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SUMMARY

This dissertation has empirically investigated some challenges and opportunities that emerge from the interaction between the world of Science and the world of Technology. The point of departure is that Science, intended as the *Episteme* or what we know, increases the understanding of the natural principles governing Technology (*Techné* or how we apply), and, with it, the range of applications of the set of techniques comprising Technology. Scientific discoveries, hence, pave the way for continuing improvements in the production process, either as refinement of existing techniques or emergence of new technological trajectories.

This dissertation has first explored two channels that should facilitate the economic exploitation of scientific knowledge: scientific eminence and entrepreneurship. By taking a simplistic view to the relation between Science and Technology, where the advancements in the former represent a necessary condition for the developments of the latter, scientific eminence can be conceived as an input of the process that transforms knowledge in profits and economic growth, whereas entrepreneurship as a throughput of this process.

Scientific eminence is only achieved when scientists discover regularities in nature which are original in their contents, rigorous in their explorations and universal in their implications for Technology, as assessed by the academic community. It hence pertains to the inherent qualities of the improvements to the epistemic base from which techniques can be built upon or improved. Technologists, who before others can have access to these new and superior pieces of knowledge, should be able to refine their techniques and consequently improve the outputs of their innovative efforts. I argued that scientific knowledge, produced in academic laboratories (the most prominent producers of Science), mostly spills over through market transactions, such as the market for graduates and technological services. From this perspective, accessibility – co-location – is crucial, because knowledge, unlike information, not only requires unanimated media to be transferred across space, but also, and foremost, face-to-face contacts with the direct source (the scientist). The first study aimed at drawing regularities with regards to this hypothesis: technologists located in the neighbourhood of universities hosting eminent research groups (in hard-science disciplines) should produce more and better innovations than technologists located elsewhere. Empirical results for 86 European regions (NUTS 1 and NUTS 2) between 1997 and 2007 confirm the role that scientifically eminent universities have on the innovative capabilities of local technologists. Other sources of scientific knowledge (intended as epistemic, directed towards the understanding of natural phenomena) do not show any statistical relation with regional innovative outputs. Nevertheless, the very small real effect attributed to the scientific eminence of academic research casts some doubts on the effectiveness of knowledge transfer between scientists and technologists.

The second study moves forward from this conclusion to investigate under which peculiarities of the industrial structure academic knowledge is better exploited from an economic standpoint. Scientific discoveries can be both evolutionary and a revolutionary with regards to the way existing techniques are designed and assembled. Indeed, the process through which scientific advancements are assessed is, in its self, a tension between conformity to the state of the art and dissent from it. Evolutionary and revolutionary scientific advancements have tremendously different implications for economic performances. Whereas most of the measured productivity growth might come from evolutionary improvements in the knowledge base, revolutionary discoveries introduce new concepts that have the potential to generate new markets and through a mix of competitive and cooperative interactions, trigger follow-up innovations and growth in other firms. They are therefore critical building blocks of nations' creative destruction capacity and their long-term economic growth. While existing organizations do not have to incur in severe reorganizations of their production processes to incorporate evolutionary discoveries, they have harder times when new discoveries require the reformulation of the existing productive logics. Entrepreneurs are not constrained by the rigidities of existing productive architectures. Therefore, they can redesign production processes so as to embed revolutionary advancements. The second study, hence, investigates whether sustained market entry is conducive to a more efficient exploitation of scientific knowledge. The starting point is the academic system because it is the place where scientific activities are carried out systematically. Universities, however, not only pursue scientific research, but they also train students and, lately, have become involved directly in the commercialization of scientific discoveries in the form of technologies. The econometric exercise carried out for 99 Italian provinces (NUTS 3) between 1999 and 2006 indicates that none of the above mentioned outputs exerts a significant impact on the rate of economic growth, neither for the manufacturing sector nor for the whole economy. It is only when research activities occur where sustained entrepreneurial activities take place that economic growth is affected: the traditional mandate of scientific inquiry seems to provide new ventures with valuable commercial opportunities overseen by established companies. Despite the positive impact of new ventures in exploiting scientific knowledge from an economic standpoint, their magnitude is very limited.

The first two studies clearly indicate that there exists potential for economic growth in the pursuit of scientific endeavours. Yet, the limited real implications call for further understanding of the process with which scientific knowledge is embedded in technological innovation. An often abused justification to the little real impact of scientists is their intellectual distance from problems of immediate practical relevance. The norms of the community of Science push for original contributions which would question the existing understanding of reality. These contributions, however, are also expected to explain a wide range of phenomena (the criterion of universality). The common sense would suggest that the introduction of clear monetary incentives should induce scientists to develop industrial applications of their scientific findings. A simple statistics, the number of patent applications from universities, would reinforce this view. The third study has hence examined a set of policy tools to increase the awareness of Intellectual Property Rights at public research

organizations. The French government embarked in a similar initiative in 1999, when it passed the Innovation Act. The Act had the explicit goal of losing the legal burdens to ease the management of IPRs at universities. The study uses a novel measure of academic inventive activity: patent applications whose inventors are scientists, irrespective of the ownership of the patent. The results show that scientists are involved in technological developments more than the common sense would suggest. Traditional statistics are misleading because scientists tend to leave the ownership of their inventions to corporate sponsors in more than two thirds of the cases. French universities own only 11% of all patent applications at EPO whose inventors are scientists between 1994 and 2001. The passage of the Act and the opening of technology transfer offices have increased the patenting rate at French universities; yet, any increase may be due, at least in part, to a redistribution of ownership rights, rather than an increase in inventive activity.

The final study of this dissertation has shifted the attention from science produced at universities to science produced in corporate environments. Companies are expected to have a comparative advantage in the production of new techniques. Investments in Science are a "necessary evil" to tap into knowledge external to the organization. However, companies increasingly pay attention to mechanisms that could secure their intellectual assets from rent-seeking forms of technological brokerage (patent trolls, patent sharks, etc…). The tremendous increase in patenting activities worldwide reflects this tendency. Patents, however, are costly to apply, maintain and enforce. The output of Science can well serve this purpose (at a lower cost): companies disclose relevant information in the public domain to pre-empt competitors from gaining exclusive rights on the technologies disclosed. This strategic use of Science has raised a debate between economists and legal scholars. Economists argue for the perfect substitutability between patents and publications for defensive purposes. Legal scholars instead The last chapter has provided for the first time an investigation of the presumed mechanism behind this strategic use of Science. The results from the Semiconductor Technology indicate that, unlike publications from the public sector, corporate publications have the power to threaten the novelty and originality of claimed inventions. This effect is not driven by any systematic difference in the contents of the articles from both communities. Moreover, publications are effective only when they are combined with other pieces of prior art, confirming the view of legal scholars.

Concluding, the underlying rationale of these studies is that scientific knowledge generated in academic communities has the potential to revolutionize the way products and processes are conceived. The emergence of science-based sectors like Biotechnology and Information and Communication Technology in the last thirty years points exactly to his. The limited magnitudes of the factors that supposedly should influence the generation and the diffusion of revolutionary scientific knowledge call for a deeper understanding of the role that Science actually plays in the generation of radical techniques and how they actually diffuse.