Introduction to the Symposium: Universities as a Source of Commercial Technology

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ABSTRACT. ■

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Since the 1860s, American universities were considered a major source of knowledge for agriculture and industry, particularly so after the adoption of the 1862 Morrill Act, donating federal lands for the creation of universities supporting both types of commercially-useful research activity. For several decades until the World War II, the links between American universities and industry grew, but it was the global conflict, as well as the activity of people such as Vannevar Bush (originator of the National Science Foundation, created in 1950) that made a decisive move to massively increase university research. Similarly in Canada, the foundation of the three funding councils (for medical, engineering and natural science, and social science research) in the 1960s and 1970s, transformed many academic institutions into research universities. Academic research, as Etzkowitz (1999) aptly points out, was a necessary condition for universities becoming a source of industrial technology.

The scientific study of universities as a major supplier of technology for industry is less than 30 years old. In one of his key papers, Edwin Mansfield (1991) estimated that in seven manufacturing industries (chemicals, drugs, electrical, information technology, instruments, metals and oil) some 11% of products and 9% of processes commercialized between 1975 and 1985, could not have been developed, without substantial delay, in the absence of recent academic research. The average concealed substantial differences between the drug (27% and 29%, respectively, for products and processes), and the oil industries (1% and 1%). Mansfield data were obtained from a random sample of large firms in these industries. His estimations were higher from those of a previous study (Gellman, 1976) based on data for the 1953–1973 period, which estimated that 7% of innovations in the same industries were based on innovations originally conceived at universities. The average time lag between the conclusion of the relevant academic research and the commercialization of the innovation was 7 years. Mansfield also estimated the average social rate of return from academic research to be around 28%, a figure he considered to be conservative. Rosenberg and Nelson (1994) highlighted the fact that, from their inception, American universities were closely related to the needs of industry, and particularly, related to local industrial needs. American universities, highly decentralized, contributed to all branches of industry through their growing and increasingly diversified engineering schools.

However, these original patterns (i.e. universities conducting research useful in industry) do not exactly fit the present triple revolution of information technologies, material sciences and molecular biology. In these areas, research conducted in universities has direct and immediate impacts on commercial organizations; very often academia and industry are competing for exactly the same goals, as witnessed by the race between public and private organizations to sequence the human genome. At the same, the rise of venture capital brought increasing funds for the conversion of academic knowledge into new firms (academic spin-offs), the number of which increased substantially during the 1990s. Also, in the last 20 years, the bulk of patents, transfers and

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spin-offs from academic research came from molecular biology and the related human life sciences (Mowery *et al.,* 2001). If information technologies are added, these two new technological fields encompass easily three-quarters of whatever academic research has produced in the recent decades with commercial value.

In the last 10 years, thus, the attention has been focused on the precise channels of technology transfer between university and industry. Increasingly, economists, administrative scientists and other observers studied the impacts of the 1980 Bayh–Dole Act in the United States, as well as the usefulness of incubators, spin-offs, offices of technology transfer, the value of university patents, etc. The times are not anymore to judge whether academic research has industrial value, but to measure the most effective mechanisms for their transfer to industry, as well as the values of contracts, consulting, patenting and licensing, as well as the incubation of new firms and the returns of public funds and venture capital invested in academic spin-offs.[1]

This special issue is entirely devoted to these new and more down-to-earth themes. The issue starts with an overview of patenting, licensing and creation of new companies in developed countries, by Tony Heher. After comparing American, Australian, British, Canadian, and European university figures on higher education research expenditures and an array of suitable outcome indicators (including patents, start-up companies, and royalties), he finds that expectations about the commercial value of university research are often too high compared with results. Most returns on investments, as measured at the level of universities are low and highly skewed: in each university most returns come from one or two patents. Also, time scales of these returns are long, and the measurement of returns are incomplete, if not unavailable. Thus, more benchmark measures are required to better understand the actual and future potential rewards on investments in university research.

Follows a theoretical section with two papers by Rob Lowe and Roberto Mazzoleni. Lowe builds a model of technology transfer between university inventors and industry that applies to the US context. He suggests that when the invention includes high levels of tacit knowledge, the inventor will most probably found a start-up firm to get the higher possible rents from his invention. Conversely, if the invention involves moderate levels of tacit knowledge, the best option will be licensing it to an existing firm. However, if universities require a royalty from academic entrepreneurs, total output may be reduced, as inventors will transfer the invention to the university instead of marketing it by themselves.

Mazzoleni recalls the conditions under which universities should patent their inventions according to the Bayh–Dole Act. This is a particular situation where downstream novelties cannot be patented, and thus the only way for industrial users to secure returns from investments in academic research results is to get exclusive licenses from universities. However, he finds that there is a second common situation, where under open access to information, several industrial users can obtain patents on their downstream inventions and thus get returns on their investments in innovation. Under open access conditions, several possible situations may occur, only one of them being one where no firm engages in downstream research. Empirical evidence shows that this particular situation is fairly atypical. Mazzoleni concludes that more attention should be given to the specific characteristics of university inventions and possible downstream innovation activities, in order to understand the social gains of university patenting and licensing compared to open access through publication.

The second section deals on incubators and spin-offs. Spin-offs, if not the most widely used mechanism of technology transfer from university to industry, are the most visible, and as new companies emerge that may become engines of regional economic development. Two papers analyze university spin-off companies. Libaers, Meyer and Geuna studied university spinouts in nanotechnology, with an emphasis on one of the leading countries, the United Kingdom, and compared it with Germany and Israel. They conclude that university spin-offs (USOs) play important but not dominant roles in the development of this new technology, but that they compete with large companies as well as corporate spin-outs (CSOs) and new technology based firms that are neither CSOs nor USOs.

In his examination of Canadian publicly quoted USOs, Niosi finds that most of these are biotechnology firms. In the new context of the after-bubble, few high-technology academic spin-offs were growing, and biotechnology USOs were particularly weak in terms of both growth and job creation. He concludes that spin-offs are only one mechanism of technology transfer from academia to industry, and probably not the most efficient one, as compared to transfer to incumbent firms, a conclusion that fits nicely with the results presented by Hanel and St-Pierre as well as Meyer in this issue.

Von Zedwits and Grimaldi studied a sample of ten Italian incubators, and through interviews developed a typology of them that includes five types, university, as well as regional business, company, independent commercial and virtual ones. They found major differences in their missions, the services they provided, their competitive scope and, consequently, their effectiveness and efficiency. The two university-based incubators provided networks, visibility, and access to academic resources, but they did not offer either venture capital or specialized managerial services. However, they had contributed to the diffusion of an entrepreneurial culture in each university.

Becker and Gassman studied some 25 corporate incubators in Europe and the US, as well as two European university incubators. They suggest that non-profit (i.e. university) incubators can learn from the more successful corporate ones. More specifically, university incubators should clarify their missions, their structure (incorporating outside advisory boards with private and public sector representatives), their processes, and the resources that spin-off companies need to receive in order to become successful. Also, different types of corporate incubators may add some specific lessons for university ones; for instance university incubators should clearly make the distinction between leveraging core university technologies requiring long-term support (i.e. biotechnology) and fast-profit spin-offs putting forward some specific short life cycle ones (i.e. software) in order to provide different services to different technologies.

Two final papers find that large, incumbent industrial firms are the most frequent adopters of university technology. Using Statistics Canada 1999 data of the Suvey of Innovation, Hanel and St-Pierre studied the patterns of collaboration between industry and university. They found that the propensity to collaborate with universities increases with the size of the firm, and is more frequent in R&D active companies. Also, firms collaborating with universities were more often active in high technology industries. Industrial collaborators had more often than other firms introduced innovations that were characterized as "world firsts", supporting the theses that university partnerships help companies to produce more radical innovations. The typical collaborator was also using government support programs for R&D, trained its workforce and more often used patents to protect its novelties. The portrait that emerges is one of university collaboration being more frequent with large incumbent companies, not university spin-offs. And industry–university collaboration appears as a strong component of Canada's national innovation system.

Last but not least, Meyer studied Finnish patents invented by academics, and their use in industry. He found that large corporations are still the most frequent users of university-invented technology. Spin-offs and other small firms are better represented in the fields of life science and natural sciences. Meyer suggest the possible idea that the creation of spin-off companies by academics is more the result of the lack of interest by large companies in some academic novelties, rather than the motivation to exploit a technological opportunity created by the researcher.

The results presented in this special issue tend to suggest some caution when universities, regions, and governments support university incubation of new technology-based firms. More research is needed to precisely understand the value of academic technology transferred to industry, comparing those transferred to SMEs and to large firms. Also, the advantages and disadvantages of university patenting and licensing, incubating and supporting firms are still fairly unclear. If university incubators are to be set up, then the best management routines are yet not clear. Other incentives for university researchers producing world-class technology are still in trials.

Notes

1. See the book edited by Branscomb et al. (1999) on these matters.

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