhaps even more importantly, not a single one of the firms had more than 500 employees.

There are also a few Swedish studies that focus exclusively on technology-based firms founded by university faculty. The most extensive of these studies is Olofsson and Wahlbin (1993). The study consists of 569 firms started between 1974 and 1989. It is clear that the direct employment and production effects of the activities of these firms are small: Total sales were approximately SEK 3 billion and the firms employed only 3,500 persons.

Lindholm Dahlstrand (1997a, 1997b) specifically address the issue 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 (among the 60 firms there are 30 spin-off firms) and by including all spin-offs from the Chalmers Institute of Technology in Göteborg. It is found that university spin-offs consistently grow much more slowly than other spin-off firms.

In summary, Swedish relative income dropped sharply from 1970 to 1998. The US per capita income relative to the OECD average also dropped at a similar rate until the late 1980s, although the drop took place from a much higher initial level. The US also remained the 2nd richest country throughout this period of relative decline. During the 1990s, however, the US economy grew faster than the OECD average. Regarding employment there was a great difference between the rapid rate of job creation in the US compared to Sweden and Europe, where employment has been stagnant since the 1970s. This has resulted in an hours-adjusted employment level in the US on the order of 35 percent higher than in Sweden and other European countries. The US high-tech production share has consistently been higher than in Sweden, but the Swedish share has increased sharply during the 1990s. However, there is ample evidence pointing towards a weak performance of new technology based firms.

4. Investment in R&D and Output from the University Sector

As shown in *Table 2* both Sweden and the US devote a large share of GDP to R&D relative to the OECD norm. Both countries have consistently held the top position together with Japan. Since the mid 1980s, Sweden has in most years had the highest R&D/GDP ratio of all countries.

Perhaps even more important for our purposes is the fact that R&D conducted in the university sector as a share of GDP is consistently the highest in Sweden.[6] The importance of the university sector for total R&D in Sweden is even higher when looking at labor input rather than expenditure.[7] As a matter of fact, an extremely large share of R&D conducted by persons holding a Ph. D. is carried out in the university sector in Sweden – in 1993 the total volume of R&D conducted by Ph. D.'s in Sweden

[6] As used here the term universities also includes colleges.
[7] 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.*

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).[8]

Table 2 Total R&D Expenditures and in the University Sector as a Percentage of GDP in Sweden, the US and the OECD, 1981–95.

	Sweden		the US		OECD weighted		OECD unweighted	
	Total	Univ.	Total	Univ.	Total	Univ.	Total	Univ.
1981	2.29	0.69	2.42	0.35	2.09	0.36	1.52	0.32
1983	2.55	0.77	2.66	0.35	2.25	0.37	1.63	0.34
1985	2.89	0.79	2.87	0.37	2.43	0.37	1.77	0.35
1987	2.99	0.86	2.82	0.41	2.44	0.40	1.84	0.37
1989	2.94	0.90	2.73	0.42	2.43	0.40	1.87	0.38
1991	2.89	0.79	2.81	0.40	2.49	0.41	1.93	0.41
1993	3.39	0.87	2.61	0.40	2.38	0.43	1.98	0.43
1995	3.59	0.79	2.54	0.39	2.34	0.42	2.01	0.43
1997	3.85	0.83	2.71	0.39	2.40	0.39	2.07	0.41

Note: Due to data limitations OECD is defined as the following 15 countries: Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, the UK, and the US.
Source: OECD, *Basic Science and Technology Statistics on diskette*, 1997; OECD, *Main Science and Technology Indicators*, No 1, 1999; OECD, *Main Economic Indicators*, January 1999.

Finally, the question naturally arises whether an important contributing factor to the Swedish decline in terms of relative income is some failure in its university system to make the kinds of research contributions upon which advanced industrial economies have become increasingly dependent. One way of exploring this question is to apply the usual measures of academic research productivity to the Swedish university community. When productivity is measured in terms of publications (in recognized professional journals) per billion US dollars of GDP, Sweden fares very well. As shown in *Figure 2*, Sweden was second to Israel in 1995 in terms of publications relative to the size of the economy, while the US is ranked 20th at less than half the Swedish level. 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).

Figure 2 Scientific and Technical Article Output in 20 Rich Countries, per Billion USD of National GDP in 1995.

Enclosed

Source: *Science & Engineering Indicators – 1998.*

The conclusion of this section is that, in terms of sheer volume, the Swedish R&D effort is impressive by international standards. The publication rate in international scientific journals is likewise high. At the same time, as documented in section 3 Sweden does

[8] According to the same source 76 percent of total R&D at universities was in technology, natural sciences, biomedicine and agricultural sciences.

not seem to get full mileage out of its R&D effort in terms of production and job creation in high-tech, high value-added industries. It seems fair to hypothesize that the commercialization of the R&D efforts is a weak link. Most basic research is carried out in the university sector, and there is evidence that spillovers in the form of new viable business ventures tied to the universities are fairly modest in the aggregate. Regarding applied research (development), this is dominated – directly and indirectly – by a handful of extremely large multinational corporations. Much of the commercialization of this R&D takes place abroad and the spillovers to new businesses are limited (Braunerhjelm, 1998).

5. Government Support Schemes and other Bridging Arrangements between Universities and Industry

As we observed in the previous section, R&D spending as a share of GDP is very high in Sweden compared to most countries, including the US. In addition, it is quite clear that a very large share of (academic) research, in particular research carried out by individuals holding a Ph. D., is carried out at universities. In a country where a large share of research is carried out at universities it becomes even more important that the interface between university research and commercialization is well developed, in order to reap large commercial benefits from research. In this section we will briefly examine the bridging arrangements between universities and industry in Sweden and the US.

The Swedish government has been keenly aware of the importance of an efficient university/industry interface for some time, and the point is emphasized in several recent government commissioned reports (e.g., SOU 1996:70 and SOU 1996:89). This changed view of the role of universities in society at large has been codified in legislation. Before the 1975 university reform, universities were stipulated to ”teach and do research based on a scientific foundation”. In 1975 a third objective was added to the agenda of universities, namely, to communicate to the surrounding society results emanating from university research and how they can be applied. Gradually this third objective came to be interpreted more broadly as collaboration between the universities, on the one hand, and private industry and the public sector, on the other. In the new regulation of the universities effective from 1998 (SOU 1998:128, pp. 153–154) this is spelled out explicitly. The 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.

Swedish universities have recently focused on developing university-industry collaboration. These collaborations have assumed at least six forms: (i) research projects commissioned and paid for by an outside agent for commercial reasons; (ii) industry consulting by university personnel, university staff whose salaries are subsidized by an outside firm and adjunct professorships, as well as doctoral studies hosted inside industrial labs; (iii) university employed contact secretaries who act as mediators between university and small and medium size firms; (iv) research institutes and other organizations jointly run by universities and private industry; (v) the creation of firms for commercial exploitation of research; and (vi) financial and advisory aid to research-based firms and to individual researchers in order to facilitate the patenting, licensing or direct commercializationof knowledge and research results originating from universities.

In Sweden, university personnel receive full patent rights for their inventions. The government has been developing a legal and financial infrastructure aimed at facilitating exploitation of these patents and other university ideas. For example, between 1983 and 1997, 17 science parks which host small startups and R&D departments of large multinationals were established. These parks employ more than 10,000 people. However, it is unclear how many of these startups are university spinoffs. In a more direct approach, universities have been allowed to set up their own wholly-owned companies for the commercialization of research since 1993. It is yet unclear to what extent universities have utilized this new privilege. In addition, all major universities run patent corporations which are intended to facilitate exploitation of patentable innovations emanating from the university.

The government has been active in providing seed financing to technology-based firms through NUTEK, the Swedish National Board for Industrial and Technical Development. In addition, since 1994 seven broker institutions called Technology Bridging Foundations 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 *et cetera*. In addition, four foundations, such as the Foundation for Knowledge and Competence Development, have been established which, among other things, are intended to improve the university/industry interface.

In the US, extensive networks of interaction between universities and the private sector were established in the course of the twentieth century. Consulting arrangements on the part of faculty proliferated, as did other forms of cooperation, involving joint research projects, student fellowships in particular fields, *et cetera*. The postwar era also marked a drastic departure from earlier years by providing huge budgets to support university research, including basic research. An essential feature of this support is that it was, overwhelmingly, dispensed by mission-oriented agencies of the federal government.

Another distinctive feature of federal government policy in the postwar years was an increasingly solicitous concern for the interests of small business. This was reflected, not only in a continuing exercise of anti-trust activity (with some variation among different administrations), but in various other forms, such as government procurement policies and, especially, new legislation to advance the interests of small business. The thrust of this legislation was strengthened in 1958 by a requirement that government agencies should conduct a ”representative” share of their business with small firms. In addition, in the same year Congress passed the Small Business Investment Act, which encouraged the creation of Small Business Investment Companies (SBICs) that could provide small businesses with risk capital. In 1976 a new Office of Advocacy was created at the SBA, with the responsibility of measuring the direct costs and other effects of government regulation on small businesses and make legislative and nonlegislative proposals for eliminating excessive or unnecessary regulations of small businesses (Brock and Evans, 1986, pp. 22–23).

The SBICs became part of a significant experiment in government efforts to provide finance for new, high-risk enterprises. It was the ultimate *failure* of this experiment that created the conditions that led to the eventual rapid growth of the venture capital industry as it now exists in the US. Although the SBICs did, in fact, provide substantial amounts of equity financing to small, fast-growing companies, their further growth

came to suffer from serious defects. Since they were heavily dependent upon the leverage provided by low-interest SBA loans, they had to concentrate their activities on debt financing to small companies that were already generating cash flows. Thus, they were seriously restricted in the effort to accommodate the early-stage financial needs of new, start-up firms. Moreover, the availability of government guarantees created familiar moral hazard problems as some SBICs chose to make very high risk investments. The SBICs also suffered from adverse selection. Finally, the program did not prove attractive to the most talented investment managers. The private equity professionals could be paid only salaries, since the provisions of the Investment Company Act of 1940 did not allow them to receive performance-based compensation.

During the economic shocks of the 1970s, many companies failed to meet their obligation to make interest payments on SBIC loans. Numerous highly leveraged SBICs, in turn, could not meet their own repayment schedules, and had to liquidate. Their role as providers of financial support for early-stage entrepreneurs went into a steady decline. The crisis was reinforced by the depressed state of the IPO market. [9]

Our description of the efforts to bridge the gap between universities and industry in Sweden clearly revealed an extensive engagement by the State in this area. Underlying this engagement is the explicitly spelled out premise that government involvement can enhance efficiency and economic growth; left to themselves the scientific research community and the market are likely to achieve less in terms of economic value and new jobs (Gibbons *et al.*, 1994, pp. 162–163).

So if Sweden largely adopted a "top-down" model, which included extensive direct involvement by the government in the transfer of knowledge with commercial potential from universities to industry, the US adopted much more of a "bottom-up" model. Central elements of this model included the institution of a legal framework that promoted the transfer of knowledge to small and new firms. Eventually, as we will see in section 8, a broad set of rules were introduced, which paved the way for the evolution of the VC industry. This has turned out to be a highly effective institution to bridge the gap between academia and industry. This industry works very differently from the SBICs, which are more comparable to many of the government-financed support schemes in Sweden.[10]

So what are the missing links? What factors could account for the apparent superiority of the American system in creating economic value from R&D activities at the universities? Our hypothesis is that the answer has to be sought through an in-depth examination of the relevant incentive structures in the respective countries. The next four sections will now be devoted to each one of these issues. Throughout the exposition particular emphasis will be put on how the incentive systems in Sweden and the US are likely to influence the supply of academic entrepreneurship.

6. Incentives to Invest in Human Capital

[9] This and the preceding paragraph are mainly based on Fenn, Liang and Prowse (1995).

[10] One can also point to other countries in addition to the US, where there is substantially more academic entrepreneurship despite very little of bridging institutions and other government support – see, for example, Klofsten and Jones-Evans (2000) for a comparison between Sweden and Ireland. One may also note that Etzkowitz *et al*. (2000) conclude from their interviews: "One opinion is that centralized organizations for external contacts are highly overrated."

According to our informal model incentives to invest in human capital, in particular with a natural science orientation, should be important for science-based entrepreneurship. The literature on economic growth also lends strong support to this view – see, e.g., Mankiw, Romer and Weil (1992), Lucas (1988), and Morrison and Siegel (1997).

Given our purpose, we focus almost exclusively on human capital investment at the university level. The US has the highest share of its active population with a university degree of all OECD nations. In 1996, 26 percent of the population aged 25–64 had a university level education. Sweden, on the other hand, is in an intermediate position at exactly half the US level. Moreover, or the OECD as a whole the share with a university degree tends to decrease with age. In Sweden this pattern does not show up. The propensity to acquire a university degree has dropped precipitously in the most recent generation, from a ratio of 16 percent among the 45–64 year olds to a ratio of 11 percent in the youngest group (OECD, 2000). Likewise the share of an age group holding a Ph.D. degree peaked among cohorts born in the 1940s.

As regards the line of study some internationally comparable data are available. In particular, there are data showing the number of science graduates per 100,000 inhabitants aged 25–34. In this regard there is tremendous variation across countries. The number of science graduates per 100,000 inhabitants is roughly five times higher in the U.K. at the top compared to Italy at the bottom. Sweden is also close to the bottom and the US figure is roughly 50 percent above the Swedish level (OECD, 1995).

As regards the allocation of academically trained people it is not just that there was a low inclination among Swedish students to specialize in the natural sciences, there was also a very strong tendency to pursue a career in the public sector. During the 1970s two thirds of all academically trained people worked in the public sector. Although this share has decreased somewhat since then, it is still roughly 55 percent.[11]

But it is well-known that international comparisons of educational levels are imperfect measures of human capital, and therefore a more direct test of the rate of human capital accumulation in Sweden relative to other OECD countries may be obtained by studying changes in the pattern of specialization. Hansson and Lundberg (1995, Ch. 3) show that during the 1980s the structure of industrial production was shifted towards industries with a low level of human and physical capital per person employed. They also examine how the use of human capital per unit of output has changed in Swedish imports and exports during the period 1969–92. The exports/imports ratio remained virtually unchanged during the 1970s, but at the end of the 1970s imports started becoming relatively more human capital intensive. Lundberg (1999) finds that this tendency was further reinforced during the 1990s. These studies show that Sweden appears to have successively lost its comparative advantage in human capital-intensive production.

According to human capital theory (Becker, 1964; Schultz, 1960), the decision to acquire human capital should be analyzed as an individual investment decision. In other words, the individual decision to acquire and use human capital is governed by the rate of return on human capital. Thus, one hypothesis is that the incentives to accumulate human capital have fallen since the 1960s.

[11] Zetterberg (1994) and Statistics Sweden, *Labour Force Surveys*.

A number of such studies have estimated the rate of return on education in Sweden for selected years during the period 1968–91.[12] The Swedish studies are summarized in Henrekson, Jonung and Stymne (1996) and in Edin and Topel (1997). Comparable estimates are also available for the US covering the same period (Goldin and Katz, 1999). First, it is obvious that the educational premium fell dramatically from the end of the 1960s to the early part of the 1980s in Sweden. The sharp increase in the college/high school premium experienced in the US between 1979 and 1989 cannot be detected in Sweden.[13] Third, since the 1970s the rate of return on education has consistently been much higher in the US than in Sweden. We conclude that the rate of return on education fell to very low levels in Sweden in the early 1980s, and as Fornwall (1991) shows, the fall was larger for young people.

Accounting for the effect of taxes, Edin and Holmlund (1995) and Björklund and Kjellström (1994) found an even steeper drop in the rate of return in Sweden (compared to educational premia) between 1968 and 1981. The rate of return on higher education was approximately zero in both studies in 1981. The effect of subsidized loans and scholarships on human capital investment is much more difficult to assess. It is of course trivially true that, *ceteris paribus*, the rate of return to attending university is increased (Björklund and Kjellström, 1994; Edin and Holmlund, 1995). On the other hand, loan subsidies and scholarships boost the rate of return by giving rise to income during studies, as opposed to educational premia which give rise to (higher) income after completion of the studies. Thus, loan subsidies and scholarships that are not correlated with the rate of return to the training are likely to lower the incentives to choose the type of education that provides the most human capital investment as measured by the rate of return in terms of relative wages. This effect is reinforced by the fact that no tuition is paid at Swedish universities.

As shown by Fredriksson (1997) and Edin and Topel (1997) the propensity to enroll at universities has been highly correlated to the educational premium. This provides further evidence that the willingness to invest in human capital is greatly affected by the rate of return.

Why did the rate of return to schooling decrease so much in Sweden? Since the Swedish labor force cannot be said to have considerably more schooling than in other countries, it can probably not be explained by a lower scarcity value. Another possibility is that the successful implementation of the solidaristic wage policy resulted in lower educational premiums. Support for this thesis is given by Hibbs (1990) and Edin and Topel (1997).

A third potential explanation for the decline in the rates of return is that the quality of education has deteriorated, despite the fact that Sweden has one of the highest ratios of educational expenditure to GDP of all OECD countries (Fägerlind, 1991; OECD, 2000). This may very well be the case, particularly considering that the incentives to acquire human capital have become weaker. If the rate of return on schooling is low, the individual can adjust to this situation to some extent by consuming education rather than investing in human capital. Hence, human capital investment may be endogenous, in the sense that the individuals have adjusted their actual investment in human capital (as opposed to the number of years of schooling) to the institutionally given rate of

[12] No reliable data set has been collected in Sweden for a date later than 1991. The next *Level of Living Survey* (LNU) will not be available until 2001.
[13] According to some studies there was a modest increase in the educational premium in the late 1980s.

return. A further factor that may lead to lower quality in the educational system is the sharp drop in relative wages of educators. As shown by OECD (1995) Sweden has the lowest wage for experienced teachers (high school) relative to PPP-adjusted GDP per capita of all countries compared.

Investment in human capital is crucial for science-based entrepreneurship. In an international comparison the level and rate of human capital investment at the university level is fairly low in Sweden. In particular, it is noteworthy that the propensity to study natural sciences has been low, the share of a cohort acquiring a university degree declined substantially in the 1970s and 80s, and a disproportionately large share of people holding a university degree work in the public sector.

The analysis in this section has shown that the incentives for individuals to invest in human capital declined in Sweden over time and became very low during the 1970s and 1980s. These incentives were further weakened by the high marginal tax rates on wage income. Furthermore, when the solidaristic wage policy was gradually reformulated into a desire for a general leveling of wages across professions (rather than equal pay for equal work),[14] this had the unanticipated side-effect of a decline in the rate of return on investment in human capital.

7. Incentives to Become an Entrepreneur

A second important factor likely to determine the contribution of science graduates and university faculty to economic performance by means of science-based entrepreneurship is the relative payoff to becoming an entrepreneur rather than becoming and/or remaining a salaried employee, notably the relative payoff for academically trained people. And once an individual has embarked on an entrepreneurial venture, the contribution of this venture is dependent on whether the institutional environment is beneficial for entrepreneurial ventures.

Self-employment in Sweden declined from 19 percent of employment in 1950 to 7 percent in 1991. A slight rise has been registered since then. In an international context as well, self employment in Sweden appears low. A 1992 OECD study (OECD, *Employment Outlook*, July 1992) found that since the beginning of the 1970s throughout the 1980s, Sweden had the lowest rate of self-employment outside agriculture of all the OECD countries. The European Observatory for SMEs (1995) found that in 1992, Sweden had a lower share of self-employed than any of the other 12 countries that comprised the EU at that time. Self-employment as a share of total employment in Sweden was less than half of the average for the 12 EU countries. But does the propensity to be self-employed change with the level of education? Utterback and Reitberger (1982, p. 92), for instance, found that the level of education among entrepreneurs in new technology-based firms was extremely high in Massachusetts compared to Sweden around 1980. From the *Level of Living Surveys* it is possible to obtain more consistent evidence on this point between 1968 and 1991. The share of self-employed with a university degree is about half as large as the share among employees, and again the earlier tendency towards a much higher share of university trained people in the public sector is confirmed. Hence, the educational level of the self-employed is considerably below the level of employees. In the US the rate of self-employment declined in a similar fashion from 19 percent in 1950 to 9 percent in 1968.

[14] See Lindbeck (1997).

However, it has stayed at that level ever since. Thus the US economy has not since then demonstrated the typical pattern of a declining rate of self-employment as the economy progresses (Fölster, 2000).

To identify the crucial incentives that will induce a university-trained individual to become an entrepreneur is of course a formidable task. First, it should be noted that these incentives are very much linked to the incentives for extant entrepreneurs to expand their business, since the expected return from transfering from being a salaried employee to becoming an entrepreneur is greatly affected by the possibilities for expansion. This will be dealt with in the next section.

Second, a highly regulated labor market gives increased power to insiders, thus raising the opportunity cost of transferring to self-employment. Most importantly, the Swedish Employment Security Act (*Lagen om anställningskydd* or LAS) stipulates the ”last in – first out”-principle in case of dismissals caused by redundancy. This implies that tenure at the present employer becomes relatively more important for labor security than individual skill and productivity. This fact increases the individual’s opportunity cost of changing employers or of leaving a secure salaried job to become self-employed. This is likely to reduce the spill-over of knowledge between industries and firms. Such spill-overs contribute to a high social rate of return on R&D and training.

Third, the costs of the unemployment insurance are almost wholly paid by the government, and this is only available for employees, and a host of other social security related benefits are more favorable for employees than for the self-employed. Among these one could mention the unconditional right to leave of absence for studies, the right to demand to work part-time as long as the employee has children below age 10, and generous rules for trade union work at the employer’s expense.

A number of arguments have been put forth in favor of the view that it is often beneficial that the academic increasingly adopts the role of the entrepreneur. Stankiewicz (1986, p. 85) mentions three reasons. First, in many cases it is likely that small business units are more innovative than large established companies – see Acs and Audretsch (1990) for evidence. Second, small newly-created companies have certain market advantages as regards new technologies, notably that at early stages they tend to develop in low volume/high price niches that are less attractive for large firms. Olofsson and Stymne (1995) find that independent firms perform better than subsidiaries to large firms in Sweden, *ceteris paribus*. Moreover, there is a great risk that innovative technological ideas atrophy when they are severed from the original innovator/researcher prematurely. The worst performers were those that were acquired by large firms. For an overview of more recent studies providing corroborating evidence, see Wennekers and Thurik (1999) and Carlsson (1999).

8. Incentives for Entrepreneurs to Expand

In the previous section we argued that the incentives for a salaried employee to become an entrepreneur may be weak in Sweden. Of equal importance is the fact that, given that somebody chooses to become an entrepreneur, he or she has sufficient incentives to develop the business to its full potential. In fact, the incentives to become an entrepreneur are largely determined by the incentives for extant entrepreneurs to

expand. Hence, the factors dealt with in this section in large part apply to the previous section as well.

A number of studies have documented a weak inclination to grow among small firms in Sweden – see Henrekson and Johansson (1999) for an overview. Thus, it is easy to point out a number of studies indicating a lack of motivation to expand among small firms. According to Birch, Haggerty and Parsons (1995) a few very fast-growing firms, what they call *gazelles* create the majority of jobs in the US. Storey (1994) argues that the small group of high growth SMEs, what he names *flyers*, are the main job creators. In contrast**,** Swedish researchers (Davidsson *et al.*, 1996; Davidsson and Henrekson, 2001) find little support for the gazelle/flyer hypothesis. Instead they find that the SME contribution to net job creation is largely the result of many small start-ups.

This is likely to show up as a weak evolution of intermediate-sized firms. The pool of firms in the intermediate size classes is tapped through mergers, take-overs and, at least in some cases, expansion into the group of large firms. At the same time, a low willingness to grow should lead to few firms growing out of the very smallest size classes. Thus a gradual depletion of the pool of intermediate-sized firms is likely. Henrekson and Johansson (1999) find this indeed to be the case.

Hence, the findings of a number of studies provide direct evidence of constraints on the growth of Swedish firms. In the remainder of this section we will attempt to identify the likely factors contributing to this situation, and make comparisons with the US situation.

8.1 Taxation of Entrepreneurial Income

Several features of the pre-1990 Swedish tax system disfavored younger, smaller and less capital-intensive firms and discouraged entrepreneurship and family ownership in favor of institutional forms of ownership. During an extended period of time, for three decades beginning in the early 1960s, there were extreme differences in taxation for different sources of finance and owner categories: (i) debt was the most favored and new share issues the most disfavored; (ii) households/individuals were taxed substantially more heavily than other owner categories. For example, an investment yielding a pre-tax real rate of return of 10 percent financed by a debt instrument meant that the tax-exempt institution received a real rate of return of 18.3 percent after tax. In contrast, a household investing in a newly issued share with the same real rate of return the situation was very different: 10 percent before tax became –3.7 percent after tax. See calculations in Södersten (1984, 1993) and Davis and Henrekson (1997). Naturally, tax rules benefiting debt financing relative to equity financing and institutional relative to individual ownership systematically favored large, real capital intensive, publicly traded and well-established firms.

Studies such as King and Fullerton (1984) and Fukao and Hanazaki (1987) also show that Swedish tax policy was extreme in these respects. Furthermore, the Swedish tax system generally subsidized housing investment and has historically had very high marginal tax rates (above 90 percent in the highest income bracket in the late 1970s) on individual income.

The 1991 tax reform entailed a substantial "leveling of the playing field" for different types of owners and sources of finance, although the leveling was in no way complete. In 1994 the tax code was further reformed and the playing field became for all practical purposes leveled. However, the respite was short-lived as a 1995 act reinstated a higher tax burden on equity financing. Although the tax reform act of 1991 reduced the distortion between debt and equity financing, there remains a substantial differential today. Furthermore, the tax code still implies a much higher tax burden for investments financed with equity owned by households rather than by institutions.[15] Finally, marginal tax rates have been and remain above 50 percent for employee income, which to a considerable extent limits owners' ability to extract wealth from their firms.

In order to analyze how the tax system impacts on entrepreneurial behavior it is not sufficient to focus on the taxation of individual owners of firms. To a large extent the return on entrepreneurial effort is taxed as wage income. First, large part of income accruing from closely held companies has to be paid out as wage income. Second, a great deal of the entrepreneurial function is carried out by employees without an ownership stake in the firm or possibly with stock options giving them a potential future ownership stake in the firm should the stock options be exercised.

Finally, it should be noted that the use of stock options to encourage entrepreneurial behavior among employees is highly penalized by the tax system, since gains on options are taxed as wage income when the stock options are tied to employment in the firm. Thus they are subjected both to mandatory social security (33 percent) and the marginal tax rate. Since the marginal tax rate is roughly 57 percent this entails a total tax rate of roughly 68 percent in 1999. The firm that issues the stock options does not pay the social security tax until the stock options are exercised, and hence the firm cannot calculate the cost of its stock option plan.

No doubt, taxation of entrepreneurial income was very high in the US as well before 1980, although it was in no way comparable to the Swedish level. King and Fullerton (1984) report that Sweden was the only country where more than 100 percent of the real return was taxed away in 1980 for households making corporate investments. Following the comprehensive tax reforms in the early 1980s, the playing field for different types of owners and sources of financing was largely leveled in the US (Jorgenson and Landau, 1993).

Perhaps even more important are the differences between Sweden and the US in the taxation of wage income, capital gains and stock options. The highest marginal tax rate (federal tax) in the US was extremely high until the mid 1960s (91 percent) and remained at around 70 percent until 1981. Since then it has been lowered precipitously, reaching a bottom of 28 percent in 1988–1989. The upper threshold for the highest marginal tax rate was set very low – to annual incomes of approximately USD 30,000. Mandatory social security contributions of 15 percent are also low compared to Sweden. Thus, high wage incomes, which often result from entrepreneurial efforts are taxed at marginal rates that are approximately half the Swedish level.

As a result of the 1978 Revenue Act, the capital gains tax was reduced from 49.5 to 28 percent. In 1981 it was reduced again, to 20 percent. In Sweden the capital gains tax is normally 30 percent since 1991, but for small closely held firms it is in effect 43 percent

[15] Details are given in Davidsson and Henrekson (2001).

since half of the capital gain is taxed as wage income (no social security payments are levied).

The Incentive Stock Option Law of 1981 in the US allowed the use of stock options as compensation by deferring the tax liability to the time when the stocks were sold rather than when the options were exercised. In general, there are (i) no tax consequences to the employee upon the grant or the exercise of the option; (ii) the employee is taxed at capital gains rates when the stock acquired upon the exercise of the option is sold after a specified holding period; and (iii) there is no deduction available to the employer.[16] This change in the law shifted the tax risk in the options back to the government, and thus accomplished two things: it increased the potential profit from the stock options and it allowed budget-constrained individuals to sell stocks whenever they chose to do so.

In summary, we have noted in this section that the taxation of entrepreneurial income has been far more beneficial in the US during the last two decades. This emanates from several sources: more favorable taxation of individuals as equity owners, lower rates of capital gains taxes and a more favorable tax treatment of stock options.

8.2 Savings Incentives

The availability of equity financing is a critical factor for both start-ups and the expansion of existing firms. In general, the riskier the business, the greater the reliance on equity relative to debt financing. The existence of collateral notwithstanding, a sizeable infusion of equity is often a prerequisite for obtaining comprehensive credits.

The smaller and newer the firm, the more difficult for outside financiers to assess the viability and profitability of the proposed investment project. Thus, *ceteris paribus*, small and newly established firms are more dependent on equity financing than large, well-established firms. Low private savings also exacerbate the inherent problem caused by asymmetric information.

There is substantial scientific evidence supporting the idea that the individual wealth position has important effects for the probability of becoming an entrepreneur and for the propensity to expand. For example, Lindh and Ohlsson (1996, 1998) find that the likelihood of starting a business in Sweden increases significantly among those who receive an inheritance or a lottery gain.[17] They also find that a more unequal wealth distribution covaries positively with the share of self-employed. Similar evidence is found for the US by Holtz-Eakin, Joulfaian and Rosen (1994). In summary, there is overwhelmingly strong empirical evidence pointing to the importance of personal assets for the degree to which entrepreneurial talent is exploited.

We subscribe to the classical view on entrepreneurship (Knight, 1921, Schumpeter, 1934; Kirzner, 1973; Baumol, 1990) that entrepreneurial talent is unevenly distributed. In that case policies that increase the likelihood that the entrepreneurially talented are not equity constrained are likely to be beneficial. The only really efficient means of increasing this likelihood is to pursue economic policies that promote private wealth

[16] See Misher (1984, p. 357).
[17] Blanchflower and Oswald (1998) arrive at the same conclusion in an empirical analysis based on British data.

accumulation across the board, and in forms that do not preclude that the wealth may be used as equity in entrepreneurial ventures.

Welfare state provisions are likely to remove a number of savings motives as long as the state's commitments are considered credible by the general public. Compensation paid by the social insurance often discourages saving above and beyond the mechanisms discussed above. For instance, Hubbard, Skinner and Zeldes (1995) find that social assistance discourages saving because it is usually conditional on the individual not having any assets. Other studies find negative effects on precautionary saving of more generous unemployment insurance – see, for example, Engen and Gruber (1996). Countries like Sweden with large transfer programs tend to have pay-as-you-go pension systems. These tend to lower national savings and investment compared to funded systems (Feldstein, 1996). Thus, in the Swedish welfare state system, total savings motives are much reduced. This has the side effect of decreasing the supply of entrepreneurial capital.

Furthermore, the real rate of taxation on financial savings was extremely high in Sweden for individuals before the 1990/91 tax reform. On interest income it typically exceeded 100 percent during the 1970s and 80s. The rate of taxation on saving and wealth accumulation is still high. First, the very high tax rates on wage income makes it hard to save a substantial portion of income that can subsequently be used for equity financing. Second, total taxation on accumulated wealth is high (1999): 30 percent on the nominal current return, 30 percent nominal capital gains tax and 1.5 percent wealth tax on real estate, interest-bearing instruments and prime stock listed on the Stockholm Stock Exchange.

Also, given the level of wealth or national savings, the composition of national savings is not neutral in its impact on entrepreneurship and small business development. The manner in which savings are channeled to various investment activities influences the type of business organization that can obtain credit. Pension funds, for example, are less likely to channel funds to entrepreneurs than business angels or venture capital firms. Hence, if the government forces individuals to carry out most of their savings through a national pension fund system, small business credit availability will suffer relative to an alternative policy and institutional arrangements that allow for greater choice by individuals regarding their savings and investments. In the Swedish case, institutionalized saving in the form of life insurance policies, where the funds are by definition withdrawn from the non-institutional venture capital market, has been and still is highly favored.

As a result of weak savings incentives due to a high rate of taxation and extensive welfare state, the savings rate of Swedish households fell to a very low level in comparison to other OECD countries. Household savings as a share of disposable income has typically been in the 2–3 percent range since 1970 as compared to typical rates in the range of 10–20 percent in most other OECD countries. As a result of the consistently low household savings rates in Sweden for several decades, individual financial wealth became low by international comparisons (Pålsson, 1998).

The combination of low private savings and an extremely even distribution (Lindh and Ohlsson, 1998) of these low savings implies that few people either themselves or from their associates, friends or relatives are able to raise the requisite equity to realize their business projects. This deficiency may to quite an extent be substituted for by a well functioning venture capital (VC) market.

8.3 The Role of the Venture Capital Industry

Before the 1980s the development of a VC industry in the US was severely hampered by two pieces of legislation passed in 1969.[18] The capital gains tax was sharply increased to 49.5 percent and tax liabilities on employee stock options were imposed when the options were exercised rather than when the stock was sold. The transformation to a new regime dominated by the limited partnership, a central feature of the US venture capital industry today, took place in the late 1970s and early 1980s. The main elements of this transformation were as follows:

1. The reduction of the capital gains tax in two steps to 28 percent in 1978 and to 20 percent in 1981.

2. In 1979 pension fund were allowed to invest in high risk securities issued by small or new companies and venture capital funds. This led to an immediate response in the market for small-company stocks and the new issues market. Public pension funds eventually became the largest investor group in the private equity market.

3. The stock option legislation of 1981 that made it possible to defer the tax liability to the time when the stocks were sold rather than when the options were exercised.

Venture capital firms converted high risk opportunities to a more acceptable risk level through portfolio diversification. This was achieved by means of aligning the incentives of the three agents – investors, VC firms and new high tech startups. The US venture capital industry experienced vastly accelerated growth in the 1980s. The growth in the venture capital stock was also accompanied by a rapid growth in the proportion of the stock that was managed by partnerships. By the late 1980s, the proportion of capital managed by partnerships grew to more than 80 percent, largely at the expense of independent SBICs, which saw their share of capital fall to virtually nothing.

The role of venture capital in successfully bringing companies to maturity cannot be overstated. This is particularly true in the computer-related and medical and health sectors, where 65 percent of all IPOs are backed by VC firms.

Within the limited partnership institutional investors enter into an agreement with a venture capital firm in which they are the limited partners, and the senior managers of the venture capital firm act as general partners. The lifetime of such partnerships is generally ten years, during which time the limited partners, as a condition of their limited liability status, are expected to refrain from any active role in the management of their investments. The usual arrangement is one in which the limited partners supply 99 percent of the capital whereas the general partners supply 1 percent. In the division of the capital gains, the general partners receive 20 percent and the limited partners 80 percent. The general partners, moreover, receive an annual management fee of between 2 to 3 percent of the total committed capital.

The first responsibility of the venture capital firm, after a partnership has been established, is to screen project proposals. This sorting process is critical, since an

[18] Much of the discussion in this subsection regarding the US is based on Fenn, Liang and Prowse (1995) and Zider (1998).

outsider can hardly be – or become – as well informed about the true situation as the managers of the firm seeking financial support. Due diligence on the part of the venture capitalist at this point, and careful monitoring of the firms receiving equity commitments, are obviously vital preconditions for success, especially since little information is ordinarily available for firms that are not yet publicly traded. For firms that are supported after the screening process, the venture capital firm will typically play an active role in the day-to-day decision making process as well as in shaping longer-term strategy. Venture capitalists sit on boards of directors, play a prominent role in recruiting key players, and in replacing them when, in their judgment, they are not performing satisfactorily. The leading figures in the startup firm are paid relatively modest salaries and their commitment to the financial success of the firm is established by the receipt of stock options.

An extremely important feature of control in the hands of the venture capitalist is that financial support is doled out in stages, with no more money made available than is necessary for the firm to reach the next stage. Thus, there are multiple opportunities to evaluate performance at each stage and to terminate support if performance is deemed to be unsatisfactory. This discourages opportunistic behavior and strengthens commitment to the firm's long-term prospects for success.

At the same time, there are interesting parallels between the ways in which the VC firm discourages opportunistic behavior on the part of entrepreneurial firms in which they are investing, and the ways in which the limited partnerships constrain the behavior of the VC firms in which they have invested. The VC management receives 20 percent of the profits from the portfolio, despite their initial investment, which is usually 1 percent. Hence, a strong direct incentive is in place to encourage the VC firm to ensure the success of the funded firms. Second, limited partnerships are typically undertaken for a ten-year period, at which time the partnership is dissolved and the venture capital firm must seek new sources of investment funds. At this point its most critical asset is its recent track record. Since, moreover, a mature VC firm may have 20 or more limited partnerships, each of eight to ten years duration, it must have recourse to establishing new partnerships, or renewal of old partnerships, every few years. Hence, the venture capitalist's performance is being continually subjected to market tests. This serves as a powerful force to limit opportunistic misbehavior.

Venture capitalists would have far fewer companies to finance if it were not for *business angels*. VC firms hardly ever participate in the earliest stages of the development of new high tech concepts that eventually make it to the stage of successful commercialization. The earliest financial support is likely to come from affluent friends or relatives or, increasingly, wealthy individuals who have already become rich from similar earlier ventures. If the original funds come from family or friends, kinship ties play a large role in preventing the firm founder/manager from squandering the money. If the original funds come from business people, moral hazard is reduced by screening and by close monitoring of the firm's progress.

Knowledgeable insiders insist that the scale of angel activity is huge, and there is extensive anecdotal evidence to support that assertion – see Zider (1998). A key ingredient is that, in return for undertaking large financial risks, there should be some prospect of earning high rewards – *after* taxes. As a result of the informal nature of these markets, there are no systematic or reliable data on these activities.

The development of a VC industry in Sweden is of more recent vintage, and as we will see it differs from its US counterparts in many respects. Around 1980 Utterback and Reitberger (1982) found that ample supplies of equity capital from private sources outside the firm gave the US firms much lower debt equity ratios, which allowed them to grow faster. They also point out that in those days the large – highly tax favored – Swedish firms played the role filled by venture capitalists and private sources of equity in the US. To the extent that there is reason to believe that large firms are less suitable for assuming this role than venture capitalists, the performance of the new firms suffered.

During the 1980s a VC industry began to develop in Sweden as well, but at least until the mid 1990s these enterprises supplied little capital for the establishment of new firms or in the first critical phase of expansion in the firm's development (NUTEK, 1994). The public sector has tried to offset the lack of private venture capital by introducing numerous support schemes. In 1998 there were more than 140 such schemes. There is no coordination of the different schemes, and the net effect is far from clear (Landell *et al.*, 1998). Moreover, the major portion goes to firms undergoing expansion. Only a tiny portion goes to the start up of new companies as seed financing. More systematic evidence on this point is provided by Isaksson (1998) and Braunerhjelm (1999). No more than 8 percent of the VC in Sweden in the late 1990s went to the seed and early expansionary phases. Over 50 percent of the VC was channeled to firms considered to be in the mature phase. Landström (1993) specifically looked at the behavior of business angels. He found that only 25 percent of the business angels' investments were seed capital in the early 1990s compared to more than 50 percent in the US in the same period. At the same time, Lindström and Olofsson (1998) show that, in new technology-based firms that actually succeeded, business angels were instrumental.

According to two new studies – Isaksson (1999) and Karaömerlioglu and Jacobsson (2000) – there has been strong growth in the Swedish VC industry during the latter half of the 1990s. With more complete data Karaömerlioglu and Jacobsson (1999) find that the amount of VC capital in Sweden relative to GDP is the third highest in Europe after the UK and Ireland, and cumulative VC funds relative to GDP had reached 50 percent of the US level in 1998, up from 25 percent of the US level in 1983.[19] The amount invested in early phases is also found to be larger than in previous studies (11.6 percent in 1998). However, compared to their American counterparts Swedish VC firms lack in competence. Isaksson (1999) reports that at most one fifth of the firms that have received VC investment perceive that the VC firm has offered significant inputs in terms of strategic advice, networks and recruitment of key personnel. Similar results are reported for biotech by Rickne (1999) and for the IT industry by E-chron (1998).

In the long run it is also likely that a serious impediment to the growth of the VC market will come from the demand side, i.e., that there may be a lack of potential projects with a development potential due to the factors discussed throughout this study. In this context it is important to note that Gompers and Lerner (1999) find that a crucial factor behind the VC industry growth in the US is that the decrease of capital gains tax rates boosted demand for venture capital as more workers now had an incentive to become entrepreneurs.

[19]It should be noted, however, that Braunerhjelm (2000) is very skeptical of the Karaömerlioglu and Jacobsson study. He claims that they both exaggerate the size of the Swedish VC market and the degree to which funds are channeled to early investment phases.

In terms of taxation, VC firms in Sweden are at a disadvantage relative to other firms. Dividends are taxed threefold: at a rate of 28 percent in both the firm itself and the venture capital firm and at 30 percent at the owners' level. This high tax burden on VC firms is likely to endanger the future supply of VC capital from firms residing in Sweden. Yet another problem is that, according to Swedish tax law, business angels that take active part in the management of the firms in which they invest are taxed at a higher rate. Active owners of unlisted firms are taxed at higher rates than passive owners. This implies that dividends above a fairly moderate threshold (some 9 percent) will be taxed as wage income, and half of the capital gains tax will also be taxed as wage income and not as capital income. Likewise the income of the general partners in VC firms will be taxed as wage income. Thus, the high rates of taxation of high-tech entrepreneurs, general partners of VC firms and the owners of the VC firms or the business angels result in a substantial reduction in the after-tax return on activities typical for VC firms in the US.

By contrast, in the US investments by venture capital firms are taxed at low rates. If the holding period exceeds five years, the total tax rate is 14 percent, and since 1997 the capital gains tax from sales of shares in unlisted companies may be deferred indefinitely, if the profits are reinvested within 60 days. Similar systems were introduced in the UK in the early 1990s.

In summary, we note that around 1980 the legal framework in the US became highly conducive to the development of a sophisticated VC industry. The industry itself has then designed a number of efficient incentive schemes that helps to overcome many inherent conflicts of interest between innovators, entrepreneurs, fund managers and investors. In Sweden, on the other hand, the legal framework facilitating the emergence of a highly competent VC industry has not been in place. As a result, the Swedish VC industry has not been able to play the same crucial role in bridging the gap between universities and industry as its US equivalent, although there are signs that the situation has begun to improve.

8.4 The Functioning of the Labor Market

Swedish labor organizations successfully pursued egalitarian wage policies from the mid 1960s until the breakdown of centralized wage bargaining in 1983 (Hibbs, 1990; Edin and Holmlund, 1995). The strength of Swedish labor organizations and the centralized nature of the wage-setting institutions appear to have facilitated a remarkable compression of the wage structure during this period, judging by cross-country comparisons of wage inequality trends (Davis, 1992). To the extent that Swedish wage-setting developments drove up wages in the lower tiers of the distribution relative to outcomes under other institutional arrangements, they reinforced the concentration of economic activity in larger, older and more capital-intensive firms and sectors. This inference follows from the ample evidence that, ordinarily, wages rise with the age, capital intensity and – especially – the size of employers (e.g., Brown and Medoff, 1989; Davis and Haltiwanger, 1999).

Centralized wage-setting institutions may also disadvantage smaller businesses and businesses aiming at promoting an entrepreneurial culture within the firm by implementing standard rate compensation policies that closely tie wages to easily observed job and worker characteristics such as occupation, education, experience and

seniority.[20] Efficiency losses associated with the imposition of standard rate compensation policies are likely to be greater for smaller employers. Since smaller and more entrepreneurial employers show greater preference for flexibility and idiosyncrasy in wage determination, standard rate compensation policies are more costly to adopt. This suggests that centralized wage-setting institutions affected the industrial structure and the organization of business activity in Sweden most likely to the detriment of small firms, flexible organizations and firms wanting to remunerate entrepreneurial behavior within the firm (Davis and Henrekson, 2000).

Another feature of the labor market that is important in our context is the existence of job security mandates. Strict employment security provisions are likely to be more harmful for smaller and potentially fast-growing employers. One reason involves the gains from efficiently matching heterogeneous workers to a variety of tasks and positions. As an employer learns about a worker's abilities over time, or as those abilities evolve with the accumulation of experience, the optimal assignment of the worker to various tasks is likely to change. The scope for task reassignment within the firm is likely to rise with firm size. In an unfettered labor market, optimal task reassignment often involves mobility between firms, and such mobility is more likely when the initial employment relationship involves a small business. Thus, any inefficiencies induced by the Swedish Employment Security Act in the assignment of workers to tasks are likely to be more severe and more costly for smaller firms. Furthermore, and for obvious reasons, one bad recruitment is proportionately more costly to bear for a small firm.

There are also theoretical models finding a likely negative effect of employment protection on entrepreneurial firms based on new technology. Hopenhayn and Rogerson (1993) emphasize that the reallocation of labor from old and declining to new and dynamic industries is slowed down. Saint-Paul (1997) finds that countries with a rigid labor market will tend to produce goods at a late stage of their product cycle with a relatively stable demand, while it is more advantageous to produce new goods where demand is more volatile in countries with a more flexible labor market.

Recent research, sometimes called "the new view of the labor market",[21] suggests that in order to understand in what ways labor market regulations impede growth and employment, one has to analyze the effects on the individual firm. For many firms – and in particular for firms with a good growth potential in terms of productivity and employment – there is a great need for flexibility both to increase the number of employees in response to rising demand and likewise to be able to rapidly contract when demand falls short of expectations. The road from small to large for a gazelle is far from straight, since the activities of new firms in particular are subject to genuine uncertainty. If, under such circumstances, rules are imposed that reduce the firms' leeway to rapid adjustment one should expect both a lower willingness to expand in general and that fewer firms, despite a good product or a viable idea, grow from small to large in a short period of time.

In addition, a strictly applied "last in – first out" principle in case of redundancies implies that tenure at the present employer becomes relatively more important for labor

[20] Blanchflower and Freeman (1992) and Blau and Kahn (1996) provide evidence that unions and other centralized wage-setting institutions compress wages among observationally similar workers by promoting standard rate compensation policies.
[21] See Davis, Haltiwanger and Schuh (1996) for an overview of this research.

security than individual skill and productivity. This fact increases the individual's opportunity cost of changing employers or of leaving a secure salaried job to become an entrepreneur. This is likely to reduce the spill-over of knowledge between industries and firms. Such spillovers contribute to a high social rate of return on R&D and training.

Finally, we note that labor market inflexibility is an element inherently inconsistent with the flexibility, nonhierarchical structures, networking and labor mobility across firms distinguishing an entrepreneurial business culture (Saxenian, 1996).

8.5 Summary and Conclusions

In this section we have documented a weak willingness to grow among small firms in Sweden. A number of likely factors contributing to this state of affairs have been identified: historically and currently a high tax burden on entrepreneurial income, weak incentives for private wealth accumulation, particularly in forms that promote the supply of venture capital, an unfavorable tax and regulatory system for the VC industry, inflexible wage-setting arrangements rendering the encouragement of entrepreneurial behavior more difficult and strict job security, which is likely to be most detrimental for small, entrepreneurial firms with a high growth potential.

9. Incentives within the University System

Even if all other elements favoring science-based entrepreneurship are at hand – such as conditions encouraging human capital investment, entrepreneurship and firm growth – results in terms of economic performance are likely to be meager, unless the right incentive structure is in place within the university system itself. This structure is of course highly multidimensional. A number of factors are likely to be crucial: (i) the degree to which up to date research results and methods are communicated to students as part of the regular instruction and whether the internal reward systems, be they monetary or nonmonetary, encourage excellence in both teaching and research; (ii) to what extent and how quickly curricula are adjusted to changing demand; (iii) the efficiency with which research budgets can be reallocated across disciplines in response to changes in commercial potential; and (iv) the incentives in a broad sense for faculty to interact with industry in economically beneficial ways. Factors (i)–(iii) will be dealt with in section 9.1 and the fourth factor will be treated in section 9.2.

We begin by examining the incentives for research and teaching in the American 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 strength 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.

Because of the decentralization and the competition among universities for professors who are visibly productive, the 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 graduate students may come to play crucial roles in advancing those frontiers. Rosenberg (1999, 2000a) 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 which 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 it is delivered by research-oriented faculty. 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 admittance and the size of a university (through budgetary allocations). 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 (1999) 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 higher education system 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, Asplund and Nordensson (2000) present evidence from their interviews that it is very difficult to change courses quickly and introduce new fields in the old Swedish universities.

The American university system is powerfully driven by competitive forces, especially by competition 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. An 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. Such competition has been taking place in an entrepreneurial culture that has encouraged, or has not constrained, high levels of faculty involvement in business activities. These activities include high tech startups in which there are a variety of potentially high financial payoffs to university faculty whose research produces knowledge that may lead to new products and processes and their accelerated commercialization.

The possibilities for commercial exploitation of university research were strengthened by the passage of the Bayh-Dole Act of 1980, which allowed universities to appropriate the property rights to an invention resulting from university research that was financed

by federal grants. As a result of the Bayh-Dole Act, universities can now, in effect, develop contractual arrangements for "profit-sharing" between individual faculty researchers, their departments, and the university. Moreover, universities now have strong incentives to set up their own Office of Technology Transfer. These offices, operating on a fully commercial basis with staffs of lawyers, technology specialists, marketing specialists and accountants, facilitate the commercial exploitation of potentially valuable research findings.

Thus, the broad picture that we have sketched here strongly suggests that the incentives within the US university system encourage active participation by faculty (and also university administrators) in commercial exploitation of research by faculty. What can be said of the corresponding situation in Sweden? At first sight incentives for faculty appear very strong: the 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 *et al*. (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. And, 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*. who conclude that "[s]ince 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. Anti-entrepreneurial peer pressure also results in tendencies among faculty to be less open about their contacts with industry and, in particular, about the private returns from these contacts. Such surreptitious behavior further reduces the much-needed presence of entrepreneurial role models.

Several scholars studying the Swedish university/industry interface emphasize that, analogous to what Zucker 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 to offer high-powered incentives to academics with whom they cooperate and, as a result, these academics tend to remain consultants. This is, of course, yet another reflection of the Swedish large-firm model of high tech innovation (Granstrand and Alänge, 1995; Lindholm Dahlstrand, 1997a).

We may conclude that there is much greater flexibility in the US system (a bottom up model) compared to a Swedish or European system. In particular, it should be emphasized that, whatever mode of cooperation between university and industry turns out to be the most suitable for a certain technology, it is more likely to prove more feasible in a more flexible and decentralized system.

10. The Recent Entrepreneurial Upturn in Sweden

The analysis in this paper has been wholly long term, i.e., we have focused on the bleak performance of the Swedish economy in a thirty-year perspective and the substantially greater degree of academic entrepreneurship in the US compared to Sweden since the 1970s. At the same time, one should note the highly visible current upturn in entrepreneurial activity in Sweden at the time of finalizing this manuscript (September 2000). The GDP growth rate was 3.0 and 3.8 percent p.a. in 1998 and 1999, respectively, and aggregate employment grew at an average annual rate of 1.8 percent during 1998–99.[22] According to Nyhetsbyrån Ticker, the number of IPOs was as high as 105 in 1999, compared to 26 in 1996. New entrepreneurial firms, in particular in the IT sector, are still formed at a rapid rate.

Should this favorable development be seen as a rejection of the thesis in this paper? We do not think so. First, the development is still of recent vintage, and hence it is too early to tell to what extent we are dealing with a cyclical phenomenon. Second, and much more importantly, a number of measures were taken during the1990s that can be expected to encourage the emergence of a stronger entrepreneurial culture:

- The corporate tax rate has been cut in half and is now 28 percent, which strongly favors equity relative to debt financing.
- The highest marginal tax rate has been lowered from close to 90 percent around 1980 to roughly 56 percent, which has increased the after-tax rate of return on human capital investment.
- The capital and foreign exchange markets have been wholly deregulated.
- The wage bargaining system is now less centralized than before, and in particular wages in the upper decile have increase rapidly in the latter half of the 1990s (Davis and Henrekson, 2000).
- Certain deregulatory measures on the labor market have already been taken, which in practice gives more room for flexibility than before, and more measures can be expected in the near future.
- The deregulation of several previously regulated markets, in particular the deregulation of the market for telecommunications, opened new arenas for entrepreneurial expansion.

[22] Statistics Sweden, *National Accounts* and *Labour Force Surveys.*

Other factors are more fortuitous, but still in line with our thesis. The Stockholm stock exchange had the strongest development of all stock exchanges in the industrialized world during the 1980s and 90s,[23] and given that 60 percent of the population own listed shares, this strong wealth creation has made a large number of people wealthy. This should spur entrepreneurial activity. For the first time since the interwar period, new family fortunes were formed, and in many cases that wealth appears to have been instrumental as angel capital in the new IT firms.

Thus, the current boom suggests that favorable changes in the conditions facilitating the emergence of science-based entrepreneurship will ultimately lead to more activity in this arena in Sweden. However, compared to the US the rules of the game are still unfavorable: the taxation of entrepreneurial income (including stock options and the overall taxation of VC firms) continues to be high, the steep rate of labor taxation reduces the rate of return on human capital investment and the labor market remains highly regulated. More specifically, academic entrepreneurship is still hampered by unfavorable incentives within the university system.

11. Conclusions

We outlined a framework for identifying strategic choices made by individuals, and policymakers relating to science-based entrepreneurship. We examined the implications of this framework, based on an in-depth analysis of experiences in the US and Sweden.

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, the performance record in recent decades has been dismal in many respects. In particular, few new jobs have been created in new technology-based firms and there are few examples of science-based success stories.

To explain why the large volume of research has given rise to comparatively little commercial activity compared to the US, we systematically studied the pertinent incentive structures in the two countries: for human capital investment, for becoming an entrepreneur, for expanding existing entrepreneurial ventures and for universities themselves. We have shown that the relevant incentive structures provide far less encouragement to science-based entrepreneurship and entrepreneurial behavior in Sweden than in the US.

We conclude that a general lack of favorable institutions and pertinent incentive structures that promote the emergence of an entrepreneurial culture is the major explanation for the modest role of academic entrepreneurship in Sweden. Several policy changes have been made in the last decade that strengthen the incentives for science-based entrepreneurship in Sweden. As our analysis would predict, this has been accompanied by a burst of entrepreneurial activity, particularly in the IT sector.

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[23] *The Economist* (1999).

More generally, our analysis suggests that a policy aimed at encouraging science-based entrepreneurship should focus on strengthening individual incentives for human capital investment and entrepreneurial behavior both within universities and in business. Key policy areas include attractive tax rates on entrepreneurial income, a tax structure that is not overly progressive, reasonably deregulated labor markets, and a university system characterized by decentralization and competition.

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