Research Policy 42 (2013) 874–885

Contents lists available at SciVerse ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Is the commercialization of European academic R&D weak?—A critical assessment of a dominant belief and associated policy responses

Staffan Jacobsson[a,1], Åsa Lindholm-Dahlstrand[b,*], Lennart Elg[c,2]

[a] Environmental Systems Analysis, Chalmers University of Technology, Sweden
[b] CIRCLE, Lund University, Sweden
[c] VINNOVA, Stockholm, Sweden[3]

ARTICLE INFO

Article history:
Received 10 September 2011
Received in revised form 8 January 2013
Accepted 11 January 2013
Available online 4 February 2013

Keywords:
Dominant belief
Academic research
Commercialization
Technology transfer
Sweden

ABSTRACT

There is a widespread belief that EU underperforms in the commercialization of publicly funded research and that the appropriate policy response is to transfer the ownership of intellectual property rights to Universities. This paper assesses the validity of these twin beliefs. In addressing the first, we limit ourselves to Sweden which still retains its "Teacher's Exemption" model. In spite of confident statements made in the literature and by Government, we provide evidence to the contrary, i.e. that Swedish academia performs well in terms of commercialization. We also have doubts about the usefulness of the medicine prescribed to cure the alleged problem. Largely drawing on US literature, we argue that the medicine risks harming strong university–industry networks, biasing technical change, reducing entrepreneurial activity and generating costs to Universities which may be detrimental to technology transfer. In conclusion, we seriously question the validity of both beliefs.

1. Introduction

In the EU (1993) White Paper, it was argued that Europe was relatively unsuccessful in converting scientific breakthroughs and technological achievements into commercial success. The perception of a strong European science base which is not translated into economic growth was labelled the "European Paradox" in the EU Green Paper on Innovation (1995). Over time, the focus shifted to the commercialization of publicly financed R&D. Even though reports (e.g. EU, 2003) have pointed to some positive trends in, for example, efforts to encourage the creation of university spin-offs, there is a strong belief that EU underperforms in the commercialization of publicly funded science. Hence, the Commission (2007, p. 7) argued that:

> "*One important problem is how to make better use of publicly funded R&D. Compared to North America, the average university in Europe generates far fewer inventions and patents.*"

A frequent policy response to this problem is to strengthen the management of knowledge and intellectual property by European Universities (European Commission, 2007, p. 7):

> "*This is largely due to a less systematic and professional management of knowledge and intellectual property by European universities.*"

While many European nations have now abandoned the "Professor's privilege" (Geuna and Rossi, 2011), some US researchers, for example Kenney and Patton (2009), criticize the university-ownership model in the US, and suggest instead an "Alternative model" with inventor ownership. Indeed, comparing the inventor ownership model of the University of Waterloo in Canada with the university ownership model of five US universities, Kenney and Patton (2011) conclude that this:

> "*. . .examination of the entire population of technology-based spin-offs . . .showed that the inventor ownership regime strikingly dominates the better funded, more highly rated, and much larger university ownership universities.*"

It is not only the university ownership model that is questioned but also the empirical foundation of the "paradox". In particular, Dosi et al. (2006, p. 1450) suggested that the European Paradox ". . .mostly appears just in the flourishing business of reporting to and by the European Commission itself rather than in the data." A thorough analysis of R&D, bibliometric, patent and industrial market share data led to the observation that (Dosi et al., 2006, p. 1461)

* Corresponding author. Tel.: +46 46 222 0298; fax: +46 46 222 4161.
E-mail addresses: staffan.jacobsson@chalmers.se (S. Jacobsson), Asa.Lindholm_Dahlstrand@circle.lu.se (Å. Lindholm-Dahlstrand), Lennart.Elg@VINNOVA.se (L. Elg).
[1] Tel.: +46 31 772 1213.
[2] Tel.: +46 84 733 086.
[3] Views expressed in this paper do not necessarily reflect the position of VINNOVA.

0048-7333/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.respol.2013.01.005

"...the European picture shows worrying signs of weakness with respect to the generation of both scientific knowledge and technological innovation. However, no overall "European Paradox" with a leading science but weak "downstream" links can be observed". Dosi et al. (2006, p. 1460) further argued that:

> "...*the presumed feeble links between science and industry should be one of the most important aspects of the paradox conjecture. Surprisingly, the evidence here is simply non-existing.*"

Hence, serious doubts are cast on the empirical foundation of the alleged paradox. Scrutinizing the interaction between universities and industry at the European, as opposed to the national level is, however, fraught with difficulties as little cross-country comparative data exist. The phenomena in question are complex and may require detailed analyses of specific countries (EU, 2003), using "local" knowledge and a multitude of national sources.

The Swedish case can be said to be of particular value for such a detailed analysis. First, Sweden is one of the few European countries which has not abandoned the "Professor's privilege", and, even though it is very much debated, still uses an inventor ownership model (the "Teacher's Exemption" model) for the commercialization of academic research. Second, for about two decades, high R&D expenditure has been the starting point for a number of analysts claiming that there is a paradoxical relationship between R&D input and output in the form of e.g. new firm formation, share of "high tech" in manufacturing output/export and growth (e.g. Edquist and McKelvey, 1998; Braunerhjelm, 1998; Henrekson and Rosenberg, 2001; Andersson et al., 2002; Goldfarb and Henrekson, 2003).[4]

This paradox initially focused on the relation between high aggregate R&D intensity and a perceived weakness of the "high tech" industry. It was not until after the "European Paradox" was coined in 1995, that the Swedish policy debate began to focus on the narrower "academic paradox", i.e. how academic R&D, perceived as voluminous, is believed to be insufficiently commercialized in the form of new firms, patents and licences.[5]

The purpose of this paper is to (a) assess the validity of the belief in poor commercialization of academic R&D and (b) identify risks of handling that alleged problem by focusing on the ownership of intellectual property rights (IPR). In addressing the first, we limit ourselves empirically to Sweden. In Section 2, we outline the emergence of the belief while Section 3 contains a scrutiny of the empirical foundation of the belief. This includes an assessment of the "performance" of Sweden, and its "Teacher's Exemption" model, with respect to (a) the number of university spin-offs and (b) number of academic patent applications – two indicators of commercialization. The analysis of the risks of copying US science policy solutions in Sweden, and in Europe as a whole, is undertaken in Section 4. Section 5 contains our main conclusions and some recommendations for policy.

2. The emergence of the belief in Sweden

At the end of the 1980s and in the early 1990s, a debate emerged on perceived problems with the relation between (high) R&D intensity, (weak) knowledge intensive industries and (poor) aggregate growth (Ohlson and Vinell, 1987; Ohlson, 1991). Edquist and McKelvey (1991) popularized this argument with the notion of a Swedish Paradox. This path was also pursued by others, with some modifications to the arguments, forming a stream of papers on the presumed paradox between R&D intensity at the national level and an indicator of outcome, be it growth or share of the "high tech" sector in production or exports (e.g. Braunerhjelm, 1998; Edquist and McKelvey, 1998).[6]

This literature set the context for the discourse as to how and to what extent academic science is made socially useful, leading to the perception of an "academic paradox". Against the background of high expectations of knowledge intensive areas (i.e. IT, biotechnology and material technology)[7] and a deep economic crisis in Sweden in the early 1990s, a search was started for institutional and organizational changes that could increase the industrial impact of academic R&D.[8] The 1992/93 Government Science Policy Bill articulated that it had two priorities; designing strategic R&D programmes and strengthening the exchange of knowledge between universities and industrial R&D. It was argued that (Swedish Government, 1993, p. 29):

> "...*it is obvious that the knowledge flow between universities...and industry is insufficient. Deficiencies in the interaction means that available knowledge does not reach industrial applications to the extent that should be possible.*"

To remedy this problem would require (Swedish Government, 1992/93, p. 10) "...substantial improvements through a continued development of existing forms for interaction and the development of new forms." Although differently phrased, this theme continues to run through later Bills. In the course of the subsequent decade, a number of science policy measures were taken, including expanding PhD programmes,[9] setting up Centres of Excellence and building infrastructure, e.g. holding companies, to support commercialization of research results in the form of patents and firms.

An increased emphasis by the Government was put on commercialization from about 2000. Thus, "...results from research at Universities and University colleges in the form of inventions ought to be commercialized to a greater extent" (Swedish Government, 1999, p. 24) and "Research results should lead to commercialization to a greater extent" (Swedish Government, 2001, p. 47).

The focus on commercialization was, arguably, strengthened by the aforementioned argumentation by the European Commission, but also by the work of a few academics; Henrekson and Rosenberg (2000, 2001), Goldfarb and Henrekson (2003) and the incorporation of key arguments in an influential government report (Andersson et al., 2002). A shared starting point for these studies was the larger "Swedish paradox". As Andersson et al. (2002, p. 25) formulated it:

> "*Sweden belongs to those countries that invest most in the knowledge based economy but not those that profit most. On the contrary, Sweden has lost a great deal in terms of economic prosperity during the last decades, even if a certain recovery took place in the end of the 1990s. To remedy this "Swedish paradox" is of great importance for our ability to strengthen growth and welfare.*"

These papers linked the "Paradox" to an insufficient contribution of the Universities to growth. An intermediate variable was the poor development of the 'high tech' sector, i.e. the starting point in the larger Paradox discourse that began at the end of the 1980s.

[4] The concept of a 'Swedish Paradox' was coined in 1991 (Edquist and McKelvey, 1991) and according to Audretsch (2009), it was later adopted as the European Paradox. According to Dosi et al. (2006), the European Paradox is quite similar to an earlier "UK paradox" fashionable about thirty years ago.

[5] Jacobsson and Rickne (2004) critically addressed the perception that Swedish academic R&D is believed to be voluminous.

[6] Ejermo et al. (2011): critically analyse this literature.

[7] "A large part of Sweden's structural renewal in the next ten to fifteen years must take place by growth in research and knowledge intensive industries" (Swedish Government Bill 1992/93:170, p. 28).

[8] Kenney and Patton (2009) explain that, similarly, a motive for the Bayh-Dole Act in the US was that universities could be a source of innovation that would strengthen economic growth.

[9] A major theme was improving the absorptive capacity of industry by employing more researchers. A policy of expansion of MSc and PhD programmes in engineering and natural science was subsequently implemented.

Henrekson and Rosenberg (2001, pp. 210, 211), thus, remarked that:

"*. . .the question naturally arises whether a contributing factor to the Swedish decline in terms of relative income is due to a failure in its university system to make the kinds of research contributions upon which advanced industrial economies have become increasingly dependent. . .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. . .Sweden does not seem to get full mileage out of its R&D efforts in terms of production and job creation in the high-tech, high value-added industries.*"

Although it was acknowledged that technology is transferred to industry in a large number of ways, the focus was on commercialization in the form of new business ventures, patents and licences (Goldfarb and Henrekson, 2003; Rosenberg and Hagén, 2003). The papers all concluded that Sweden performed poorly in terms of commercialization. For instance, when comparing Sweden and the US, Goldfarb and Henrekson (2003, p. 655) argued that:

"*Although the general performance of technology transfer in Sweden is unknown, it is clear that the performance of its academic-based start-ups is weak. . .because of lack of data, we were only able to determine that Sweden has performed poorly in academic entrepreneurship.*"

This message of a high R&D input that contrasts with a low output in terms of new firms was, as mentioned above, incorporated into an influential government report (Andersson et al., 2002). It was argued that not only were there few academic spin-offs in Sweden but also that these did not grow (Andersson et al., 2002, pp. 37, 38), suggesting that the potential for commercialization was not realized (Andersson et al., 2002, p. 48). The report was written by members of the Innovation Policy Expert Group from the Ministries of Industry and Education. The work was conducted in close interaction with various stakeholders (e.g. industry, unions, policy-makers, researchers) and the Heads of the two Ministries published a joint debate article in a leading newspaper based on the report. Arguably, this work influenced the 2004 Government Science Policy Bill (2004/5, p. 140) which claimed that:

"*The investments in research do not give, however, enough benefit in the form of economic growth. . .there is an under-utilised potential with respect to the commercialization of research results. . .knowledge transfer to industry and commercialization of research results has to increase.*"

In subsequent years, the same message was repeatedly put forward. A selection of the statements, including those by two additional Ministers, is found in Box 1.

Not surprisingly, the same message was repeated in the Government's Science Policy Bill of 2008. It makes clear statements on key empirical issues, taking a stance that may well be seen as the ultimate reflection of a belief that emerged in the first years of the millennium:

"*The outflow of patents and licences from research at Universities and University colleges is at a relatively low level given the extent of Swedish research. . . Seen from an international perspective, there are relatively few products and firms that in reality have come directly out of an academic environment.*" (Swedish Government, 2008, pp. 121–122)

Box 1: Selected repetitions of the ''academic paradox'' message (We are grateful to E. Perez Vico for helping us with the last two citations.)

- Braunerhjelm et al. (2003, pp. 33, 34) "Sweden is the country in the world which invests the highest share of GDP in R&D [. . .] Despite this, in comparison with other industrialized countries, Sweden is still specialized in low and medium-tech production. Accordingly, the Swedish system of innovation lacks the ability to transform research into products and services; there is a missing link between industry and university. [. . .] This academic entrepreneurship is missing in the Swedish growth-process."
- Delmar et al. (2005, p. 79): "In Sweden, there is substantial knowledge creation in terms of large expenditure on R&D. However, it is well-known that this knowledge is only marginally transformed into economic growth. In this report, we tap into one of the important reasons why this is the case. . .Sweden appears to be in a situation where there is an imbalance between knowledge creation and entrepreneurial activity with the latter being insufficient."
- Thomas Arctaedius, Head of Business relations at Stockholm University (Svenskt Näringsliv, 2006): "Sweden invests large sums (in an international comparison) in research and development but relatively few firms are created."
- Private member's Bill 2006/07, p. 1 from Finn Bengtsson and Andreas Norlén, Members of Swedish Parliament: Increased support for the commercialization of academic R&D results: "Sweden has had evident problems in transforming research results into new products and services in expanding firms. We are one of those countries that spend most on R&D but one of the poorest at creating new firms."
- Sven-Thore Holm, CEO of Innovation Bridge South (Ideon, 2007, p. 1): "The Swedish paradox. . .consists of Sweden being best in the world at allocating funds to R&D but does not reach the same position at all when it comes to generating research based products and firms."
- Nils Karlsson, CEO of Ratio (IVA, 2009, p. 1): "Sweden leads the league of research intensive countries. However, when it comes to . . .commercialisation, Sweden does not play in the highest division. . ..it is the lack of rapidly growing companies. . ..that is Sweden's Achilles' heel, not top class scientific results."
- Annie Lööf, Minister of Industry: ". . .in Sweden, we are very good at research but very poor at commercialization, that is getting bang for the buck" (Sveriges Radio, 2012).
- Lars Leijonborg, Minister of Research: with respect to nanotechnology Sweden is ". . .well-performing in research but it has not really yielded the extent of entrepreneurship that one hoped for a few years ago" (Thulin, 2010).

3. A scrutiny of the empirical foundation of the belief

Clearly, the perception of poor commercialization of academic R&D results is seen as a powerful explanatory factor behind the "Swedish Paradox." This perception builds upon two detailed beliefs; in an international perspective (a) there are few university spin-offs and these firms remain small and (b) there is a paucity of patents and licence agreements emanating from the academic sector. In what follows, we will critically assess the empirical foundation of these two detailed beliefs. We end the scrutiny by going beyond these beliefs, pointing to evidence of substantial indirect impact of academic R&D on commercialization, a hitherto neglected issue in the Swedish science policy debate.

Before we proceed, we will briefly comment on a serious methodological problem in the "paradox" literature. When tracing the impact of academic R&D investments on growth, it is of utmost importance to consider various time-lags. These involve, at the simplest level, the lag between the initiation of R&D and its effects in terms of published papers. This lag alone may be in the order of half a decade (Crespi and Geuna, 2008). Transforming academic results to commercial products takes additional years. Mansfield (1998,

Table 1
Key features of empirical studies.

Study	NTBF/USO[a]	Number of firms in the sample	Years covered	Average age of firms (years)	Size of firms (average employees and average sales)
Utterback and Reitberger (1982)	NTBF	60	1965–75	10	49 employees Sales 18 MSEK
Olofsson and Wahlbin (1993)	USO	569	1974–1989	8–9	7 employees
Rickne and Jacobsson (1996)	NTBF	53	1965–1975	n.a.	64 employees[b]
Rickne and Jacobsson (1999)	NTBF	1284	1975–1993	7–8	15.2 employees
Lindholm Dahlstrand (1997a)	NTBF	60	1965–1975	21	Sales 130 MSEK
Lindholm Dahlstrand (1997b)	NTBF/USO	60 NTBFs + 193 USOs = 253	1965–1993	23/10	NTBFs: 160 employees USOs: 14 employees

SEK, Swedish krona.
[a] NTFBs, new technology based firms; USO, university spin-offs.
[b] Employment in Sweden only. One firm had grown into a multinational firm with a turnover of SEK 10 billion in 1994.

p. 673) reported that the lag from recent academic research results, i.e. within 15 years, to commercial introduction in large corporations is on average 6 years. Yet another time-lag (discussed more below), which is often 10 years, is the one between the formation of a university spin-off and its eventual growth. Further time-lags are involved for these innovations and firms to diffuse/grow in such a way that a significant impact on economic growth can be traced. As is well-known in the literature, the diffusion of a new technology and the associated growth of new industries is a process that often takes several decades (e.g. Porter, 1990; Rosenberg, 1996; Grübler, 1996; Carlsson and Jacobsson, 1997). Yet, the "paradox" literature does not generally consider time-lags.[10]

Having pointed out this methodological problem, we proceed to scrutinize the empirical base of the two propositions stated above.

3.1. *"There are few university spin-offs and these firms remain small"*

The scrutiny of this belief is made in three steps. First, we assess the empirical base of the literature which argued for a Swedish "academic paradox" in the first years of the millennium. Second, we provide a comprehensive mapping of different types of university spin-offs in Sweden. Third, we compare new data on a subset of these with what has been found in previous surveys in the UK and the USA.

The collection of data on new technology based firms is not the responsibility of any government body so the empirical studies of academic spin-offs referred to in the Swedish "academic paradox" literature are academic studies. We will, therefore, begin by specifying the sources used in the paradox literature and scrutinize the data in those studies.

In the beginning of the 2000s, when the belief in poor commercialization became dominant, there were only a few empirical studies analysing the phenomenon (see Table 1). Moreover, the authors of these studies (including two of the authors of this paper) did not claim that there were few university spin-offs and that these firms did not grow. This interpretation was instead made by other authors citing these studies, authors who did not provide new data.

With reference to Utterback and Reitberger (1982) and Rickne and Jacobsson (1996, 1999), both Henrekson and Rosenberg (2001) and Goldfarb and Henrekson (2003) argued that there was empirical evidence of a low growth rate among new Swedish technology-based firms. They also suggested that existing studies of university spin-offs (Olofsson and Wahlbin, 1993; Lindholm Dahlstrand, 1997b) showed that the direct employment generated by these firms was small. The same studies[11] were used in the influential report from the Innovation Policy Expert Group (Andersson et al., 2002) where it was argued that there were few university spin-offs in Sweden and that these had limited growth. Braunerhjelm et al. (2003) referred to the same studies as well as to Henrekson (2002), Henrekson and Rosenberg (2000)[12] and Andersson et al. (2002), while Delmar et al. (2003) make the same argument based only on Andersson et al. (2002).

Table 1 reveals that the empirical evidence on which the belief stands is only contained in a few studies and we will argue that this evidence cannot support the conclusions drawn by those who cited these studies. First, none of the studies provide data that allow any firm conclusions about the number of new technology-based firms (NTBFs) or university spin-offs in Sweden. Five of the studies contain analyses of new technology-based firms in general. Four of these are limited to a sample of 60 NTBFs (the original Utterback and Reitberger sample) while the most comprehensive study (Rickne and Jacobsson (1999) excluded a large number of very small new firms. Only two studies analyse university spin-offs (USOs) specifically. These two were, likewise, not comprehensive studies of the frequencies of university spin-offs; Olofsson and Wahlbin (1993) only included 12 Swedish universities and Lindholm Dahlstrand (1997b) only one university. Thus, at the beginning of the millennium, there was no empirical evidence for arguing that there were few university spin-offs in Sweden.

Second, the data mainly include firms that were very young; as can be seen in Table 1, there were no studies of university spin-offs older than ten years. At this age, university spin-offs appear to be smaller than other NTBFs. However, Lindholm Dahlstrand (2008) found that there are long lead times between the formation and growth of university spin-offs. While many university spin-offs had very limited growth during their first ten years, they managed to improve significantly later.[13] Hence, allowing for the young age of the firms, acknowledging that it can take a decade or so before

[10] Indeed, typically, the discussion starts with a reference to Sweden's poor performance in terms of growth since the 1970s. For instance, Henrekson and Rosenberg (2001) show that the Swedish relative income dropped sharply from 1970 to 1998. In addition, they find high R&D expenditure in the Swedish university sector from 1981 to 1997 and a very high publication output for 1995. That is, no time-lags are taken into consideration when they raise the question "whether an important contributing factor to the Swedish decline in terms of relative income is due to some failure in its university system" (p. 210).

[11] The exception was Utterback and Reitberger (1982).

[12] This is a Swedish version of Henrekson and Rosenberg (2001). Henrekson (2002) is a Swedish version summarizing results from Henrekson and Rosenberg (2001) and from Goldfarb and Henrekson (2003).

[13] At the age of ten years, the average size of the *direct spin-offs* (see below) was 15.5 employees. Five years later the mean had grown to an average of 33 employees, i.e. an annual increase of 16.3 per cent. The corresponding figure for *indirect spin-offs* is about the same, i.e. an annual increase of 17.6 per cent. At the age of 15, the average number of employees in the indirect spin-offs was 44. Thus, in both direct and indirect university spin-offs, the size increased considerably after the initial ten years of operations.

university spin-offs start to grow, it is arguable that at the turn of the millennium,[14] there was not any conclusive evidence for claiming that university spin-offs remain small.[15]

Third, the coverage is only of Swedish firms so no international comparisons were made. The same limitation applies to Henrekson and Rosenberg (2001) and Goldfarb and Henrekson (2003). While these include a discussion of both Sweden and the US, they do not contain data on US university spin-offs. In the absence of internationally comparative data, it is not, of course, possible to conclude that the frequency and growth of university spin-offs is low compared to other countries. This is not a unique Swedish limitation as Arundel and Bordoy (2008, p. 5) point out:

> "*To date, there are very few... internationally comparable indicators...for evaluating the success of policies to promote the commercialisation of public science.*"

This calls into question what yardstick has been used in order to allege that Swedish spin-offs are few in an international comparison and that they remain small.

In contrast to the belief, acknowledging that there are great methodological problems involved in defining and measuring the number of university spin-offs, there appears to be a steady flow of such firms over the past decades in Sweden. In what follows, we will (a) review historical data on the frequencies of various types of academic spin-offs, (b) present novel data on a subset of these and (c) make a preliminary comparison with the UK and USA.

We distinguish between direct and indirect spin-offs, both of which have two sub-categories. In all four cases, university spin-offs are defined as firms founded on the basis of Swedish university based research. First, for direct spin-offs, Wahlbin and Wigren (2007) analysed data for 2006 and found that 2.5 per cent[16] of the researchers still employed at a Swedish university started a (side-line) firm in that year. The figure corresponds to approximately 500 new firms in a single year.[17] Of these, 55 per cent were based on the individual researcher's own research, i.e. corresponding to approximately 275 side-line university spin-offs if we define such a firm as one in which an academic starts a firm to exploit his or her previous research. Second, Lindholm Dahlstrand (2008) estimated that some 200 spin-offs started by academic researchers who left university employment, were formed annually between 1975 and 1993 (Fig. 1).

In addition to direct spin-offs, there are two categories of firms that involve spinning off knowledge from University research (see Fig. 1). These indirect spin-offs are not normally included in Swedish studies of academic spin-offs which focus on researchers, rather than research, spun out of universities.

First, we find firms where the founder was an "external entrepreneur" and not the university researcher. In these firms, the university researcher stays with the university and keeps his/her university employment. Slightly over one hundred such university spin-offs were estimated to have been started annually between 1975 and 1993. These 100 spin-offs are likely to have been included in the figure of 275 identified by Wahlbin and Wigren (2007). Hence, in Fig. 1, we divide these into approximately 100 external entrepreneurial spin-offs and 175 sideline spin-offs in which the researcher continues working for the University.

Second, we have the indirect university spin-offs which are firms established by previously employed university researchers (alumni) but not until the founder has worked some time in industry. These firms are based on the founder's own earlier academic research, but they are not likely to have been included by Wahlbin and Wigren (2007) as their method involved asking only researchers remaining at the university. Lindholm Dahlstrand (2008) estimated that some 400 indirect university spin-offs were started each year in the period 1975–1993.

Taken jointly, this estimation suggests that about 875 new firms were started every year based on university research in Sweden.

We have also collected more recent data on a subset of these spin-offs using the MONA database of Statistics

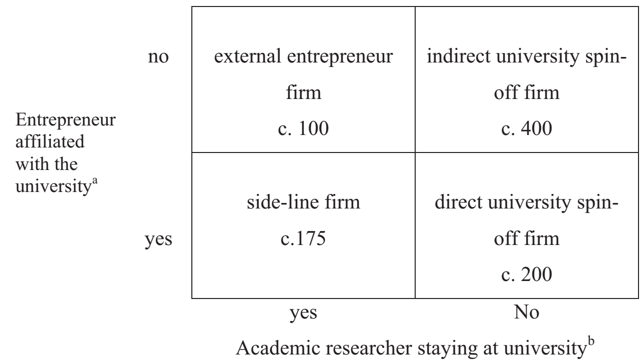

Fig. 1. Categories of spin-offs founded on Swedish university research (estimation of the annual number of new firms). [a]At the time of founding the firm. [b]After the founding of the firm.

Source: Lindholm Dahlstrand (2008) and Wahlbin and Wigren (2007). Lindholm Dahlstrand estimated Swedish spin-off frequencies between 1975 and 1993. Wahlbin and Wigren (2007) analysed spin-offs made in 2006 by Swedish researchers staying at the university.

Table 2
Swedish, British and US university spin-offs.

	Sweden (SCB)[a]	UK (HE-BCI)[b]	US (AUTM)[c]
2010	n.a.	268	651
2009	348	206	596
2008	396	191	595
2007	366	221	555
2006	388	226	553
2005	381	187	527
2004	378	148	462
2003	259	167	n.a.
Average	359	202	563

Source: SCB, HE-BCI and AUTM.

[a] Data from the MONA database, Statistics Sweden (SCB). The data include direct university spin-offs where the researcher left the university the same year as the new firm was founded.

[b] Data from the HE-BCI survey (higher education-business and community interaction survey, by Higher Education Founding Council for England and the Higher Education Statistics Agency). The data include Formal spin-offs, with direct application of HEI-owned IP.

[c] Data from the AUTM licensing survey (Association of University Technology Managers Licensing Survey). Spin-offs are dependent on the institutions' IP, and thus equivalent to those in the UK HE-BCI survey.

[14] The same problem exists in later studies, e.g. in Wennberg et al. (2011) who only included a two-year time-lag in their comparison of university and corporate spin-offs.

[15] Åstebro and Bazzazian (2011) report university spin-off sizes (in a number of countries) ranging between 4.8 and 83 employees, but as the age of these USOs is not provided, we cannot conclude whether or not the Swedish USOs grow slowly or rapidly in an international perspective.

[16] Compared to the general start-up frequency of the Swedish adult population (0.76 per cent in 2006, ITPS 2007), this is a high figure. Moreover, Delmar et al. (2003) found a start-up frequency of over 20 per cent in their population of university graduates.

[17] There were some 10 000 responding researchers in the sample. On average, the firm founders started 1.2 firms each. There were on average 4.3 founders in each firm, out of which 2.7 were university employees. In the sample, this corresponds to $0.025 \times 10{,}000 \times 1.2/2.7 = 111$ new firms. Estimation on the national level includes a scaling up for the 45,200 active researchers in Sweden that year, resulting in 500 new firms.

Sweden (see Table 2).[18] This data consists of Swedish matched employer–employee panel data where we can find information on all new university spin-offs set up by researchers leaving the university. The data in Table 2 therefore only include the subcategory of direct university spin-offs where the researcher left the university the same year as the new firm was founded, i.e. the data cover only quadrant 4 in Fig. 1.

The database provides information on spin-offs created between 1997 and 2009. In this period, there was a total of 3998 Swedish university spin-offs created directly by former university researchers. The average figure of about 300 firms is of the same magnitude as reported for the period 1975–1993 by Lindholm Dahlstrand (2008). Whether this figure is high or low is, however, impossible to say without internationally comparative data.

Unfortunately, available international data are not directly comparable with the Swedish and, indeed, internationally comparative analyses are very problematic to undertake. One reason is that in countries with a university ownership model, it is normally the IP and the disclosures that are measured, for example by university TTOs and associations like AUTM (Association of University Technology Managers) in the US. This means that in available spin-off data, information is not usually given about whether the university researchers have kept their university employment or not. Even so, in Table 2, we present a rough comparison with UK and US spin-off data. The UK data are drawn from the HE-BCI survey.[19] In addition, Table 2 holds information on the US data collected by the AUTM.[20] The figures for both UK and US are of the same magnitude as the direct university spin-offs in Sweden. The AUTM reports some 400–650 university spin-offs each year, while the British HE-BCI survey reports between 150 and almost 300, i.e. within the range of the figures for Sweden.[21,22]

In the Swedish data, however, the number of spin-offs is underestimated since they only include direct university spin-offs founded by university staff who set up the spin-offs directly after leaving university employment. The national data do not include university researchers creating firms while continuing university employment, nor do they include indirect spin-offs set up after more than one year, or university research being commercialized by someone other than the university researcher (external entrepreneur). A comparison with the studies of Wahlbin and Wigren (2007) and Lindholm Dahlstrand (2008) suggests that if these firms were also to be included, the Swedish figures would be at least doubled – the uncertainty is considerable.

However, being based on official register data means that the Swedish data in Table 2 have a much higher quality than the HE-BCI or AUTM data. In turn, this would suggest underreporting of both UK and US data. Almost ten years ago, Shane (2004) argued that university spin-offs were rare, and at that time he could find no other national data than the AUTM's figures for the USA. This problem was discussed by Fini et al. (2010) who found that only 35 per cent of new firms started by university researchers in the US were based on patented inventions within the IP system. Since the AUTM data only report spin-offs based on disclosures registered at participating universities, that is, within the IP system, this would suggest that the US figure in Table 2 is seriously underestimated (the number should be increased to about 1600). Åstebro et al. (2012) instead used SESTAT data to identify university spin-offs in the US. They followed established practice using SESTAT data and defined start-ups as those cases where faculty switched principal employment from university to own business, i.e. similar to those in quadrant 4 above. They found 622 spin-offs in the data (equivalent to 125 firms annually) and by scaling this up to represent a national estimate they arrived at 2571 university spin-offs per year.

Even using this higher US figure, the Swedish performance is impressive. A simple comparison involves calculating the number of spin-offs per million inhabitants in Sweden and the US (9.1 and 314 million respectively). Using the average of 359 Swedish spin-offs in Table 2 and Åstebro et al.'s 2571 for the US, we arrive at 8.2 spin-offs per million in the USA and 39 in Sweden. In sum, acknowledging the uncertainties involved, the available evidence suggests that Sweden has had a substantial number of university spin-offs, and that this has been the case for a long time.

3.2. *"There is a paucity of patents and licence agreements emanating from the academic sector"*

This belief is surprising as there is no relevant data collected by the Swedish Government. Collecting such data is, furthermore, difficult in Sweden where the Teacher's Exemption means that the Universities do not own patents. Instead, these are owned by the individual researchers, institutes or firms. This means that specially designed studies have to be undertaken to investigate patenting activity by Swedish academics.

In a survey of 10,000 university researchers (including PhD students), 1.8 per cent applied for a patent in 2006 (Wahlbin and Wigren, 2007, Table 1). This is equivalent to 115 patents and with approximately 2500 Swedish patent applications that year (with a Swedish applicant) these university researchers would be applying for at least four per cent of the Swedish patents.

Lissoni et al. (2009) set out to specify this magnitude in several countries, including Sweden. Their starting point was dissatisfaction with the empirical foundation of recent policies with the purpose of stimulating patenting by Universities (Lissoni et al., 2009, p. 190):

> "*All these initiatives to stimulate patenting by universities and university staff. . .were based on scattered or no data at all. Most information on university patenting came either from surveys submitted to university liaison offices or from cursory looks at the identity of patent assignees.*"

In order to develop a database (drawing on European Patent Office) that captures patenting activity by academic researchers, they included academics not only as assignees but also as inventors. In this manner, they were able to capture patents held by individual researchers as well as by firms collaborating with an academic researcher who is the inventor, but not the owner. The share of academic patents, defined in that way, of total patents was found to be at the same level in Sweden as in the US (6 per cent) and higher than that of France and Italy.[23]

The significance of this relatively high figure is magnified by the extensive patenting activity for Sweden as a whole. In the EU (27),

[18] We thank one of our anonymous reviewers for the suggestion to include the SCB, HE-BCI survey and AUTM data in our analysis.

[19] Funding of British HEIs (Higher Education Institutes) partly depends on spin-off creation, and, thus, the data reporting is not likely to be an underestimation. See http://www.hefce.ac.uk/econsoc/buscom/hebci/. This data is collected annually from British HEIs since 2003.

[20] The American AUTM (Association of University Technology Managers) data for 2004 to 2010 is available at http://www.autm.net/home.htm.

[21] The AUTM data only report spin-offs based on disclosures registered at participating universities. It should be noted that the AUTM studies only include data from less than 200 US Universities. These universities are, however, the most research intensive ones.

[22] Unfortunately, these firms are still very young, which is why a comparison of their growth has limited value. It is, thus important that such comparisons are made in future research.

[23] The US share of 6 per cent is calculated by Lissoni et al. (2009), based on Thursby et al. (2009). For Sweden, Ejermo (2011) arrives at a figure of 4–5 per cent but using the same method of Lissoni et al. (2009), he adjusts the figure to 6 per cent (Ejermo, 2012).

108 patent applications per million inhabitants were, on average, made to the EPO in 2010 (Eurostat, 2012). Sweden's figure was as high as 306, well above that of Germany. At the global level, Sweden is outperformed only by Switzerland and Japan in terms of triadic patent families in 2008 (OECD, 2010). Hence, Swedish academics account for a high share of an internationally very high number of patent applications! The Swedish Government's (2008) statement that Swedish academics perform poorly in terms of patenting is simply wrong.[24]

Most of Swedish patents are, however, not owned by the academics but by firms collaborating with Universities. Geuna and Rossi (2011, Table 5) point to a very high Swedish share of business ownership (81 per cent), higher than other European countries. Moreover, the European shares are much higher than that of the USA. As Lissoni et al. (2009, p. 203) argue[25,26]:

> "*Well over 60 percent of academic patent applications in France are owned by business companies, which also own almost 74 per cent of Italian academic patents and 82 per cent of Swedish ones; in contrast, business companies own only 24 per cent of US academic patents... The key piece of evidence...can be summarized as follows: universities in France, Italy and Sweden do not contribute much less than their US counterparts to their nations' patenting activity; rather, they are less likely to reclaim the property of the patents they produce.*"

In the Swedish case, the top companies owning academic patents include the large multinational companies ABB, Ericsson, Pharmacia and UpJohn, Astra Zeneca, Telia, Siemens and Sandvik. These companies interact to a great extent with Universities and obviously very often come out of that collaboration with the IPR. In the case of Royal Institute of Technology, for example, Rosenberg and Hagén (2003, p. 36) argue that:

> "*Ericsson had direct access to much of the research capability that resides in the technical universities. ...about two thirds of the patents that come out of the research at KTH became the property of private companies, in spite of the fact that these companies had contributed less than a fifth of KTH's research budget.*"

To conclude, there is strong evidence that (a) substantial academic patenting activity takes place, although 'invisible' without detailed scrutiny of patent data bases and (b) the IPR rests within the business community to a greater extent than in other countries – the transfer mechanism obviously works.

3.3. Indirect impact of academia on commercialization

Contrary to the dominant belief, the evidence suggests that Swedish academics perform well in terms of commercialization, as indicated by the number of academic spin-offs and academic patents. Yet, these indicators do not reflect the full contribution of academic research to commercialization in that much of that impact is indirect, i.e. mediated through other actors (Jacobsson and Perez Vico, 2010; Wennberg et al., 2011). There is substantial evidence of such impact mediated through both markets and networks.

In terms of markets, enquiries were already made in the 1980s about academic spin-offs in Sweden, revealing that they contributed to growth through other means than their own growth (VINNOVA, 2003). The Royal Academy of Engineering Sciences called these firms Research Based Knowledge firms and argued that:

> "...*these are strongly specialised and their business idea is to through 'productification' transfer technology and knowledge from the science system. These...firms emerge and develop primarily in close collaboration with larger established firms. Through their specialisation, they can function as effective supplements to the large firms* (VINNOVA, 2003, p. 19)."[27]

Hence, more than two decades ago, there was an appreciation that some of the impact of academic spin-offs can only be grasped by applying a system perspective. The importance of these firms was subsequently emphasized by Olofsson and Wahlbin (1993) who found that half of 569 academic spin-offs worked as (technology) consultants at start up. Almost a third of the income of these firms came from selling R&D services, usually to other (large) companies. Indeed, a total of about 44 per cent of the technology traded within Sweden originated in these university spin-offs.[28] More recently, Lööf (2005) provided evidence that university researchers working as consultants to industry are often more important than the purchase of patents and licences. In Sweden, these consultants are often found in university spin-off firms. Thus, the university spin-offs may have a significant, but indirect impact on industrial growth in that their sale of technology generates an increased activity in the customer organization.

In terms of network interaction, it is well recognized that relationships between academia and industry are strong in Sweden. Indeed, the Swedish Government (2004, p. 11) stated that: "Sweden has a long tradition of collaboration between academia and industry" and it also (Swedish Government, 2004, p. 79) claimed that: "The activities in the [energy research] program have relatively strong links to industry ... more than 50 per cent of the projects are lead by members of industry and more than 70 per cent of the projects deal with applied research, development or demonstration". Goldfarb and Henrekson (2003, p. 647) similarly argued that: "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". Finally, studies of the role of academic research in the energy, pharmaceutical and telecommunication fields suggest that "... these academic fields were more or less inseparable from industry...for long periods of time" (Hellström and Jacob, 2005).[29]

These networks are of central importance to our understanding of how academia contributes to commercialization in indirect ways. Drawing on ongoing work analysing how science is made useful at Chalmers University of Technology, we will point to three central ways in which strong network interactions contribute to commercialization.[30]

First, academia may indirectly contribute to the formation of a spin-off (see also Section 3.1) and, subsequently, to the renewal of an existing firm as it acquires the spin-off. The case of the

[24] Jacobsson and Rickne (2004, Table 6) show that in terms of number of person years spent on R&D in Natural Sciences and Engineering per million inhabitants, Sweden is just above the average for 12 countries studied. Hence, its good performance cannot be explained by a higher input into academic research than in other countries.

[25] The reason for the high ownership share differs between European countries but a common feature of the countries studied was the poor control that university administration has on IPR issues (Lissoni et al., 2009). In Sweden, it appears as if academia routinely transfers ownership to firms as a part of setting up collaborative research projects.

[26] Wahlbin and Wigren (2007, Appendix 7) show that 54 per cent of the academic patent applications were made together with an external organization which is broadly consistent with the results of Lissoni et al. (2009).

[27] The original source is not listed in VINNOVA (2003).

[28] The customers of the spin-offs were found to use this technology in their own R&D (over 30 per cent), in their production (over 35 per cent), and in their own products (approx 20 per cent) (Olofsson and Wahlbin, 1993).

[29] See RRV (2001) (The Swedish National Audit Office) for additional evidence of strong collaboration with industry by researchers at technical universities and in medicine.

[30] The remaining part of this section is based on Jacobsson et al. (2012).

Box 2: LignoBoost (Theliander, 2009)
The LignoBoost Process was developed in a network including Chalmers, the Institute Innventia and firms in the paper and pulp industry. Through modelling work, Professor Berntsson understood that the paper and pulp industry had a potential for improving energy efficiency which was so large that it should be possible to extract some of the lignin and use it for other purposes. Chalmers then (1996) contacted its network partner Innventia which is owned by, and conducts research for, the paper and pulp industry. In a project co-ordinated by the Institute, Professor Theliander investigated why it was so difficult to obtain pure lignin with high dry content when extracting lignin from black liquor. This led to the idea of a novel process solution which was tested on laboratory and pilot plant scales. Theliander's work was supported by Professor Berntsson, who led the work on integrating the LignoBoost process into the Kraft pulp process. The idea of a novel process solution was given to Innventia, which applied for patents. In the subsequent demonstration phase, Innventia took the main responsibility and Chalmers assisted in technical matters. The demonstration was undertaken in 2007 by a company that was a spin-off from the Institute and which used a factory that the company had bought for that purpose. It was shown that the process concept worked. In June 2008, the spin-off company, including the IPR, was acquired by Metso Power, a capital goods supplier.

new production process LignoBoost illustrates this (see Box 2). Academia provided ideas and knowledge that were subsequently patented by an Institute which spun off a company for testing the process. The IPR as well as the firm was then acquired by a capital goods supplier, Metso Power.

Second, academia may indirectly contribute to patenting, for example, by educating PhDs. An example is found in the Centre of Excellence (CoE) for Catalysis, a well funded Centre pursuing applied research. Yet, only a few patents have been granted to its staff. The manager of this Centre explains this (Skoglundh, 2011):

> "*If the centre staff would apply for patents themselves, the cooperation with the diverse member companies would be obstructed since the foundation of the Competence Centre rests on knowledge sharing. As a matter of fact, the member companies are not very interested in patenting activity connected to the Centre. It is mainly the research funding agencies that call for this as an indicator of success.*"

Instead, Skoglundh explains that one of the main benefits to industry is the formation of specialized human capital. Indeed, in the same Centre, it has been observed that the (former) PhD students apply for patents when they are employed by industry. The CoE has traced six previous PhD students and found that they had been involved in 20 patent applications within a 10 year period after graduation. These applications largely deal with catalysis-related issues which suggest that the former PhD students, and the firms in which they are employed, capitalize on the knowledge gained as academic researcher. A recent study of inventors in Sweden validates this observation (Ejermo, 2011, p. 7):

> "*The most important link among inventors to academia is, however, to education. Over 80 per cent of the inventors have a higher education and more than 20 per cent have a post graduate education.*"

Third, academia may contribute to the renewal of existing industry by influencing the perception of opportunities and by providing specialized human capital that can realize these opportunities. One example is that of control engineering in the transport equipment industry where Professor Egardt (2011) has collaborated with industry for two decades. With a background in control engineering at ABB Research, he has influenced the initially very hesitant Swedish transport equipment industry to engage in control engineering by pointing to technological opportunities of a knowledge field that today permeates all aspects of vehicle development. The search into that knowledge field was enabled by a supply of PhDs and engineers from Chalmers into an industry dominated by mechanical engineers, creating an absorptive capacity in control engineering. It was also enabled by a collaboration which is so dense that he characterizes it as experiencing an 'organic growth', fuelled by informal and formal networks and a range of meeting places.[31]

In sum, academia has substantial indirect effects on commercialization, mediated through both markets and networks. These effects are not considered in the "academic paradox" debate, which is a serious neglect. Including them strengthens the evidence that the dominant belief is erroneous.

4. A critical discussion of the EU policy response to the alleged problem of poor commercialization

There is a strong pressure to change the institutional framework so as to increase the perceived poor level of commercialization. Goldfarb and Henrekson (2003) suggested that the US university system is more effective in facilitating commercialization than the Swedish system in which rights are awarded directly to the inventor. Since then, the OECD has repeatedly argued that Sweden should abandon the Teacher's Exemption and the issue was brought up again in the 2008 Science Policy Bill (Swedish Government, 2008). As was noted in Section 1, there is a distinct move away from the Professor's privilege in Europe towards various systems of institutional ownership in the belief that the commercialization of research results will be facilitated (EU, 2007, 2008; Geuna and Rossi, 2011).[32]

There are two substantial problems with this institutional change. First, the Swedish case is not an exception in that there is a tension between the belief and empirical data. In an attempt to find internationally comparable indicators of the commercialization of academic research, Arundel and Bordoy (2008) analyse the performance of several EU countries, Australia, Canada and the USA. Whereas the United States is found to be the leader on patents granted, Europe performs better in terms of numbers of licences executed and numbers of start-ups. Contrary to the belief, the high rate of start-up formation in Europe suggests that European academics might not be less 'entrepreneurial' than their US counterparts. Bergman's (2010) findings of European researchers favouring entrepreneurial start-ups rather than other commercialization paths, further underline this finding. Not surprisingly, Arundel and Bordoy (2008, p. 15) conclude that other factors than a "failure of commercialization" should receive more attention in the EU. Hence, for our purposes, the diagnosis of the problem may well also be incorrect for these EU members.

Second, it is not necessarily so that a Bayh-Dole-type institutional change has a positive effect on technology transfer and economic growth. Kenney and Patton (2009) provide three examples where new models like the Bayh-Dole have not been successful: Cambridge, UK (Breznitz, 2011), Japan (Carraz, 2008; Takahashi and Carraz, 2011) and Denmark (Valentin and Jensen, 2007). Of these, the University of Cambridge is the clearest case

[31] A recent evaluation of the transport equipment R&D programme pointed to strengthened networks and impact of competitiveness of industry (VINNOVA, 2009).

[32] It is, however, important to note that before Bayh-Dole, the US Federal Government retained ownership of all patents granted using government funding. In Europe, it has instead been common that these ownership rights belonged to the university inventor.

for showing that an inventor ownership model can be successful for transferring technology and encouraging entrepreneurship (Breznitz, 2011). Abandoning this model, to mimic the US Bayh-Dole model, did not lead to increased technology transfer or entrepreneurship. Instead, there are indications that entrepreneurship declined. Additionally, in a six university comparison, Kenney and Patton (2011) conclude that inventor ownership has a positive effect on entrepreneurship. Their work is part of a growing literature in the US that critically addresses institutional ownership. In what follows, we will identify central criticisms and discuss risks associated with European "copycat" behaviour in this field.

As is well-known in the literature, and as was argued above for the Swedish case, firms (in particular large ones) actively monitor academic developments and have a range of links with the scientific community in the form of university-industry networks. These may be formal, such as partnership in a Centre of Excellence, or informal personal networks. Through these networks, firms gain many benefits, e.g. learn of promising academic knowledge developments via other channels than the technology transfer offices (Colyvas et al., 2002) or, as was shown above in the Swedish case, IP rights based on research projects with joint funding are assigned to existing firms. Not surprisingly therefore, Dosi et al. (2006, p. 1452) point out that:

> "*Interestingly, only very rarely has a critique of the Open Science System and the public funding of basic research come from corporate users.*"

US studies suggest that the transfer of IP rights to the University may interfere with the operation of other channels through which university inventions reach commercial application (Mowery et al., 2001; Litan et al., 2007; Kenney and Patton, 2009). Indeed, a negative impact on university–Industry interaction has been seen in Denmark which relatively recently abandoned the Professor's privilege (Valentin and Jensen, 2007; Åstebro and Bazzazian, 2011). Valentin and Jensen (2007) examined the effects of the Danish policy change by comparing patenting in Denmark and Sweden and found a significant reduction in contributions from Danish academic inventors. Helge Sander, the Minister for Science, Technology and Innovation explains: "...a mid-term evaluation of the new proof of concept-scheme indicates that private investors have become more reluctant to invest in university inventions" (The Danish Agency for Science Technology and Innovation, 2009, p. 7). In the Swedish case, where about 80 per cent of the academic patents are assigned to industry, abandoning the Teacher's Exemption for a University ownership model could well have a similar effect since it would risk disrupting the strong knowledge sharing networks.[33] As Geuna and Rossi (2011, p. 1075) argue:[34]

> "*In countries where university enforcement of IPR has traditionally been weak...because of the professor's privilege...academic inventors have...patented their inventions individually or assigned IPR ownership to collaborating firms. In these contexts, regulations ...enforcing university ownership may increase university-owned patents at the expense of university-invented patents. Care must be taken...not to disrupt pre-existing functioning knowledge transfer relationships between academic inventors and firms.*"

With university ownership, enhancing university revenues, which was not a central argument for the policies articulated in Bayh-Dole, has become an important objective of US universities in their patenting and licensing policies (Colyvas et al., 2002; Jensen and Thursby, 2001). According to Colyvas et al. (2002, p. 68), however, "...there is no reason to believe... that policies that maximize a university's revenues are always aligned with those that maximize technology transfer." This may have implications for both the types of technology to be commercialized and the frequency of spin-off firms.

As regards the former, revenue maximization may influence the type of technology that is being focused on. As Litan et al. (2007, p. 8) explain about the US university ownership model[35]:

> "... *the current reward structure and the centralization that accompanies it have turned TTOs into monopoly gatekeepers. Like any monopoly, this means that [...] TTO officers focus their limited time and resources on the technologies that appear to promise the biggest, fastest payback. Technologies that might have longer-term potential—or that might be highly useful for society as a whole, even if they return little or nothing in the way of licensing fees (...)—tend to pile up in the queue, get short shrift, or be overlooked entirely.*"

In terms of the latter, Markman et al. (2005) argued that US Technology Transfer Offices (TTOs) typically focus on short-term cash maximization and are extremely averse to financial and legal risks, over-emphasizing royalty income and underestimating entrepreneurship. Thus, granting IP ownership to universities instead of university inventors (see footnote 32) may hamper entrepreneurial processes and the frequency of university spin-offs (Kenney and Patton, 2009, 2011; Åstebro and Bazzazian, 2011).

Only very few universities reap any significant financial returns from commercialization activities (e.g. Rogers et al., 2000; AUTM, 2007; Litan and Mitchell, 2009, 2010; Kenney and Patton, 2009; Åstebro and Bazzazian, 2011). Even with university ownership, income flows from licensing are usually quite small as compared to the overall university budget; in most cases, they are even unable to cover the administrative costs of the 'technology-transfer office' (Dosi et al., 2006; Litan and Mitchell, 2009; Kenney and Patton, 2009; Åstebro and Bazzazian, 2011)! The Danish example demonstrates that even if revenues increase, the surplus may be very low indeed (The Danish Agency for Science Technology and Innovation, 2009).[36] The risk is, of course, that Universities may not allocate the required funding to fully exploit the IP rights while simultaneously blocking the exploitation in the form of spin-offs or through other means.

With university ownership, Kenney and Patton (2009) argue that in cases where the academic researcher wants to form a firm to exploit the invention, there is a high probability that the inventor's interests will diverge from the interests of the TTO. This is, of course, serious, especially since Litan et al. (2007) found that while spin-offs from universities are few in number, they are disproportionately high performing companies, and often (as in the Swedish case) serve as a mechanism to bridge the development gap between university technology and existing private sector products and services.

In sum, this literature suggests that European copycat behaviour may be counterproductive in that it involves risks in terms of obstructing the formation and effective operation of university–industry networks; biasing the types of technologies focused on; reducing frequencies of entrepreneurial spin-offs, and requiring a level of expenditure that Universities may be unwilling

[33] Disrupting the strong university-industry networks is likely to lead to a loss of social capital and, by implication, a reduction in also the indirect effects on commercialization, see Section 3.3.

[34] Breznitz (2011) study of the University of Cambridge adds to our concern.

[35] See also Mowery et al. (2001) and Markman et al. (2005).

[36] The Danish Agency for Science, Technology and Innovation (2009) reports that in Denmark, the public institutions' combined revenues from commercialization more than doubled from just short of 38 million DKK in 2007 to approximately 83 million DKK in 2008. However, the costs were high too, for example paying for the equivalent of 54 full time university employees to assist in the commercialization of university research.

to spend. Awarding universities the IP rights risks hampering rather than promoting technology transfer. Hence, it may not only be the diagnosis that is questionable, but also the medicine.

5. Concluding discussion

The purpose of this paper was to (a) critically assess the validity of the belief in the poor commercialization of European academic R&D and (b) identify risks of handling that alleged problem by focusing on the ownership of intellectual property rights (IPR). In addressing the first purpose, Sweden was used as a case in which we drew upon our "local knowledge" and a number of national sources of data to assess the validity of the widely held European belief in the poor commercialization of academic R&D. Sweden is also one of few European countries where university researchers (still) own the rights to their inventions. The Swedish case is, thus, a rare example of an 'Alternative model' of inventor ownership (Kenney and Patton, 2009, 2011). Our assessment of the "performance" of Sweden, and its "Teacher's Exemption" model, with respect to commercialization is, therefore, of interest to a broader audience.

The first step in the analysis was to scrutinize the literature arguing for an "academic paradox" at the beginning of the millennium. We found that it had drawn on a small number of studies carried out by others and formulated conclusions that went way beyond those found in the sources. Altogether far too strong statements were made from incomplete data on the number and growth of spin-offs, without access to internationally comparative data, leaving us with large question marks about how Sweden may be said to perform poorly in terms of the volume of university spin-offs and their growth.

The second step was to estimate the number of four types of academic spin-offs in Sweden, mainly in the period prior to the formulation of the "academic paradox". The annual number came to around 200 direct university spin-offs per year (where the researcher left the University), but many more firms if other categories of university spin-offs were included. The third step was to compare new data on this subset of Swedish university spin-offs to spin-off data in the UK and USA. We demonstrated that there are serious problems in comparing across nations, in particular in making sure that the same type(s) of spin-offs are included in the analysis. Acknowledging the uncertainties involved, we concluded that the available evidence suggests that Sweden has had a substantial number of university spin-offs, and that this has been the case for a long time. Indeed, the data suggest that Sweden, on a per capita basis, generates more direct university spin-offs than the US.

Much the same conclusion was drawn when we focussed on commercialization in terms of patenting. There is very strong evidence that substantial academic patenting activity takes place, although it is 'invisible' without detailed scrutiny of patent data bases, and that the IPR lands within the business community to a greater extent than in other countries – the transfer mechanism obviously works very well!

Contrary to the dominant belief, the evidence clearly suggests that Swedish academics perform well in terms of commercialization. Yet, spin-off and patent data do not reflect the full contribution of academic research to commercialization since substantial indirect effects can be discerned. This impact is mediated through both markets and, perhaps most importantly, through networks, which are very strong in Sweden. These indirect effects are so noticeable, at least at one Technical University, that impact assessments must include them in order to capture how academic research contributes to commercialization.

All in all, our assessment of the "Alternative model" which Sweden represents comes out very favourably. Whilst the data may not be as solid as we would wish, it is clear that in spite of the very confident statements made in the literature, there is a strong tension between the dominant belief and available data. According to Arundel and Bordoy (2008), the tension between belief and empirical data is not limited to Sweden. This tension needs to be relieved and one way forward is to conduct more internationally comparative studies which generate a solid empirical foundation that can inform policy.

There are also strong doubts about the usefulness of the medicine prescribed to cure this, alleged, problem. We pointed to a set of risks associated with European copycat behaviour where the prescription is a change in the IP legislation. Drawing largely on US literature, we argued that transfer of property rights from the researcher to the University risks harming strong university–industry networks, biasing technical change, reducing entrepreneurial activities and generating such high costs to the University that the technology transfer may not work well. These risks are being discussed at the very same time as European policy-makers and universities are putting more emphasis on the licensing route.

Rather than assuming that the US has the only institutional model of good practice from which the rest of the world can learn, Pavitt (2001) suggested that maybe larger European countries, and the European Union itself, has more to learn from the Scandinavian countries and Switzerland. In contrast, the OECD's tenacity in the belief in the efficacy of University ownership of IPR is pointed out by Kenney and Patton (2009) and in Sweden, the Government Science Policy Bill (2008) mentioned that the OECD has repeatedly recommended Sweden to reconsider its Teacher's Exemption. If the OECD recommendations were also to be followed in Sweden, it would not only risk the performance of a seemingly well-functioning academic sector but there would also be one less 'Alternative model' for other policy-makers in the world to consider.

These risks make it of utmost importance to ensure that efforts are made to avoid a repetition of the process whereby a belief becomes dominant without a solid empirical base. As is well-known in political science, policy-making takes place in a context where advocacy coalitions, made up of a range of actors sharing a set of beliefs, compete in influencing policy in line with those beliefs (Smith, 2000). Science Policy is, of course, no exception. It is, therefore, essential that the civil servants engaged in preparing policy documents have the necessary competence, back-up and working conditions that allow them to critically assess proposals from various lobbyists, irrespective of how these proposals are presented. Moreover, policy needs to be based on documented evidence which is referred to by governments. In Sweden, Government Bills lack references to sources which mean that Members of Parliament and others concerned cannot critically assess the empirical foundation of policy proposals.

Acknowledgements

This paper was written within the project 'Commercializing academic R&D – from counting spin-offs to knowledge transfer and entrepreneurship in a system perspective'. We are grateful to VINNOVA for their financial support. An earlier version was presented at the 2010 ERSA (The European Regional Science Association) Congress, Jönköping, August 19–23, where we received useful comments from Robert Gold, Max-Planck, Jena. Many useful comments were also received from Thomas Åstebro, HEC, Paris. We would also like to thank Eugenia Perez Vico, Chalmers University, for sharing her material in Section 3.3, and Lina Ahlin and Niclas Lavesson, Circle, Lund University, for help with the Swedish University spin-off data in Table 2. Thanks also to the three anonymous reviewers who provided useful comments.

References

Andersson, T., Asplund, O., Henrekson, M., 2002. Betydelsen av innovationssystem: Utmaningar för samhället och politiken, En fristående studie utarbetad på uppdrag av Näringsdepartementet och Utbildningsdepartementet. Vinnova, VFI 2002:1, Stockholm.

Audretsch, D., 2009. The entrepreneurial society. Journal of Technology Transfer 34, 245–254.

AUTM (The Association of University Technology Managers), 2007–2012. http://www.autm.net/Surveys/3396.htm (visited June 2012).

Arundel, A., Bordoy, C., 2008. Developing internationally comparable indicators for the commercialization of publicly-funded research, Working paper series #2008-075, UNU-MERIT, Maastricht, The Netherlands.

Åstebro, T., Bazzazian, N., 2011. Universities, entrepreneurship and local economic development. In: Fritsch, M. (Ed.), Handbook of Research on Entrepreneurship and Regional Development. Edward Elgar, Cheltenham, U.K.

Åstebro, T., Bazzazian, N., Braguinsky, S., 2012. Startups by recent university graduates and their faculty: implications for university entrepreneurship policy. Research Policy 41, 663–677.

Bengtsson, F., Norlén, A., 2006/2007. Ökat stöd till kommersialisering av akademiska forskningsresultat, Private Member's Bill to the Parliament 2006/2007. Ub311, Stockholm.

Bergman, E.M., 2010. Marshall's Dilemma and Commercialization of European Research. Paper presented at the 2010 ERSA (The European Regional Science Association) Congress, Jönköping, August 19–23.

Braunerhjelm, P., 1998. Varför leder inte ökande FoU-satsningar till mer högteknologisk export? Den svenska exportparadoxen. Ekonomiska Samfundets Tidskrift 2, 113–122.

Braunerhjelm, P., Svensson, R., Westin, F., 2003. Akademiskt entreprenörskap – den svaga länken i de svenska innovationssystemen? Ekonomisk Debatt årgång 31 (3), 33–46.

Breznitz, S., 2011. Improving or impairing? Following technology transfer changes at the University of Cambridge. Regional Studies 45, 463–478.

Carlsson, B., Jacobsson, S., 1997. Variety and technology policy – how do technological systems originate and what are the policy conclusions? In: Edquist, C. (Ed.), Systems of Innovation: Technologies, Institutions and Organizations. Pinter, London.

Carraz, R., 2008. Incentives to patent in a leading Japanese university. Paper presented at the SPF Project on Role of Universities in National Innovation Systems, 3rd Workshop, Beijing, 30–31 October 2008.

Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R.R., Rosenberg, N., Sampat, B.N., 2002. How do university inventions get into practice? Management Science 48, 61–72.

Crespi, G., Geuna, A., 2008. An empirical study of scientific production: a cross country analysis, 1981–2002. Research Policy 37, 565–579.

Danish Agency for Science, Technology and Innovation, 2009. Public Research Commercialisation Survey: Denmark 2008, Innovation: Analysis and Evaluations 13/2009.

Delmar, F., Wiklund, J., Sjöberg, K., 2003. The Involvement in Self-employment among the Swedish Science and Technology Labor Force between 1990 and 2000, A2003:017. ITPS, Sweden.

Delmar, F., Wennberg, K., Wiklund, J., Sjöberg, K., 2005. Self-employment among the Swedish Science and Technology Labor Force: The Evolution of the Firms Between 1990 and 2000, A2005:001. ITPS, Sweden.

Dosi, G., Llerna, P., Labini, M.S., 2006. The relationships between science, technologies and their industrial exploitation: an illustration through the myths and realities of the so-called 'European Paradox'. Research Policy 35, 1450–1464.

Edquist, C., McKelvey, M., 1991. Högteknologiska produkter och produktivitet i svensk industri', in Forskning, Teknikspridning och Produktivitet, Expert Report number 10 to the Productivity Delegation.

Edquist, C., McKelvey, M., 1998. High R&D Intensity without High Tech Products: A Swedish Paradox? In: Nielsen, K., Johnson, B. (Eds.), Institutions and Economic Change: New Perspectives on Markets, Firms and Technology. Edward Elgar Publishing Ltd, Cheltenham UK, pp. 131–148.

Egardt, B., 2011. Interview with Professor Bo Egardt, Signals and Systems, Chalmers University of Technology, Gothenburg, Sweden, January 17th.

Ejermo, O., 2012. Gammal uppfinner bäst – lärosätenas effekter på patentering via anställda och studenter. Ekonomisk Debatt (2), 37–51.

Ejermo, O., 2011. Svenska uppfinnare – nytt datamaterial och ny inblick i innovationsprocessen. Working Paper 2011:14, Tillväxtanalys, Östersund.

Ejermo, O., Kander, A., Svensson Henning, M., 2011. The R&D-growth paradox arises in fast-growing sectors. Research Policy 40, 664–672.

European Commission, 1993. Growth, Competitiveness, Employment: The Challenges and Ways Forward into the 21st Century – White Paper COM (93) 700, December.

European Commission, 1995. Green Paper on Innovation, COM (95) 688 final, 20 December.

European Commission, 2003. European Report on Science & Technology Indicators, Directorate-General for Research, Brussels.

European Commission, 2007. Improving knowledge transfer between research institutions and industry across Europe, DG Research and DG Enterprise and Industry, EUR 22836, Brussels.

EU, 2008. PROFESSOR'S PRIVILEGE: monitoring and Analysis of technology transfer and intellectual property regimes and their use, draft report to the Commission (DG Research), December 2008.

Eurostat, 2012. Patent applications to the European Patent Office, Applications per million inhabitants, http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsiir060&plugin=1 (accessed 11.09.12).

Fini, R., Lacetera, N., Shane, S., 2010. Inside or outside the IP system? Business creation in academia. Research Policy 39, 1060–1069.

Geuna, A., Rossi, F., 2011. Changes to university IPR regulations in Europe and the impact on academic patenting. Research Policy 30, 1068–1076.

Goldfarb, B., Henrekson, M., 2003. Bottom-up versus top-down policies towards the commercialization of university intellectual property. Research Policy 32, 639–658.

Grübler, A., 1996. Time for a change: on patterns of diffusion of innovations. Daedalus 125, 19–43.

Hellström, T., Jacob, M., 2005. Taming unruly science and saving national competitiveness: discourses on science by Sweden's strategic research bodies. Science, Technology, & Human Values 30 (4), 443–467.

Henrekson, M., 2002. Strategier för framgångsrikare kommersialisering av svensk universitetsforskning. Ekonomisk Debatt årgång 30 (2), 159–170.

Henrekson, M., Rosenberg, N., 2000. Akademiskt entreprenörskap. Universitet och näringsliv i samverkan, SNS Förlag, Stockholm.

Henrekson, M., Rosenberg, N., 2001. Designing efficient institutions for science-based entrepreneurship: lesson from the US and Sweden. Journal of Technology Transfer 26, 207–231.

Ideon, 2007. Uppdraget fullgjort – nu lämnar Sven-Thore Holm. www.ideon.se/presspaa-g/pressmeddelanden/artiklar/select_category/5,4/artikel (accessed 19.05.09).

IVA, 2009. Företagandets villkor avgör framtiden, www.iva.se/IVA-aktuellt-artiklar/Foretagandets-villkor-avgor framtiden (accessed 19.05.09).

Jacobsson, S., Rickne, A., 2004. How large is the Swedish 'academic' sector really? A critical analysis of the use of science and technology indicators. Research Policy 33, 1355–1372.

Jacobsson, S., Perez Vico, E., 2010. Towards developing a systemic framework for capturing and explaining the effects of academic R&D. Technology Analysis and Strategic Management 22, 765–787.

Jacobsson, S., Perez Vico, E., Hellsmark, H., 2012. The many ways of academic researchers – how science is made useful at a University of Technology, mimeo, Environmental Systems Analysis, Chalmers University of Technology, Göteborg, Sweden.

Jensen, R., Thursby, M., 2001. Proofs and prototypes for sale: the licensing of university inventions. The American Economic Review 91, 240–259.

Kenney, M., Patton, D., 2009. Reconsidering the Bayh-Dole Act and the current university invention ownership model. Research Policy 38, 1407–1422.

Kenney, M., Patton, D., 2011. Does inventor ownership encourage university research-derived entrepreneurship? A six university comparison. Research Policy 40, 1100–1112.

Lindholm Dahlstrand, Å., 1997a. Growth and Innovativeness in technology-based spin-off firms. Research Policy 26, 331–344.

Lindholm Dahlstrand, Å., 1997b. Entrepreneurial spin-off enterprises in Göteborg, Sweden. European Planning Studies 5, 661–675.

Lindholm Dahlstrand, Å., 2008. University knowledge transfer and the role of academic spin-offs. In: Potter, J. (Ed.), Entrepreneurship and Higher Education. OECD Publication, Paris, France, pp. 235–254.

Litan, R.E., Mitchell, L., 2009. Accelerating the Commercialization of Government-Funded University-Based Research, Memorandum to Esther Lee, Dept of Commerce, USA, August 17.

Litan, B., Mitchell, L., 2010. A faster path from lab to market. Harvard Business Review January–February, 52–53.

Litan, R.E., Mitchell, L., Reedy, E.J., 2007. Commercializing university innovations: a better way. Working Paper, National Bureau of Economic Research, Cambridge, MA, USA.

Lissoni, F., Llerena, P., McKelvey, M., Sanditov, B., 2009. Academic patenting in Europe; evidence on France, Italy and Sweden from the KEINS database. In: McKelvey, M., Holmén, M. (Eds.), Learning to Compete in European universities. From social Institution to Knowledge Business. Edward Elgar, Cheltenham, U.K.

Lööf, H., 2005. Vad ger samarbetet mellan universitet och näringsliv, Tillväxtpolitisk utblick, ITPS, No 1, January.

Mansfield, E., 1998. Academic research and industrial innovation: an update of empirical findings. Research Policy 26, 773–776.

Markman, G.D., Phan, P.H., Balkin, D.B., Gianiodis, P.T., 2005. Entrepreneurship and university-based technology transfer. Journal of Business Venturing 20, 241–263.

Mowery, D.C., Nelson, R.R., Sampat, B.N., Ziedonis, A.A., 2001. The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980. Research Policy 30, 99–119.

OECD, 2010. Science, Technology and Industry Outlook, http://dx.doi.org/10.1787/sti_outlook-2010-en

Ohlson, L., 1991. Förnyelsepolitiken & riskkapitalet. Industriförbundets förlag AB, Stockholm.

Ohlson, L., Vinell, L., 1987. Tillväxtens drivkrafter. En studie av industriers framtidsvillkor. Industriförbundets förlag, Stockholm.

Olofsson, C., Wahlbin, C., 1993. Teknikbaserade företag från högskolan, Slutrapport till näringsdepartementet, IMIT.

Pavitt, K., 2001. Public policies to support basic research: what can the rest of the world learn from us theory and practice? (And what they should not learn). Industrial and Corporate Change 10 (3), 761–779.

Porter, M., 1990. The Competitive Advantage of Nations. Macmillan Press, London.

Rickne, A., Jacobsson, S., 1996. New technology-based firms – an exploratory study of technology exploitation and industrial renewal. International Journal of Technology Management 11, 238–257.
Rickne, A., Jacobsson, S., 1999. New technology based firms in Sweden – a study of their direct impact on industrial renewal. Economics of Innovation and New Technology 8, 197–223.
Rogers, E.M., Jing Y., Hoffmann, J., 2000. Assessing the Effectiveness of Technology Transfer Offices at U.S. Research Universities, Association of University Technology Managers.
Rosenberg, N., Hagén, H.O., 2003. The responsiveness of the universities, ITPS A 2003:019.
Rosenberg, N., 1996. Uncertainty and technological change. In: Landau, R., Taylor, T., Wright, G. (Eds.), The Mosaic of Economic Growth. Stanford University Press, Stanford, CA, pp. 334–355.
RRV, 2001. Från forskning till tillväxt – statligt stöd till samverkan mellan högskola och näringsliv, RRV, 2001:11, Stockholm.
Shane, S., 2004. Academic Entrepreneurship: University Spinoffs and Wealth Creation. Edward Elgar, Northampton, MA.
Skoglundh, M., 2011. Interview with M. Skoglundh, Manager at Chalmers Competence Centre for Catalysis, November 3, Chalmers University of Technology, Gothenburg, Sweden.
Smith, A., 2000. Policy networks and advocacy coalitions explaining policy change and stability in UK industrial pollution policy? Environment and Planning C: Government and Policy 18, 95–118.
Sveriges Radio, 2012. Regeringen måste satsa på uppfinnare, tycker Socialdemokraterna, Samtal med Annie Lööf (C) och Jennie Nilsson (S), P1-morgon, Sveriges Radio, March, http://sverigesradio.se/api/radio/radio.aspx?type=db&id=3834651&codingformat=.m4a&metafile=asx
Svenskt Näringsliv, 2006. Lärosäte lägger krut på kommersialisering, Nyhet Publicerad 2006-02-23, www.svensktnaringsliv.se/skola/hogskolan/article14239, (accessed 19.05.09).
Swedish Government, 1993. Forskning för kunskap och framsteg, Stockholm.
Swedish Government, 1999. Vissa forskningsfrågor, Stockholm.
Swedish Government, 2001. Regeringens proposition 2001/02:2: FoU och samverkan i innovationssystemet, Stockholm.
Swedish Government, 2004. Forskning för ett bättre liv, Stockholm.
Swedish Government, 2008. Regeringens proposition 2008/09:50: Ett lyft för forskningen, Stockholm.
Takahashi, M., Carraz, R., 2011. Academic patenting in Japan: illustration from a leading Japanese university. In: Wong, P.K. (Ed.), Academic Entrepreneurship in Asia. Edward Elgar Publishing, Cheltenham, U.K., pp. 86–107.
Theliander, H., 2009. Personal communication with Professor Hans Theliander, Chalmers University of Technology, March 4th.
Thulin, C., 2010. Leijonborg Sveriges nya nanoansikte, Dagens industri, http://di.se/Templates/Public/Pages/ArticlePrint.aspx?pl=207139_ArticlePageProvider, May 19th.
Thursby, J., Fuller, A.W., Thursby, M., 2009. US faculty patenting: Inside and outside the university. Research Policy 38, 14–25.
Utterback, J.M., Reitberger, G., 1982. Technology and Industrial Innovation in Sweden – A Study of New Technology-Based Firms, Report submitted to National Swedish Board for Technical Development (STU), Stockholm.
Valentin, F., Jensen, R.L., 2007. Effects on academia–industry collaboration of extending university property rights. Journal of Technology Transfer 32 (3), 251–276.
VINNOVA, 2003. VINNFORSK, VINNOVAS förslag till förbättrad kommersialisering och ökad avkastning i tillväxt på forskningsinvesteringar vid högskolor, VINNOVA Policy VP 2003:1, Stockholm.
VINNOVA, 2009. Effekter av statligt stöd till fordonsforskning, VINNOVA Analys 2009:2, Stockholm.
Wahlbin, C., Wigren, C., 2007. Samverkan i det akademiska vardagslivet, NUTEK.
Wennberg, K., Wiklund, J., Wright, M., 2011. The effectiveness of university knowledge spillovers: performance differences between university spinoffs and corporate spinoffs. Research Policy 40, 1128–1143.