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The universities' contribution to economic prosperity through technology transfer

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Abstract. Our economy is a knowledge-based economy an economy founded on the production, distribution and use of knowledge. Thus a connection of main economic actors (firms) to main knowledge producers (universities) is necessary. The process of technology transfer from universities to market is however not simple and consumes resources and infrastructure. European universities face this challenge in a way not similar to the American ones, looking for great revenues, strengthening of basic research and local growth. The latter is analysed in this work and proposals are made to universities, to match society's expectations without jeopardizing their core mission, education and research.

1. Introduction

Once again, following the so called 2008 crisis, European capitalist system worries about its future and pushes the political system to support it, exploiting another form of social capital, the knowledge produced in universities. There is a vast majority of literature, underlying the importance of universities as an engine of the economy, their obligation to justify the money they take from the governments and even the concept of "entrepreneurial" universities have been invented [1], to take over another social gain.

However, this is the real world and universities are challenged to respond to these pressures in order to continue to serve their core missions, higher education and basic research. Since last century numerous examples of university involvement in successful technological achievements in US economy have been recorded: University of Akron became a leader in research on the processing of rubber. In the 1920s and 1930s, university agricultural research formed the foundation of the hybrid corn revolution. More recently, several industries such as the digital computers, lasers, and biotechnology can track their origins to research conducted in university laboratories.

This is neither strange not even a discovery, as many researchers, politics and economists want to present. If we recall the foundation of the first medical and engineering universities, it was natural to build their research upon real problems and to use the outcomes of their research to solve problems either directly or indirectly with the provision of skilled graduates.

As a consequence of all the above, naturally a question comes out. Which is the purpose of all this debate and how universities would "survive"? The purpose of the current study is to answer these issues keeping always in mind the society's expectations for a fair and prosperous life.



2. Framework of analysis

Conventional economic theories have proven how important is to undergo basic research in the fields of technological innovation and the related economic growth [2-3]. Basic research is one of universities core missions, and the term is used rather to describe the free research driven from faculty scientific curiosity rather to express that only universities perform basic research. As a result, it may have little immediate economic value [4]. Also its usefulness varies considerably across disciplines and across industries. Nevertheless, university creates and advances technology which is necessary for the operation, success and survival of private firm's sector.

Taking into consideration that it is difficult, even for companies at the cutting edge of technology to 'digest' the university driven technology we have witnessed the birth of a series of transfer mechanisms as patent licensing, contractual research, students hiring, spin-offs and so on. Though patent licensing is a system upon which grounded the industrial revolution, many scholars [5] tend to use that as an indicator of universities potential to support firms, otherwise to commercialize their R&D results. And then, the intermediaries (as in any capitalist activity) were born, namely the technology transfer offices, which "recognizes the realities of the business world" [6] and can overcome traditional beliefs that university commercial activity is not appropriate for academic scientists.

The real motivation for the enforcement of technology transfer mechanisms and their market orientation is that innovation coming from research is costly, as it requires substantial investments, high commercial uncertainty and of course a certain kind of human capital. It would be difficult, even immoral for companies to press universities, or "persuade" university researchers to leave their jobs and move to firms R&D departments, so the political system took over and the first main intervention was the Bayh-Dole act in the US. The act was an instrument to pass the ownership of research funded from the state to the research sector. Many consider this as a trigger, to provoke universities to be interested in research commercial applications. It was a matter of time for Europe to follow and implement adapted versions of Bayh-Dole [7]. The rhetoric of Bayh-Dole act was that universities will assist the declining industrial competitiveness demonstrating that they are actively engaged in disseminating research results attractive to industry. Society suddenly wonders if universities deserve the money the state spends, so they have to prove their social role. This is not strange by itself, however it is rather notable how easily and urgently society demands from universities to respond as entrepreneurs.

It is worthwhile to underline the core mission of universities which is to serve society providing high level education and research. Always universities were serving societies providing graduates, the human capital which transfers knowledge to any activity they are involved and generate added value not only to firms, but also to public activities as basic education, healthcare, public safety and so on. And always universities were producing new ideas through research results, open to the public, a collective good which also firms could exploit, depending on their innovative initiatives and the risks they were willingly undertaking. The notion that this research may was not focused to real problems or "market-oriented" because was serving only scientists' curiosity is at least naive considering for example the mathematical games theory [8] and its applications in economy, political science, computer science and biology.

The former analysis overturns the idea that universities are knowledge ivory towers, rather underlines their continuous service to society since the first university foundation (University of Bologna, 1088-faculty of medicine was formed approximately 1200 A.D.). Of course the changing social, economic and political environment affects the way, the speed and the form of activities a university has to perform without jeopardizing core missions as education and basic research. The best-known success stories of licensing, patenting and spin-offs, cannot hide what is the greatest path of knowledge that is the continuous flow of university trained students and researchers.

An issue we face is that technology transfer is a sophisticated and often complex process. "It needs significant resources and infrastructure to make it work well" [6]. Moreover, universities themselves as complex organizations dealing with a variety of educational and social objectives cannot integrate a non-academic structure dealing with technology transfer in their organizational scheme. It would be more convenient to form an affiliate structure to perform such activities.

Another worthwhile dimension needing a closer look is the effect of a university in its area of activity. The pressure but also the incentives, regional governments are eager to disclose to local universities, are connected with their expectations for local development. This is especially obvious in the case of the flagship examples of Silicon Valley, the Boston area, and Cambridge in the UK.

3. European route

Globalization pushes Europe to imitate US paradigm for an entrepreneurial university [1] and governments welcome the prospect of a knowledge transfer from universities to society in a more intensive and “commercial” way, to guarantee economic recovery [9]. The well-known and successful paradigms of Stanford University licenses given to well-known companies as Cisco, Google, and Yahoo, however are strongly atypical either in patenting [5] or in licensing and also in licensing income. However, these stories empowered the view of the “entrepreneurial” university and technology transfer as a necessary growth tool.

As a lot have been read about the willingness of European universities to exploit their research results, we will comment first on the fact that European industry has not the US firms’ willingness to engage in a series of multiple transactions which affect the potential of effectively transferring meaningful university-based knowledge. The highly uncertain nature of scientific know-how, creates considerable transaction costs and cannot avoid systemic failures in the market and the industry side has to decide to take this risk. The more radical the technology to be transferred the more extensive research investment is necessary to reach commercial viability. The successful transfer of this new knowledge generally requires close and ongoing interactions between the inventor and the purchaser. This is particularly true if the recipient has limited direct experience with the technology [10]. This implies that the firm’s capacity and willingness to engage in multiple transactions will affect the potential of effectively transferring meaningful university-based knowledge.

Having this as a given fact we cannot ignore a further structural difference: “Heterogeneity in Europe, in terms of both institutional texture as well as legislative framework conditions pertaining to the ownership of publicly funded research, is partly responsible for the observed country differences [5]”. European Union recognizing the “European paradox” [11], that is no matter the great higher education system, the world recognized research infrastructure and the consequent results, the marketable innovations are few as universities fail in this sector, launched a series of funding initiatives (FTP, Horizon) to close this gap.

From universities’ side exists always the concern that a continuous pressure is applied upon them to deviate from their historically successful role and that it is almost certain, “commercialization” will destroy the norms of open science [12]. In addition, universities have a series of complex functions that include a range of different educational and societal objectives in addition of the complexity of their scientific community interests. Keck [13] underlines the fact that the intellectual orientation of German university professors made them averse to exploiting new ideas for commercial purposes even as they were encouraged to do so by university and government policy.

Having that peculiar European context in mind and also the existing literature on the evaluation of different formal ways of university –industry cooperation, we try to make some proposals to the universities, to match society’s expectations without jeopardizing their core mission, education and research.

4. Human capital

A new and critical source of capital, the so called human capital, is recognized as an inherent development factor. Education institutions are considered as the most important factor in society growth, however over long time intervals as it is apparent for the creation of new ideas. Vandenbussche et al [14] study how a higher education level “*enhances productivity growth all the more the economy is closer to the world technological frontier*”.

Cosh et al [15] through a UK-US survey show that the university-industry interactions most contributing to their innovation activities were the informal contacts. Second is the undergraduate and,

in less extent, master level recruitment and finally, publications in journals and proceedings of conferences. In contrast with “commercialization” fans expectations, patenting and licensing do not favor business preferences as far as university interactions contributing to innovation are concerned (see figure1). This outcome is in agreement with the findings indicating the flow of graduates or PhDs from their universities to new jobs in industry as the best form of technology transfer, or in other words universities’ education and training govern also this contribution.

This is also supported for American universities by Rosenberg & Nelson [2] noting that in each one of the new engineering disciplines, universities were eager to start new courses and train postgraduates. After showing that this was the case in electrical engineering, in chemical engineering and aeronautical engineering, they show that it was also true of computer science and of course of biotechnology. He notes that “the development of a number of important engineering disciplines, it seems apparent that engineering education in the US has consistently attempted to provide reference points for inquiry into the details of very practical problems” and underlines the fact that “university research has been instrumental in providing an appropriate intellectual framework for training efficient professional decision-makers”, [2]. Finally, Gennaioli et al. [16], using a database of 1569 regions from 110 countries, find that human capital (measured using education) emerges as the most consistently important determinant of both regional income and productivity.

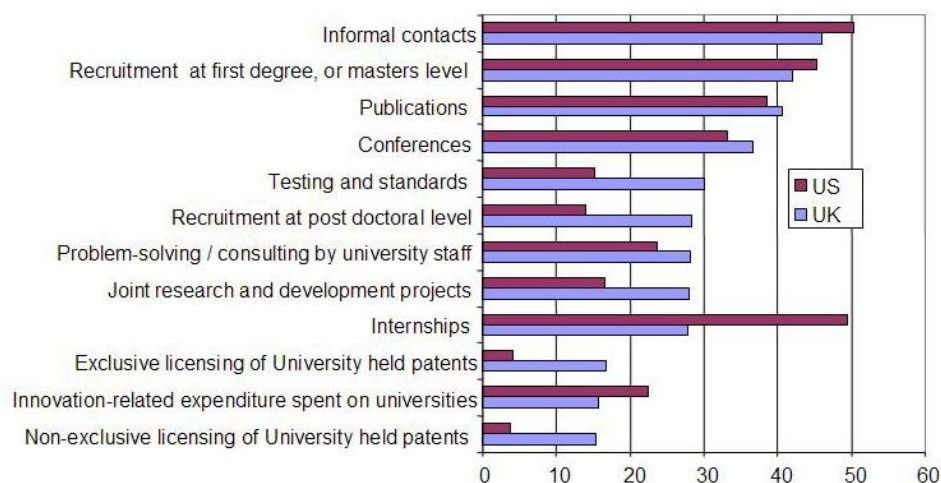


Figure 1. Types of university-industry interactions contributing to innovation % of firms rating mode [15].

5. Evidence or Wishful Thinking?

Veugelers and Del Rey [17] in their report for European Commission show that the evidence existed on technology transfer by universities is rather skewed, refers to certain countries, for selected disciplines, based on special kind of data and challenged by too many scholars. For example, they refer to a 2011 HEFCE study according to which the “real income from external sources for UK universities more than tripled between 2001 and 2010”. However, it came from contract research, which accounted only for one third with Continuing Professional Development and Continuing Education being the next most important source of external income, its share rising from 15% to 18%, confirming the human capital parameter. At the far end of the list was intellectual property with only 2% to 4% of income.

As far as university patenting is concerned, their research confirms the scattering, and small size of the phenomenon. Figure 2 shows that 68% of all university patents are held by the United States but the worldwide top 25 players in university patenting (22 US institutes, with the University of California, coming first, followed by MIT), although they represent only 2.6% of all patenting universities, hold almost 40% of all university patents.

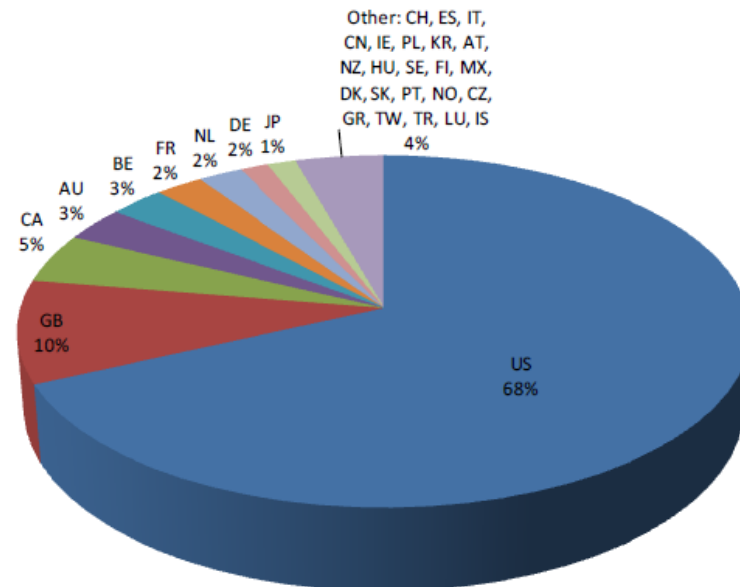


Figure2. University patenting by country (EPO, application years 1980-2000) [5].

In contrast, Europe (EU-15) accounts only 21% with the UK having around half of it (10%), being second worldwide. The low European performance owes to the fact that patenting in most countries is mainly not university patenting. In some countries the regulations on intellectual ownership within academia do not favor university patenting. In others, as Germany, France and Italy, a considerable part of publicly funded research is conducted at Public Research Organizations, like CNRS, CNR, and Fraunhofer which are not considered universities. All though the US is clearly dominant, only 7% of US academic patents are cited by the corporate sector, meanwhile in Europe the percentage is 28% but again far behind Japan (48%).

The possibility for a US university to get its patents granted is higher than that of a European one. This favorable climate leads to higher number of executed university licenses in US than in Europe. But again we can see using reports of Thursby and Thursby [18] that only the 0,48% of all active licenses generated income of \$1 million or more (the well-known success stories).

The data are even more scattered for university spin-offs, which seem to create much more jobs than a typical start-up. We cannot confirm with concrete evidence the rate by which students start up new businesses upon graduation (only several university-specific alumni surveys exist).

Veugelers and Del Rey [17] conclude that “the overall economic significance of the technology transfer model, with its focus on patenting and spin-offs, has often been exaggerated”. It practically means that the European policies, seeking to trigger university-industry osmosis, are not planned with a proper evaluation strategy, having as a result a non-systematic evidence collection on the impacts of these policies. Most of them are looking for quick “success stories”, ignoring the long term perspective. Of course it serves a few targeted interventions, however the need for a systemic approach with supporting institutions is ignored. The policies are, in most cases focused on university technologies commercialization, rather than in a strategically planned, broader contribution to economic development with other pathways, pressing public universities to contribute to local economic development.

6. Universities Contribution to Local Economy

The fact that universities contribute to local growth and regional innovation builds upon their missions [17]:

- “providing excellence in education, leading to students who will stay in the region and contribute to its growth”;

- “providing excellence in research that will be the sow beds for new ideas, products and services in areas that underpin the region’s economic base”;
- “providing excellence in transfer and collaboration that will support public and private actors in the region”.

Beyond the direct universities impact, it’s rather common, that they can attract other key economic resources, such as firms and workers, who may want to locate close by, as well as people seeking to exploit new business opportunities. In addition, universities are frequently among the largest employers in their regions and can generate indirect employment in different sectors of the local economy.

They may also be “important actors to help transform existing industries, - improving the abilities of the existing network of local firms to take up new knowledge, and to apply this knowledge productively; universities can help to attract new knowledge, and financial resources from elsewhere”, [19]. Their capability to adapt knowledge originating elsewhere to local economic and social or conditions, and to integrate apparently discrete technology areas, gives them the key to unlock and redirect existing knowledge in the market. Especially in the case of world-famous research institutes which are considered as powerful symbols of learning and expertise, their presence can be important to regional branding. Historically the world’s older universities have shown a continuous and inseparable relationship with their surrounding region identity: e.g. Bologna, Heidelberg, Uppsala, Leuven, Oxford and Cambridge. Case studies on individual institutes and their impact on their local economy are plentiful [20].

The “regional clusters” were another form of some industrialized countries to acquire substantial national economic returns from the investments in university research made by the state. The idea was to stimulate the creation of a critical number of innovative firms around universities campuses. Incentives used were funding or tax credits for “science parks”, such as the Bio-Regio cluster in Germany but they have not yet managed to generate mature, innovative industrial clusters. In Europe exists the European Institute of Technology, a common effort of many countries which is subsidized by FP7 & H2020 funding. It combines in a unique way research, teaching and technology transfer with a profound purpose to yield spillovers on local economic development and beyond. Unfortunately, the time period is not so long for the realization of EIT potential for regional spillovers.

All the above evidence indicates that universities affect positively regional development, without giving a clear proof causation that is the growth is not evident without university support. There is also lack of data about regions development after the close or transfer of existing universities in the area. In other words, the notion of universities as institutions holding important assets necessary for economic development, does not give a clear guarantee of a knowledge-based local economic development.

7. Technology Transfer Offices

Still we can’t ignore the fundamental importance of technology transfer. Technology is one of the primary forces shaping the evolution of modern society. The response of the European academy community to the questions posed by society and the political system is to set up a technology transfer infrastructure in universities that recognizes the business world, capable to review and evaluate faculty research, “develop innovative applications for new technologies, explore the viability of markets, evaluate the competition, procure investment capital if needed, develop corporate relationships, and utilize the entire process as a learning experience for students” [6]. In that way university researchers, will remain focused on their research, not bothering with technology transfer issues and saving valuable time, skills and interest. It’s really unfair to accuse them about research findings “sitting on the shelf”, when university or state does not allocate resources in the technology transfer process. The assumption that a new technology in and of itself will provide the necessary push to market, lays far away from reality according Thomas Edison who said that successful inventions are 1 percent inspiration and 99 percent perspiration.

In many European universities such Technology Transfer Offices (TTO) have been developed, however they are considered as an ancillary activity, and therefore are poorly staffed and have a low budget, acting as gatekeepers than what must be: facilitators. Our proposal is that creation of specialized

and decentralized TTOs within the university is instrumental to secure a sufficient level of autonomy for the development of any kind of relations with the industry. Practically it acts as a “buffer” between the university side fighting for free research and teaching activities and the industry side interesting in technology commercialization. “Also allows for specialization in supporting services, most notably management of intellectual property and business development. A higher degree of financial and managerial independence further facilitates relations with third parties, such as venture capitalists, investment bankers and patent attorneys” [6]. We underline the fact that technology transfer at a university, as one of its missions, needs strong support from university leaders in order to instill a climate on campus which will enhance their ability to do transfer technology. That approach begins with the university’s top leadership and the institutional characteristics of the university [21]. The adoption of certain university policies influence even the comparative cost of technology transfer, and the ways in which participation in technology transfer activities is rewarded.

However, the TTO job is based on the amount of innovations produced by research labs, which practically means that smaller universities often lack the resources and technical skills to effectively support such organizational arrangements and investments [22] and this raises the importance of a critical size for the TTO in order to be successful [23]. We propose a solution to this problem through cooperation of local universities, as in the EU area, “most intermediary organizations are rather small and below the necessary critical mass to be effective” [24]. They have to avoid focusing too much on the traditional ways of technology transfer (ie licensing and spin-offs), to manage a considerable economic return which in turn enhances further technology transfer activities.

Nevertheless, recent findings show that the majority of US TTOs fail to break even, lacking a sufficiently large deal flow [25]. In EU, we cannot still make conclusions on specialized TTOs, either on their effectiveness or their role in the improvement of university-industry relations [24].

The new role of universities as “engines of local economic development” or “magic beanstalks of invention and research”, [26] led many universities to restructure their TTOs to be more responsive to local industry focusing e.g. on revitalizing existing industries. It’s true that universities contribute with technology transfer, to the stock of technologies that firms may draw on for innovation and economic growth. But firstly universities need to develop long term relationships with businesses, relationships that boost a continuous flow of technology transfer, as the process of university-led economic development takes considerable time and patience that is often outside of the immediate demands of the political process. Sturgeon [27] finds that the genesis of Silicon Valley may be traced to the early twentieth century.

8. Conclusions

We must see technology transfer in the context of the fundamental mission of the university. “Chasing profits from tech transfer is potentially very corrosive ethically. That is why we need to have strong conflict-of-interest safeguards in place and why we must constantly guard against undermining the basic purpose of the academy” [6]. Tradition keeps our values as high as it is necessary but at the same time we have to recognize that universities have to actively participate incorporating new approaches.

Technology transfer is a challenge for universities but this is not the question: the question is what means technology transfer for society as a whole. It means a better life and as such has to be “accepted” by the universities adding new dimensions to their research, while at the same time providing new educational opportunities for faculty and students. Far from us the adoption of the idea for an easy, or socially automatic process. Two disparate cultures have not only to be met but also to cooperate fruitfully. We have to understand the ways in which social interaction is initiated, the governance and evolution of working relationships, and ultimately, the efficiency with which knowledge is absorbed and put into economic use considering the economic, social, and political influences that shape the ability of universities to both create new knowledge and deploy that knowledge in ways that are economically useful to firms.

Governments should see universities “as sources of human capital; and as key components of social infrastructure and social capital, in order to act as creators, receptors, and interpreters of innovation”

[17] and ideas for the local economies. They should adopt a long-term perspective avoiding the temptation of immediate “success stories”. They must have in mind the general perspective and not just a “few targeted interventions”, ignoring the need for a systemic approach. Ultimately they must not sacrifice the broader university contribution to economic development with other pathways, as training and mobility of human capital, focusing only on the commercialization of university technologies.

Unfortunately, the state of the literature is not yet sufficiently developed to support policy making with evidence indicating which policy instruments will be more effective to stimulate the contribution of universities to the economy.

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